MANIPULATION IN CRUDE OIL FUTURES MARKETS: EVIDENCE FROM PRICE-VOLUME RELATIONSHIP

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Declaration

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

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ANOVA	Analysis of variance
CFTC	Commodity Futures Trading Commissions
CSE	Colombo Stock Exchange
EC	European Commission
EIA	Energy Information Association
EMH	Efficient Market Hypothesis
GARCH	AutoRegressive Conditional Heteroskedasticity
GMM	Generalized method of moments
ICE	Intercontinental Exchange
IEA	International Energy Agency
ISSM	Institution for the Study of Security Markets
MDH	Mixture of distribution hypothesis
NYSE	New York Stock Exchange
NYMEX	New Year Mercantile Exchange
SAIH	Sequential arrival of information hypothesis
VR	Variance-Ratio
WTI	West Texas Intermediate

ABSTRACT

This study examines existence of manipulation in the West Texas Intermediate (WTI) and Brent crude oil futures markets during the period of 2005-2014. To detect the occurrence of manipulation for respective crude oil futures market, five hypotheses are tested. Variance-Ratio (VR) test (Lo & MacKinlay, 1988), trading-induced manipulation equation (Aggarwal & Wu, 2006) and price-volume relationship equation (Lee & Rui, 2002) are adopted. Empirical result provides three findings. First, the VR test shows that the Brent futures market is inefficient, while, the WTI futures market is found to be efficient. However, manipulation is observed in the efficient market. Second, price and volume are found to have positive relationship before the crash in Brent futures market, whereas, positive relationship between the series is not detected in the WTI futures market. Third, no negative price-volume is detected at the post-manipulation period for both markets. This study suggests that CFTC should consistently monitor both Brent and WTI crude oil futures markets and should aware of any unusual market activities. Besides that, CFTC should have the new technology on hands and knowing the trading patterns in the market.

CHAPTER 1: INTRODUCTION

In this chapter, we discuss the background of study of manipulation in the crude oil futures market and followed by the problem statement of the research. The research questions and objectives are stated in the subsequent section. The significance of study is explained at the next section. The study layout is stated in the last section.

1.1 Background of Study

Manipulation is an intentional action or movement to affect the normal daily operations of a market and create a false, confusing phenomenon in the aspects of price and trading volume. Although there is normal trading dominating the market, the irregular market behaviors happen now and then, especially in existing commodity market.

There are many arguments regarding the increase in market price due to manipulation. For instance, Allen and Gale (1992) identified the market manipulation in stock market. The purpose of the manipulation process is to inflate the prices by purchasing excessive stocks. While at the same time, it gives a false impression of higher future prices to the traders who are uninformed. Hence, the price of the stocks will be decline sharply after the selling process.

In the futures markets, contract price of commodity market able to provide information to producers and traders (Nicolau, Palomba, & Traini, 2013). The futures market is an active, effective and highly traded market which information flow in the markets is fast and efficient. According to Nicolau, Palomba, and Traini (2013), they found that the supply decisions of producers were related with the price of futures contracts. Moreover, the futures contracts were taken as a reference for the traders to value their commodities Therefore, spot commodity markets might be dominated by the futures markets.

Khwaja and Mian (2005) studied the pump and dump process to explain how the mechanism of manipulation works in commodity market. The investors or traders are able to gain abnormal profits through the practice of "pump and dump". This is the factor that causes manipulation. According to Khwaja and Mian's (2005), the act of "pumping" is manipulators buy stock at higher price. Their reaction gives the incorrect signals to the market. The price is expected to increase by the uninformed traders, hence buying more stocks.

Then, the manipulators can sell off the stock at higher price and exit the market, causing a slump in the stock price. The uninformed traders will act after the manipulators, sell off those stocks they own which may allow the manipulators to re-enter the market with lower price. Another way to manipulate the market is by "dumping", manipulators aim to burst the price bubble so that they can enter the market at lower price by selling off the stocks at lower than fundamental price. This will cause a fear and eventually the price will crash.

1.2 Problem Statement

During 2006-2008, market manipulation is an arguable and hot issue in commodity market. Nowadays, manipulation has extend to different kind of situation, it normally refers to the large traders manipulate the market.

Manipulation in crude oil market causes a huge impact towards the global economy. A fluctuation in crude oil price provides different impacts towards oil producing and oil consuming countries. For the case of oil consuming countries, they will benefit with lower oil prices due to lower cost. The fall of oil price will have negative impact for the oil producing countries as their profits were reduced. A fall in the oil price will result to wealth distribution from oil producing nation to oil consuming nation.

The legal cases of manipulation are adopted to identify the manipulation period. For example, the Telegraph stated that the indictment filed a lawsuit in New York

about Royal Dutch Shell and British Petroleum (BP) is manipulating more than a decade in the Brent crude oil market (Godsen, 2013). In May 2012, the companies Shell, BP and Statoil were raided by the European Commission (EC). EC warned that the small distortions of assessed prices have a big collapse on the crude oil's price and sales that impacting the customers.

According to Bloomberg Business, the manipulation happened in Brent crude oil market in September 2012 (Voris, Nguyen, & Olson, 2013). Whereas in the West Texas Intermediate (WTI) crude oil futures market, there was manipulation found in December 2007 by the United States District court case between U.S. Commodity Futures Trading Commissions (CFTC) versus Parnon Energy Inc., Arcadia Petroleum Ltd, Arcadia Energy (SUISSE) SA. Nicholas J. Wildgoose and James T. Dyer.

Table 1.1 shows the characteristics of two primary crude oil benchmarks. First is the New York Mercantile Exchange (NYMEX) West Texas Intermediate (WTI) Crude Oil and second is the Intercontinental Exchange (ICE) Brent Blend (Brent).

Table 1.1: Characteristics between Brent and WTI crude oil futures markets

	Brent	**WTI**
Market	Intercontinental Exchange (ICE)	New Year Mercantile Exchange (NYMEX)
Market Participants	About two-thirds around the world	Mostly in United States
Location Extracted	North Sea (Brent, Forties, Oseberg, Ekofisk)	Wells in United States
Supply of crude oil	Water-borne	Land-locked
Refined Location	Northwest Europe	Midwest and Gulf Coast region in US
Density (API Gravity)	38.3	39.6 (lighter)
Level of Sweetness	0.37% sulphur	0.24% sulphur (sweeter)
Usage	Diesel fuel, gasoline and middle distillates	Gasoline refining
Transportation Cost	Lower (due to the supply is water-borne)	Higher (due to transport via pipeline)

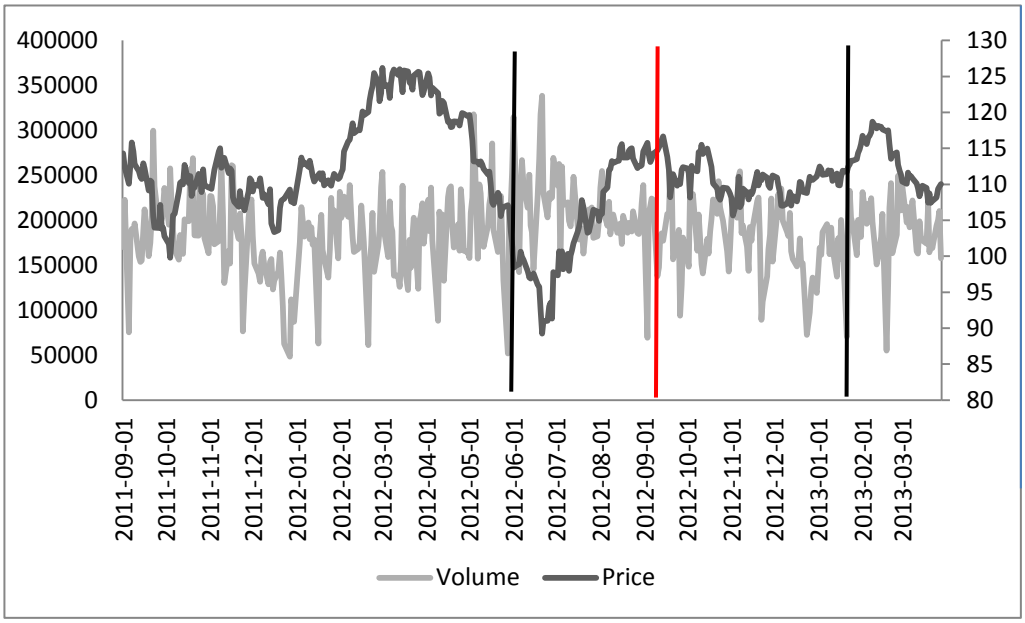

Figure 1.1: Brent crude oil futures market price and trading volume, September 1, 2011 – March 31, 2013
Source: Bloomberg (2015)

As observed in Figure 1.1, there is a slump of price at the pre manipulation period. After that, the price rise significantly from June 2012 to August 2012 before the manipulation. It is consistent with the "pump and dump" theory by Khwaja and Mian (2005). There is increasingly high price of commodity futures market and send a false signal to the market. The manipulation takes place in September 2012.

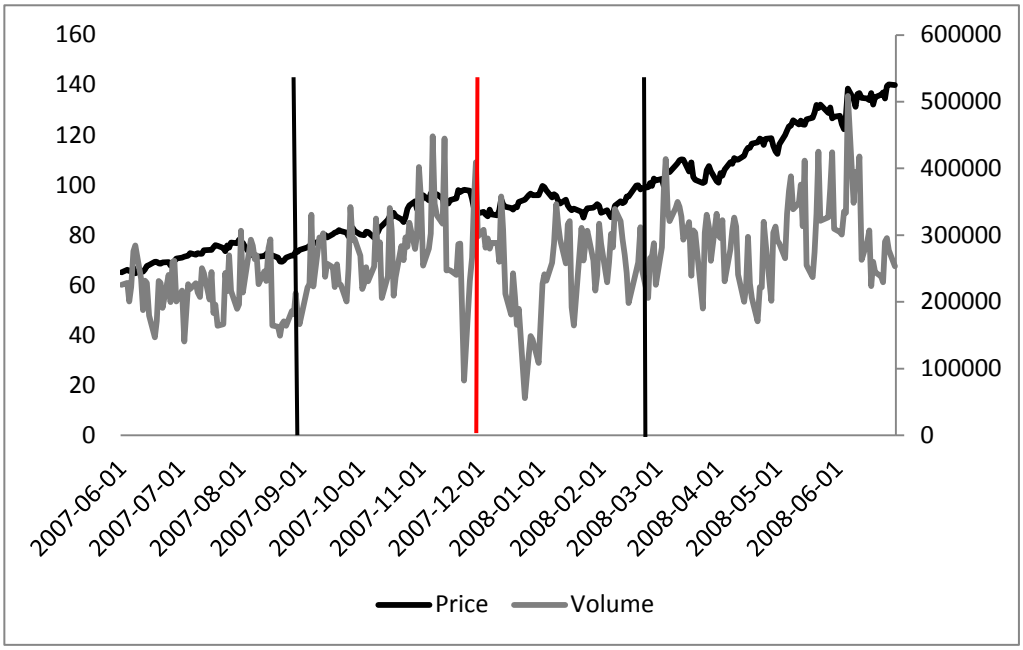

Figure 1.2: WTI crude oil futures market price and trading volume, June 1, 2007 – June 30, 2008
Source: Bloomberg (2015)

By adopting the legal case of U.S. Commodity Futures Trading Commission (CFTC) versus Parnon Energy Inc. and others from United States District Court (New York), manipulation also happen in WTI crude oil futures market. The case stated that there is an occurrence of manipulation about late 2007 through April 2008. U.S. CFTC sued the Parnon Energy Inc. and others tried to manipulate the WTI financial contract prices illegally.

As observed in Figure 1.2, information obtained from the legal case enables us to identify the period of manipulation. In December 2007, there is a sharp decrease in the volume accompanied with tightness of crude oil price. The case of manipulation is able to move the entire volume index. The further discussion on the manipulation period can find in the finding part.

In 2013, United States Energy Information Association (EIA) reported the average prices for the Brent and WTI crude oil markets are $108.56/barrel and $93.98/barrel respectively. From International Energy Agency's Oil Market Report (IEA), the total demand for oil in 2013 was 90.9 million barrels. Whereas in 2015, EIA forecasted the average prices for the Brent and WTI crude oil market, are $60.00/barrel and $55.00/barrel respectively.

EIA also forecasted the total demand for year 2015 will be around 93.6 million barrels. By taking the Brent crude oil market as example, using the price multiply with the volume, the total wealth distributed from oil producing nations to oil consuming nations is amounted to $1.55 trillion per year.

From the economic point of view, during the World War II (WWII) aftermath, the economy was experiencing stable oil price, low inflation rate and high employment rate. That shows a good sign to economy back then. After the 1974 Gulf War, the high inflation and unemployment caused a shock decline in economy growth due to the drastically increase in the oil price.

Oil is one of the major inputs in the economy. Most of the activities such as fuelling transportation, production and manufacturing required this input to operate. When the oil price increases, this effect will then pass to consumer with bearing higher cost. Hence, it eventually causes inflation. However, when oil price decreases, it is a good sign for investors and consumers which allow them to have more money to spend on their investments and the daily expenses. Subsequently, a continuous decrease in price will reduce the interest rate. This will result in earning lower income saving and potentially affect the share price.

1.3 Research Questions

1) Does manipulation occur in Brent and WTI crude oil futures markets respectively?

1.4 Research Objectives

The following three objectives are stated as below:

- To test the market efficiency of Brent and WTI crude oil futures markets.
- To determine whether manipulation occurs in Brent and WTI crude oil futures markets.
- To examine price-volume relationship for the detection of manipulation in Brent and WTI crude oil futures markets.

1.5 Hypotheses Development

This study attempts to test the following five hypotheses.

The study of Fama (1970) explains the idea of market efficiency. He proposes the Efficient Market Hypothesis (EMH). The author suggests that the price of an efficient market is fully reflect by the available information is so general that it has no empirically testable implications. For the case of efficient market, the return from the market will be in random walk return which prices will react quickly and fully reflect the all available information. Hence, this will disallow manipulators to earn abnormal return. This prompts the hypothesis of H1.

Hypothesis of H1: Informational inefficiency is found in Brent and WTI crude oil futures markets.

After testing the market efficiency, we proceed to test hypotheses from H2 to H5. The authors of the referred study suggest that at the starting period of the manipulation will experience a huge increase in the buying volume that causes the increase of price. This motivates to test the following hypothesis of H2:

Hypothesis of H2: During the manipulation period, there is a significant increase in the trading volume.

Next, if there is existence of information asymmetry among uniformed traders, when manipulator increases the buying volume, the price will be increased too. Kapoff (1987) strongly believed that there is causal relationship between price and volume. The early studies on price-volume relation suggest that there are positive relations between the absolute value of daily price changes and daily volume for both market indices and individual stocks. This suggests that there is an existence of positive price-volume relationship before the crash of price.

Hypothesis of H3: There is a positive price-volume relationship exists before the crash.

After most of the contracts had sold by the manipulator, there was a decrease in the total volume during the last phase of the crisis. This will considerably in the post manipulation period, as there was an end of the period of artificially inflated volume.

Hypothesis of H4: During the post manipulation period, a decline in trading volume exists.

When the manipulated price bubble bursts in the last phase of the manipulation period, the contracts sold excessively. Hence, it will cause a sharp decline in the price of contracts. This suggests that in the last phases of the crisis, there's a strong negative price-volume relationship.

Hypothesis of H5: At the end of the manipulation period, there is a negative price-volume relationship.

After tested all hypotheses, we can determine whether manipulation occur in the Brent and WTI crude oil futures markets. Other than that, the detection of manipulation through the price-volume relationship is able to examine in both crude oil futures markets.

1.6 Significance of Study

This study delivers information to Commodities Futures Trading Commission (CFTC) about the manipulation in the Brent and WTI crude oil futures markets. The CFTC can take note of the study manipulation cases. For instance, CFTC can differentiate the characteristics of the manipulation by categories it into three periods which are pre-manipulation, crash period and post manipulation.

After that, CFTC able to detect the presence of manipulation in the crude oil futures markets with the price-volume relationship. Therefore, the result obtained able to help CFTC to avoid the manipulation from happening. Furthermore, the study allows CFTC to revise the existing policies (Dodd Frank Act). CFTC allows implementing Dodd Frank Act for the protection of public and market users from fraud manipulation and abusive financial practice. CFTC can take the price-volume relationship for manipulation detection to increase the transparency and accountable of the Dodd Frank Act.

1.7 Chapter Layout

The remaining chapters are organizing as follows. Chapter 2 provides the literatures review about the concept of manipulation and price-volume relationship. After that, Chapter 3 discusses the data and methodologies that will be used to investigate the occurrence of manipulation. Next, the obtained empirical results and findings are explained and shown in Chapter 4. The last chapter would be the discussion based on our findings in previous chapter, and policy implications that could be taken and conclusion for the study.

CHAPTER 2: LITERATURE REVIEW

This section discusses about the types of market manipulation and the price-volume relationship. Then, a further discussion conducts based on the relationship between these two. In the crude oil market, there is lack of study that carried out to examine the presence of manipulation. Most of the past studies are mainly focus in the stock market manipulation. Based on the past studies about the manipulation in stock market, we adopt the five hypotheses that using the price-volume relationship to test the unchecked manipulation in Brent and WTI crude oil futures markets. In order to examine the manipulation in both crude oil futures markets, we need to study the market efficiency of crude oil futures market.

2. 1 Types of Market Manipulation

Theoretically, the explanation of manipulation is defined as adjusting or changing in accounts, data and records to fulfill one's purpose of benefits (Abrants-Metz & Addanki, 2007). Ogut, Dogany, Ceylan and Aktas (2012) state that the manipulation is an intervention or action to the mechanism of financial market that avoids a fair and retail price to prevail.

The study of Allen and Gale (1992) was focused on the stock price manipulation. The fundamental of manipulation in crude oil futures market was on the basis of demand-supply balance. The demand of oil price was reflected the economic cycle in the market. While the supply of crude oil price was determined by the oil producer (Dulaimi, 2014). Manipulation practices able to bring abnormal profit to the manipulators.

In the crude oil futures markets, the intense speculation caused the oil price to increase and the manipulators able to seek profit through this process. Furthermore, the participants that involved in the crude oil futures markets manipulation are producer, trader, investors and consumers. The producers able to

influence its competitors' production decision by get involved in the futures market (Dulaimi, 2014). Hence, the producers can control and affect the price level of the crude oil. Traders were the person who executed trading in the financial or commodities markets in the capacity of speculators, hedgers and arbitrageurs. The allocation of capital that expected a return in the future was known as the investor. Lastly, consumers were known as the party who took the oil for their personal use.

Generally, manipulation can be classified into three types (Allen & Gale, 1992). The finding was supported by Azad, Azmat, Fang, and Edirisuriya (2014) who also found that manipulation can classified into three types. The first can be known as action based manipulation. For this type of manipulation, the actual or perceived value of the assets affected by the cautions or manipulation action by one party.

The second type was the information based manipulation. The market manipulators released the false information or rumours to give the market a wrong perception towards the market movement (Van Bommel, 2003). Hence, the manipulation took place in the market.

The trade based manipulation was the third type of manipulation. It occurred where the manipulators simply buy and sell the stocks without taking additional observation into account to affect the firm's value (pump and dump). These well informed participants would then prevent the manipulators to earn abnormal profit. The impact of buying excessive (pumping) or selling (dumping) stocks by manipulators would be offset by the act of traders who buy or sell off their stocks. The uninformed traders will leave overprice stock on hand.

The act of “pumping" can be described as manipulators buy stock at rising high prices and send the false signals to the market (Khwaja & Mian, 2005). The traders that are uninformed would expect the price to increase, hence buying more stocks. During the “dumping”, manipulators can sell off the stock at much higher price and exit the market, causing a slump in the stock price. The uninformed

traders would then act after the manipulators, sell off those stocks they own which allow the manipulators to re-enter the market with lower price.

The researchers Allen and Gale (1992) study the stock price history manipulation by using the Twentieth Century Fund's securities as their discussion in the study. They concluded that it is hard to disallow trade based manipulation as the manipulation able to occur in different way by the action of release false information by the insiders.

On the other hand, Van Bommel (2003) studied the information based manipulation in stock market manipulation based on the public and non-public announcement. The finding was consistent with Aggarwal and Wu (2006) that established a model to explain trade based manipulation on the cases of Securities and Exchange Commission (SEC) stock market manipulation from January 1990 to October 2001. The authors found that the higher volatility of stock, greater liquidity, and the return is high were the signs of manipulation period began.

The manipulation practice can take place due to the market become inefficient. The idea of market efficiency refers to Fama (1970) as he proposes the theory of EMH. The author suggests that the price of an efficient market is fully reflect by the available information is general that it has no empirically testable implications. For the case of efficient market, the return from the market will be in random walk return which prices will react quickly and fully reflect the all available information. Hence, this will disallow manipulators to earn abnormal return. In the same paper, Fama (1970) points out three forms of market efficiency. But we just adopt the first form which is weak-form efficiency. It indicates that the information is purely based on historical prices.

Based on Aggarwal and Wu (2006)'s model, there was no existent of manipulator in the market with more information seekers. Besides that, the market was more efficient, where information was reflected rapidly in stock price when there were high information seekers. However, when there were many information seekers, it was possible that manipulators pool with informed party and earn profit from the trade with information seekers. Therefore, when there were more manipulators in

the market, the information seekers lost more. As a result, there were less information seekers in the market and caused the market to become informational inefficient. In short, Aggarwal and Wu (2006) concluded that more information seekers can improve market efficiency yet can also increase manipulation.

2.2 Price-Volume Relationship

To study the price-volume relationship in stock market, Azad et al. (2014) had taken the markets are informationally inefficient into account as the first hypothesis. Then, the researchers continued the other four hypotheses that employed several econometric tests and included the evidence of legal case of manipulation periods in order to carry out the investigation. The results of the investigation proved the case evidence of manipulation bubbles was resulting from excessive buying and burst later through selling stocks.

They found that manipulation occurred in South Asian stock markets which "pump and dump" take place in the market. After the manipulator sends misleading information by buying stock excessively in order to drive up the stock price, uninformed investors will have false impression toward stock price and tend to buy more stock in hoping stock price will increase. Thus, traded volume will increase dramatically during manipulation.

Before the crash, the price and volume relationship is positive because of the increasing buying volume accompany by increasing price in manipulation period. Then, trade volume will slightly fall during the last phrase of the crash which due to the manipulator will sell most of the stock. In the end, when manipulation bubble burst, there will be excessive selling of stock that causes decrease in prices. In other word, negative relationship of price and volume occur at post-manipulation period.

In the early study of price-volume relationship, Ying (1966) highlighted the importance of traded volume in forecasting price. He found that the correlation

between price and volume is positive by applying chi-square tests, analysis of variance (ANOVA) and cross-spectral analysis to price and volume data from 1957 to 1962 in the New York Stock Exchange (NYSE). Easley, Kiefer and O'Hara (1997) conducted a study on Ashland Oil during 1990 from Institution for the Study of Security Markets (ISSM) transaction database, their findings is consistent with previous study. Chevallier and S évi (2012) studied on the crude oil price and volume relationship by reporting strong significant and positive relationship between price and volume. They used GARCH test to examine this relationship period from January 2007 to December 2010 on NYMEX. He, Yang, Xie, and Han (2014) found a positive unidirectional causality relationship between return and volume.

In contrast, Stickel and Verrecchia (1994) found price and trading volume were negative correlated. He used multivariate analysis and graphical analysis to examine price and volume relationship on NASDAQ National Market System for fiscal years from 1982 to 1990. Kocagil and Shachmurove (1998) documented negative correlation between price and volume in orange juice futures contract. In NYMEX, Moosa, Silvapulle and Silvapulle (2003) identified a strong negative correlation between price and volume in WTI crude oil.

On the other hand, Pathirawasam (2011) found stock return is positively related to contemporary changes of trading volume but past changes of trading volume is negatively related to stock return. He examined these relationships of listed stock from 2000 and 2008 in Colombo Stock Exchange (CSE) data.

Information Flow Hypothesis

When new information is arrived in the market and associate with trading volume, significant relationship between price and volume will occur price will respond to arrival of new information. In order to explain how information is affect price and volume, there are three basic hypotheses underpinning in the price-volume including mixture of distribution hypothesis (MDH), sequential arrival of information hypothesis (SAIH) and noise traders' hypothesis.

Most of the past studies supported MDH in the examination of price and volume relationship. In MDH, price and volume is responding contemporaneously toward new information. All participants receive the new information simultaneously and thus past price can be used to predict the volume (vice versa). For cotton futures market, Clark (1973) used Bayes' tests and Kolmogorov-Smirnov tests to investigate on price-volume relationship, he found a positive correlation on both variables on cotton futures market from 1945 to 1958.

There was similar finding found by other researcher. For instance, Cornell (1981) studied commodities futures, Tauchen and Pitts (1983) studied 90-Day T-Bills Futures, Grammatikos and Saunders (1986) studied Foreign currency futures, Bessembinder and Seguin (1993) studied eight futures market and Easley et al. (1997) studied Ashland oil common Stock, they reported positive contemporaneous relationship between these two variables in different market.

In SAIH, traders receives new information in dynamic effect which mean when new information arrives in market traders will change their position because past volume has ability to forecast future return. Copeland (1976) proposed SAIH where information on volume needs time to be reflected on change of price in the future. His findings were further supported by other studies. For example, Fujihara and Mougou é (1997) examined nonlinear causality relationship for crude oil from 1984 to 1993. They used third-order moment test and found nonlinearities in futures price and volume for crude oil futures contracts. They then used GARCH-filtered data to test nonlinear Granger-causality. The result is significant bidirectional nonlinear Granger-causality between price and volume.

Besides that, Moosa and Silvapulle (2000) and Moosa et al. (2003) examined in crude oil futures also found bidirectional causality one after another. However, He et al. (2014) investigated on agriculture commodity futures contract found a positive unidirectional causality relationship between return and volume.

Kocagil and Shachmurove (1998) examined of contemporaneous and intertemporal causality relationship between price and traded volume of crude oil and other futures commodity from 1980 to 1995. They used Granger causality test

and obtaining result is consistence with both sequential information arrival hypotheses, mixture of distribution hypothesis and heterogeneous investor model of Wang's (1994). However, the result of high volume market such as crude oil has no causality in both directions.

In Noise trader hypothesis, due to traders' actions are not based on economic fundamentals and relevant information, their decisions are unpredictable and tends to cause stock prices temporary mispricing in the short run. The trade of noise traders are conducted on the basis of price movement. In the study of Delong, Shleifer, Summers, and Waldmann (1990), they found that there is significant causal relationship from movement of futures prices to volume of trading. The result indicated that the trading volume is affected by the movement of futures price. Besides that, Bhar and Hamori (2005) investigated on crude oil futures market from 1990 to 2000. They found one-way causality from price to volume. However, Fujihara and Mougoué (1997) reported futures return and volume have bidirectional nonlinear Granger causality in Petroleum Futures during 1984-1993.

Asymmetric Hypothesis

The presence of heterogeneity of trading behavior can lead market adjusts to new information partially. The information arrival will cause investors to response differently on market shock and this will cause asymmetric in information. Epps (1975) developed a hypothesis indicated the existence of an asymmetric relationship between price and volume. The heterogeneity of traders' hypothesis can be tested by distinction between bull and bear. Bull is more optimistic and will react to positive information whereas bear will react to negative information. Therefore volume is greater on positive price than negative price.

Jennings, Starks and Fellingham (1981) extended Copeland (1976)'s model by included margin requirement to restrict on short sales. The restriction made short seller to be less responsive to information that affected price and caused short position to be more costly compare to long positions. Thus, they have also found asymmetric price-volume relationship which the positive relationship is greater than negative relationship. The studies of Smirlock and Starks (1985),

Bessembinder and Seguin (1993), Brailsford (1996) and Cooper, Downs, and Patterson (2000) likewise provided empirical evidence of an asymmetric price and volume relationship where positive relationship is greater than negative.

On the contrary, Wood, McInish and Ord (1985) studied in NYSE stock and Moosa et al. (2003) studied in crude oil futures markets, they documented asymmetric price and volume relation which negative price and volue changes are greater than the positive price and volume changes. In contrast, Foster (1995) used Generalized ARCH (GARCH) and generalized method of moments (GMM) and found symmetric price and volume relation in crude oil futures market. The results indicated that trading volume is not affected by price change.

CHAPTER 3: DATA AND METHODOLOGY

In this chapter, we explain the data used in the first section. The following section is to explain Variance-Ratio (VR) test in examining market efficiency. Then, we explain equation of Aggarwal and Wu (2006) in examining trading-induced manipulation. Then, it is followed by equation of Lee and Rui (2002) in examining price-volume relationship.

3.1 Data

This study uses daily closing price of New York Mercantile Exchange (NYMEX) West Texas Intermediate (WTI) Crude Oil Futures and Intercontinental Exchange (ICE) Brent Crude Oil Futures. The daily data of WTI futures cover from January 1, 2005 to December 31, 2014, with total 2518 observations. Due to different scheme of market holidays, daily data of Brent futures are covered from January 1, 2005 to December 31, 2014 with 2576 observations.

These data are collected from Bloomberg, where daily closing prices of Brent and WTI are recorded in Dollar, while trading volume of both futures markets which is equals to 1,000 barrels per contract and the trading. Both data of price and volume are transformed into logarithmic form in order to reduce the variances.

3.2 Methodology

This study involves three steps in testing five hypotheses. First, in testing market efficiency, Variance-Ratio (VR) test from Lo and MacKinlay (1988) and Charles and Darné (2009) is used to check the validity of hypothesis of H1. Lo and MacKinlay (1988) proposed the asymptotic distribution of VR (x;k) by assuming that k is fixed when $T \rightarrow \infty$. They showed that under the assumption of

conditional heteroscedasticity, then under null hypothesis that V(k) = 1, the test statistic M(x;k) is given by:

$$M(x;k) = \frac{VR(x;k) - 1}{\phi^*(k)^{1/2}} \quad (1)$$

which follows the standard normal distribution asymptotically, where:

$$\phi^*(k) = \sum_{j=1}^{k-1} \left[\frac{2(k-j)}{k}\right]^2 \delta(j) \quad (2)$$

$$\delta(j) = \left\{ \sum_{t=j+1}^{T} (x_t - \hat{\mu})^2 (x_{t-j} - \hat{\mu})^2 \right\} \div \left\{ \left[\sum_{t=1}^{T} (x_t - \hat{\mu})^2 \right]^2 \right\} \quad (3)$$

If the VR is equal to 1, the price series is a pure random walk series, any trial to create profitable trading and predictions on the price series will fail. While, if VR is lesser than 1, indicating that it is mean reversion and the price will tend to move back to average price over time. Whereas for VR larger than 1, indicating it is mean aversion and the price will tend not to move back to the average price over time. The null hypothesis of the test is written as:

H_0: Market is following Random Walk process.

Hypothesis of H1 is supported when the test statistic computed from Equation (1) is greater than the critical values, rejecting the null hypothesis and indicating that market is not efficient.

To test the hypotheses of H2, H3, H4 and H5, we use one sub-period for each market according to the published news and legal cases that justified the existence of manipulation. Referring to the legal case U.S. Commodity Futures Trading Commission (CFTC) v. Parnon Energy Inc. & Anors and U.S. CFTC official

released statement; U.S. CFTC sued Parnon Energy Inc. and others with manipulation and attempted manipulation of the WTI crude oil futures market from late 2007 to April 2008. According to Bloomberg, Reuters, Law360 and Yahoo Finance, several oil majors and trading houses have been manipulating the Brent crude oil futures since 2002. The manipulators are BP, Trafigura Beheer, Phibro Trading, Royal Dutch Shell, Vitol and Morgan Stanley.

Then, how the volume changes before, during and after the manipulation period is examined. Following Aggarwal and Wu (2006), the pre-manipulation period is used as the base case, while dummy variables are included for the manipulation and post-manipulation periods. Equation (4) is written as:

$$V_t = a_0 + \sum_{i=1}^{n} a_{1i}\,\mathrm{SM}_{i,t} + \sum_{i=1}^{n} a_{2i} C_{i,t} + a_3\,\mathrm{PM}_{i,t} + e_t \qquad (4)$$

where V_t represents the volume on day t. $SM_{i,t}$ are the dummies capturing the start of the manipulation period, $C_{i,t}$ stands for the crash period dummies and $PM_{i,t}$ is the post-manipulation period dummies. This equation is used to test the hypotheses of H2 and H4. H2 is supported if the coefficient of the dummy variables ($SM_{i,t}$) that capture the start of the manipulation period is positive and significant. This indicates that an increase in the volume happened during the manipulation period. H4 is supported if the coefficient of the dummy variables ($C_{i,t}$) that capture the crash period and coefficient of the post-manipulation ($PM_{i,t}$) is statistically relatively small or insignificant. This indicates that when the manipulation ends, the volume fell during the post-manipulation period.

For third step, we use the following Equation (5) which is adopted from Lee and Rui (2002) to test the hypotheses of H3 and H5 based on price-volume relationship during the manipulation period. This equation consists of the slope dummies to capture the effect of manipulation. The slope dummies are calculated by multiplying the daily trading volume with the time-period dummy.

$$R_t = b_0 + b_1 V_t + b_2 V_{t-1} + b_3 R_{t-1} + \sum_{i=1}^{n} b_{4i}\,\mathrm{SLOPE}_{it} + e_t \qquad (5)$$

where R_t is the return on the day t. The lagged volumes (V_{t-1}) and lagged returns (R_{t-1}) are included according to the research. For this equation, the pre-manipulation periods is used as the base case, while the slope dummies in the equation are to capture the manipulation effect and post-manipulation periods of the price-volume relationship. The positive and significant value of slope dummy that capturing the start of the manipulation support the hypothesis H3, indicates the increase in price is accompanied by the increase in volume. The negative and significant value of slope dummy variable that capture the crash period supports hypothesis H5, suggest that there is an excessive selling at the end of the manipulation period and hence causes the price to crash.

CHAPTER 4: EMPIRICAL RESULTS

We present estimated results for Variance-Ratio (VR) test at first section. The estimated results of Brent and WTI crude oil futures market regarding the trading-induced manipulation and price-volume relationships are presented and interpreted in second and third sections, respectively.

4.1 Market Efficiency

Variance-Ratio (VR) test (Lo and MacKinlay, 1988) is used to compute test statistics for weekly returns for two crude oil futures markets. This test allows us to test the hypothesis of H1, to check whether the market is informational efficient or inefficient. The critical values assume that the test is conducted for a single value of lagged, k. If the test is conducted for several values of k, the probability of rejecting the null hypothesis for some value of k is greater than the size of the test, even asymptotically. From Table 4.1, VR test gives mixed results, rejecting the null hypothesis for lag of 16 but not for others. Almost all of the existing studies about the VR tests provide the same inferences, rejecting the null hypothesis for some values of k but not for all.

Table 4.1: Variance-Ratio (VR) test statistics

Lag (k)	2	4	8	16
Brent	-0.893826	0.444016	1.016388	1.712818*
WTI	-0.930430	0.037346	0.589777	1.348071

Notes: The study covers the weekly data from January 2005 to December 2014. *** indicates that the rejections are significant at the 1%. ** indicates that the rejections are significant at the 5%. * indicates that the rejections are significant at the 10%.

As shown in Table 4.1, the result of Brent crude oil futures market at value k equals to 16 with test statistics of 1.712818. This shows a rejection of null hypothesis at 10% level of significance. For value k of 2, 4, 8, there is no rejection of null hypothesis at any level of significance. These results indicate that Brent

crude oil futures market is less efficient. However, in the WTI crude oil futures market, no rejection is found for any lagged value k. This suggests that the WTI crude oil futures market is efficient. This empirical test tells us that the Brent crude oil futures market is less efficient whereas the WTI crude oil futures market is in weak form efficient. Although the WTI crude oil futures market follows Random Walk process, there are supporting evidences such as published news and legal cases proved that manipulation occurred during the selected time period. Market manipulators tend to enter into an efficient market to use the advantage of information efficiency to manipulate the market (Aggarwal and Wu, 2006). Therefore, manipulation can still happen in an efficient market. Thus, we proceed to test the remaining four hypotheses for both markets.

4.2 Manipulation in the Brent Crude Oil Futures Market

Table 4.2: Trading-induced manipulation in Brent crude oil futures market

Parameters	Variable	Coefficient	Std. Error	t-statistic	Prob.
α_0	Constant	184244.4	4746.048	38.82059	0.0000
α_1	JUN_2012	48750.27	10885.63	4.478404	0.0000
α_2	JULY_2012	20784.24	7536.258	2.757899	0.0061
α_3	AUG_2012	18051.40	7329.186	2.462947	0.0142
α_4	SEPT_2012	-3902.757	11329.81	0.344468	0.7307
α_5	OCT_2012	37767.361	9364.317	0.402310	0.6877
α_6	NOV_2012	1359.668	12440.42	0.109294	0.9130
α_7	DEC_2012	-18687.58	18529.68	1.008521	0.3138
α_8	POSTM_2013	1667.117	6922.285	0.240833	0.8098
Adjusted R^2	0.073479				
F-Stat	5.014893				

Notes: Result from the above OLS regression model (expanded from Eq. (4)): $Vt = \alpha_0 + \alpha_1$ JUN2012 + α_2 JUL2012 + α_3 AUG2012 + α_4 SEP2012 + α_5 OCT2012 + α_6 NOV2012 + α_7 DEC2012 + α_8 POSTM2013 + e_t where the dependent variables V_t is the volume of the day t. Month dummies are taken to capture the manipulations. SEP2012 is when the price crashed. Standard errors of the estimated coefficients are corrected for autocorrelation and heteroskedasticity by using the Newey-West methods (with lag truncation = 6). Sample covers the period from September 2011 to March 2013 with 406 daily observations.

Referring to the Bloomberg news (Voris, Nguyen and Olson, 2013) the manipulation was happened during September 2012. We then consider the manipulation period, one year before and six months after September 2012. Table 4.2 shows the results of Brent crude oil futures estimated from Equation (4) during September 2011 - March 2013.

As shown in Table 4.2, it indicates that monthly dummies which is capturing the period before September 2012 crash namely June 2012, July 2012 and August 2012 have large coefficients and statistically significant. This result supports hypothesis of H2 that the trading volume increases significantly before crash and throughout the beginning of the manipulation. With this result, we can say that the manipulation has begun since June 2012.

Next, insignificant dummy of September 2012 provides the relatively small coefficient of -3902.757 shows that trading volume has dropped significantly during the crash. Besides that, dummies of October 2012, November 2012, December 2012 and post-manipulation 2013 has the relatively small coefficient values are found to be insignificant even at the 10% level. These insignificant dummies indicate that there was a significantly decline in trading volume by comparing to pre-manipulation's (June 2012, July 2012 and August 2012). This supports hypothesis of H4, where the trading volume was declined during the post-manipulation period.

Table 4.3: Manipulations and price-volume relationship for Brent crude oil futures market

Parameters	Variable	Coefficient	Std. Error	t-statistic	Prob.
b_0	Constant	0.037729	0.017011	2.217904	0.0271
b_1	Volume	-0.005646	0.002843	-1.986088	0.0477
b_2	Volume (-1)	-0.001719	0.002841	-0.605040	0.5455
b_3	Return (-1)	-0.104929	0.050465	-2.079258	0.0382
b_4	SLOPE_JUN_2012	-0.000101	0.000605	-0.167127	0.8674
b_5	SLOPE_JUL_2012	0.001025	0.000597	1.716878	0.0868
b_6	SLOPE_AUG_2012	0.001033	0.000581	1.779390	0.0759
b_7	SLOPE_SEP_2012	-0.000191	0.000630	-0.302542	0.7624
b_8	SLOPE_OCT_2012	-0.000156	0.000584	-0.267635	0.7891
b_9	SLOPE_NOV_2012	0.000338	0.000598	0.565382	0.5721
b_{10}	SLOPE_DEC_2012	-9.22E-05	0.000642	-0.143584	0.8859
Adjusted R^2	0.008466				
F-Stat	1.344100				

Notes: Results from the following OLS regression model (expanded from Eq. (5)): $R_t = b_0 + b_1V_t + b_2V_{t-1} + b_3R_{t-1} + b_4\ SLOPE_{JUN2012} + b_5\ SLOPE_{JUL2012} + b_6\ SLOPE_{AUG2012} + b_7\ SLOPE_{SEP2012} + b_8\ SLOPE_{OCT2012} + b_9\ SLOPE_{NOV2012} + b_{10}\ SLOPE_{DEC2012} +$ et where, Rt is the return on day t and V_t is the volume on day t. SEP2012 is when the price crashed. The lagged volume and lagged returns are included following Lee and Rui (2002). Standard errors of the estimated coefficients are corrected for autocorrelation and heteroskedasticity by using the Newey–West method (lag truncation = 6). Sample covers the period from September 2011 to March 2013 with 406 daily observations.

Table 4.3 shows the estimated results of price-volume relationship for Brent crude oil futures market by using Equation (5). As observed in Table 4.3, the slope dummies of July 2012 and August 2012 are statistically significant at 10%. The coefficients of 0.001025 and 0.001033 for both dummies indicate that increase in volume in July and August 2012 was accompanied by huge increase in price. This finding supports hypothesis of H3, indicating that there is a positive price-volume relationship at the start of the manipulation.

In addition, the slope dummy of September 2012 is found to be statistically insignificant with negative sign of coefficient. This shows that there is no price-volume relationship at the post manipulation period. Thus, hypothesis of H5 is not supported. For a series of volume, coefficient of -0.005646 suggests that there is no price-volume relationship in the pre-manipulation period from June 2012 to August 2012.

4.3 Manipulation in the WTI Crude Oil Futures Market

Table 4.4: Trading-induced manipulation in WTI crude oil futures market

Parameters	Variable	Coefficient	Std. Error	t-statistic	Prob.
α_0	Constant	222146.8	6044.530	36.75171	0.0000
α_1	SEPT_2007	38398.35	11253.28	3.412192	0.0007
α_2	OCT_2007	51459.13	12649.32	4.068135	0.0001
α_3	NOV_2007	76429.13	22249.33	3.435121	0.0007
α_4	DEC_2007	-38.83787	35137.91	-0.001105	0.9991
α_5	JAN_2008	47245.84	10996.60	4.296403	0.0000
α_6	FEB_2008	45046.54	11095.55	4.059874	0.0001
α_7	MAR_2008	91669.81	15437.20	5.938242	0.0000
α_8	POSTM_2008	79351.39	15130.02	5.244633	0.0000
Adjusted R^2	0.010249				
F-Stat	1.406941				

Notes: Result from the above OLS regression model (expanded from Eq. (4)): $Vt = \alpha_0 + \alpha_1$ SEP2007 + α_2 OCT2007 + α_3 NOV2007 + α_4 DEC2007 + α_5 JAN2008 + α_6 FEB2008 + α_7 MAR2008 + α_8 POSTM2008 + e_t where the dependent variables V_t is the volume of the day t. Month dummies are taken to capture the manipulations. DEC07 is when the price crashed. Standard errors of the estimated coefficients are corrected for autocorrelation and heteroskedasticity by using the Newey-West methods (with lag function = 6). Sample covers the period from December 2006 to June 2008 with 396 daily observations.

For the case of WTI, the legal case of CFTC versus Parnon Energy Inc. & Anors has identified month that manipulation happened was during December 2007. We then consider the sub period: one year before the manipulation happened and six months after the manipulation happened. Table 4.4 shows the results of WTI crude oil futures market estimated from Equation (4) during December 2006 to June 2008.

As shown in Table 4.2, it indicate that monthly dummies which are capturing the period before December 2007 crash namely September 2007, October 2007 and November 2007 are statistically significant and have large coefficients. This result supports hypothesis of H2 that the trading volume increases significantly before crash and throughout the beginning of manipulation. With this result, we can say that the manipulation has begun since September 2007

Next, insignificant dummy of December 2007 provides the relatively small coefficients of -38.83787 shows that trading volume has dropped significantly during the crash. Besides that, dummies of January 2008, February 2008, March 2008 and post-manipulation 2008 have the relatively small coefficient values. These dummies indicate that there was a significantly decline in trading volume by comparing to pre-manipulation's (September 2007, October 2007 and November 2007). This supports hypothesis of H4, where the trading volume was declined during the post-manipulation period.

Table 4.5: Manipulations and price-volume relationship for WTI crude oil futures market

Parameters	Variable	Coefficient.	Std. Error	t-statistic	Prob.
b_0	Constant	-0.002414	0.022751	-0.106124	0.9155
b_1	Volume	-0.006682	0.004751	-1.406493	0.1604
b_2	Volume (-1)	0.007514	0.004676	1.607156	0.1088
b_3	Return (-1)	-0.103551	0.050502	-2.050427	0.0410
b_4	SLOPE_SEP_2007	0.000710	0.000831	0.854133	0.3936
b_5	SLOPE_OCT_2007	0.000855	0.000758	1.127932	0.2601
b_6	SLOPE_NOV_2007	-0.001003	0.000791	-1.268164	0.2055
b_7	SLOPE_DEC_2007	0.000342	0.000843	0.405945	0.6850
b_8	SLOPE_JAN_2008	-0.000771	0.000791	-0.974294	0.3305
b_9	SLOPE_FEB_2008	0.000616	0.000810	0.760023	0.4477
b_{10}	SLOPE_MAR_2008	-0.000354	0.000807	-0.439038	0.6609
Adjusted R^2	0.007753				
F-Stat	1.307064				

Notes: Results from the following OLS regression model (expanded from Eq. (5)): $R_t = b_0 + b_1V_t + b_2V_{t-1} + b_3R_{t-1} + b_4\ SLOPE_{SEP2007} + b_5\ SLOPE_{OCT2007} + b_6\ SLOPE_{NOV2007} + b_7\ SLOPE_{DEC2007} + b_8\ SLOPE_{JAN2008} + b_9\ SLOPE_{FEB2008} + b_{10}\ SLOPE_{MAR2008} +$ et where, Rt is the return on day t and V_t is the volume on day t. DEC2007 is when the price crashed. The lagged volume and lagged returns are included following Lee and Rui (2002). Standard errors of the estimated coefficients are corrected for autocorrelation and heteroskedasticity by using the Newey–West method (lag truncation = 6). Sample covers the period from May 2006 to June 2008 with 394 daily observations.

Table 4.5 shows the estimated results of price-volume relationship for WTI crude oil futures market using Equation (5). As observed in Table 4.5, the slope dummies of September 2007, October 2007 and November 2007 are statistically insignificant at 10%. The positive coefficients of 0.000710 and 0.000855 for September and October 2007 indicate that there is no increase in volume accompanied by huge increase in price. This finding does not support hypothesis of H3, no positive price-volume relationship is observed.

In addition, the slope dummy of December 2007 is found to be statistically insignificant with positive sign of coefficient. This shows that there is no price-volume relationship at the post manipulation period. Thus, hypothesis of H5 is not supported. For a series of volume, coefficient of -0.006682 suggests that there is no price-volume relationship in the pre-manipulation period from September 2007 to November 2007.

4.4 Comparison between manipulation in the Brent and WTI Crude Oil Futures Markets

Table 4.6: Summary of hypotheses results

Hypothesis	Brent	WTI
H1: Informational inefficiency is found in the market.	Support	Not Support
H2: Trading volume increases during pre-manipulation.	Support	Support
H3: Positive price-volume relationship before crash.	Support	Not Support
H4: Trading volume declines during post-manipulation.	Support	Support
H5: Negative price-volume relationship after crash.	Not Support	Not Support

For hypothesis of H1, as compared between market efficiency for Brent and WTI futures market which is measured by Variance-Ratio (VR) test, the Brent futures market is found to be less efficient. This indicates that WTI futures market is more efficient than the Brent futures market. By referring to the supporting evidences from the legal case CFTC versus Parnon Energy Inc. & Anors, although VR test shows that WTI is in the weak form market efficiency, market participants still have opportunities to manipulate the market. In this regard, this study proceeds to test price-volume relationship during the selected manipulation period.

For hypothesis of H3, before the crash period, price and volume in the Brent futures market has positive relationship. However, both price and volume in the WTI futures market are found to be as independent. This is due to different market characteristics between the Brent and WTI futures markets. For example, WTI is used as a benchmark in United States and Brent is used by approximately two-third of participants around the world. Participants in WTI crude oil market can switch to Brent crude oil market as benchmark, but participants of Brent futures market cannot switch to WTI futures market for benchmarking purpose.

Hypothesis of H3 is found to be not supported in the WTI futures market. The reason is crude oil for WTI is extracted from wells located in United States by using land-locked approach and is refined at Gulf Coast and Midwest region in United States. While, crude oil for Brent is extracted from North Sea (Brent, Forties, Oseberg, Ekofisk) via water-borne approach and is refined at Northwest of Europe.

With different sources of supply, crude oil price in the Brent market is more expensive than the WTI market, where buyers of crude oil are willing to pay a higher price to the crude oil which has lower transportation cost. Due to the pricing gap between Brent and WTI, when the price of WTI is closer to Brent during the pre-manipulation period, market participants switch from WTI to Brent crude oil futures market.

For Hypothesis of H5, there is no price-volume relationship in both Brent and WTI futures markets after the manipulation period. The reason is due to structure differences between stocks and crude oil markets. Stock investors normally seek for income earnings from capital gains and dividends. Thereby, after the price crashes, investors will exit the market due to psychological behavior and minimizing their losses. They may not enter into the market for a certain period. This causes a large increase in the stock market volume due to the excessive selling. At the same time, manipulators will re-enter into market to purchase those stocks with low price in order to make sure their ownerships are undiluted.

Furthermore, in both crude oil futures market, no negative relationship between price and volume is found after the price crash in post-manipulation period because there is no excessive selling of contracts.

Market participants anticipate that price to rebound after the price crash. Besides, they can enter long position or short position where the long party expects the price to increase while the short party expects the price to decrease in future. Therefore, after the price crash in the post-manipulation period, market participants can easily switch from long position to short position or even close up their position. This leads to no negative relationship between price and volume after crash.

Other than making profits from price changes, market participants enter into the markets for the consumption of crude oils. It is used in daily fuelling activities, transporting and manufacturing. The crude oil futures market is also depends on its supply and demand. Therefore, the price of the market will not be as volatile as stock market at the end of the manipulation period.

CHAPTER 5: CONCLUSION

5.1 Major Findings

As overall, this study concludes that the Brent crude oil futures market is inefficient. It is possible that manipulation is occurred from January 2005 to December 2014. Based on empirical results in testing five hypotheses, we find three findings.

First, Brent futures market is inefficient and WTI futures market is found to be efficient. By referring to the supporting evidences from the legal case CFTC versus Parnon Energy Inc. & Anors., although VR test shows that WTI is in the weak form market efficiency, market participants still have opportunities to manipulate the market.

Second, hypothesis of H3 is found to be supported for Brent futures market. There is a positive price and volume relationship in the post-manipulation period where the trading volume increases with increasing of price and trading volume decreases after the price crash. The supporting hypothesis of H3 indicates that the existence of pump and dump scheme where trading volume increases significantly during the manipulation period and declines during the post-manipulation period. However, the pump and dump scheme is not found during the manipulation period in the WTI futures market due to both price and volume do not has relationship.

Third, hypothesis of H5 is not supported for both futures markets. After the price crash, no sign of negative relationship between price and volume is observed. The reason resulting to this contrast of findings is due to difference of market structure between stocks market and crude oil futures market. For instance, short selling is prohibited in stocks market. So, stock market participants are unable to make profits like futures market participants when the stock price dropping.

5.2 Policies Implications

Commodities Futures Trading Commission (CFTC) plays an important role to solve market manipulation because the issue of manipulation is now associating with futures market. In futures market, manipulators use the loopholes in the regulations to artificially influence price and volume to earn abnormal profits. Therefore, CFTC should consistently monitor both Brent and WTI crude oil futures markets because both markets are interrelated.

Moreover, CFTC should aware of any unusual market activities such as large increase of volume which causes the movement of the price. For example, they should take intermediate investigation to capture the unusual market activities. If the price movement is caused by other than the factor of supply and demand, it indicates that there is a high chance of manipulation.

In addition, CFTC should have the new technology on hands and knowing the trading patterns in the market. So far, there is no single database that provides access to all market orders and executions. Thus, CFTC should seek for more efficient access to data through a far more effective market order and execution trading system. Furthermore, punishments against the manipulators should be taken to protect uninformed, small and weak market participants. With these practices, the crude oil futures market will be more efficient and operate in fair condition.

5.3 Recommendations

This study suggests two recommendations for future researchers. First, since this study emphasizes on trading based manipulation, therefore, we suggests that future researchers should focus on action based manipulation and information based manipulation. This is because there are insufficient studies on market manipulation especially for crude oils.

Second, future researchers should examine market manipulation for major traded vegetable oils such as crude palm oil and soybean oil because they have different characteristics in terms of transportation cost, storage cost and lifespan. Moreover, vegetable oil is important to fulfill the global consumptions of oil and fats in producing food, manufactured products and biodiesel.

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