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How the key factors will affect the market trading behaviors in Crude Oil Futures Market:

An analysis on convenience yield, inventory level and price volatility.

By

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05/2018

Master´s Programme in Accounting and Finance

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Abstract

The paper focuses on three key factors in WTI crude oil futures market: Convenience yield, inventory level and price volatility. The main purpose of the paper is to investigate the relation between those three key factors and analyze how those key factors will affect the market trading behaviors. Market trading behaviors could be measured from various aspects though, our paper will use open interest, long & short position volume held by crude oil traders and long & short position held by money managers as dependent variables and to represent the market trading behaviors. Our empirical results have proved that the relation between the three factors is consistent with previous theories by using the most recent data. E.g. Convenience yield keeps a negative relation with Inventory level. However, our results showing how the key factors would affect the market trading behaviors are beyond our expectations. To summarize, convenience yield and inventory level indicate positive effects on dependent variables while price volatility mostly has negative impact on the dependent variables except for short position volume held by money managers.

Keywords: Convenience yield, Inventory level, Volatility, Open interest, Long & Short positions, Crude oil traders, Money managers.

Acknowledgements

First of all, I would like to sincerely express my gratitude to my supervisor: Håkan Jankensgård, who did me a big favor with the final decision on my thesis topic and provided me with very useful recommendations and guidance during my thesis work.

Secondly, I would like to thank to Niclas Andrén, who helped me with my empirical methodology and who always replied the mails very quickly.

Contents

1.Introduction

1.1. Background

Crude-oil is regarded as one of the most important and frequent-traded commodities in the world, it weighs 15% of the Bloomberg commodity index which far exceeds the other traded commodities (Bloomberg L.P. (2018)). Crude-oil has profound impact over companies, world economy and also the global political relations. The fluctuation of the price of crude oil has always drawn intensive attention by countries since it is directly linked with the expenses for energy, transport and thus daily operations of the economy of countries.

Many countries and companies try to avoid losses caused by price fluctuation through entering into the crude oil futures market. The main method they use is to trade futures contracts to lock in the price of the delivery in the future. A futures contract is defined as the financial contract setting two parties´ obligations to purchase and sell the commodities at a locked price in the future, the party who requires to buy the commodity is defined as the long position of the futures contracts while the party who requires to sell the commodity in the future is defined as the short position of the futures contracts (SchweserNotes level one (2018)). Intuitively, the long position holders are mainly crude oil consumers and the short position holders are mainly crude oil producers.

Though crude oil futures market provides the occasion for crude oil traders to hedge price risk exposure, there are also many financial investors making speculative benefits through the futures market. Recent data has showed that trading volume held by money managers occupies nearly half of the total trading volume while crude oil traders dominate the other half (U.S. Energy Information Administration, (2018)).Therefore, market participates involving in the crude oil futures market is consisted of two groups: Crude oil traders, mainly producers and consumers, who hold hedging purpose; Money managers who hold speculative purpose and will not involve in the physical delivery of crude oil in the future.

It is considered that the crude oil futures market provides an effective way to transfer risks and discover the price information for hedging and speculation.(Büyükşahin & Harris, (2009)). More specifically, Crude oil futures market could serve the function of price discovery and hedging since the futures contracts contain the price information which could reflect the supply and demand status of crude oil and investors´ perspectives on futures price (Lautier, (2003)).There are two dominating benchmarks of crude oil price and with its corresponding futures market: The first one is Brent Crude whose crude oil is extracted from

the North Sea and classified as sweet and light, its futures contracts are traded on Electronic Intercontinental Exchange (known as ICE); the second one is West Texas Intermediate (WTI), it prices the lighter and sweeter crude oil comparing with Brent Crude, its futures contracts are traded in New York Mercantile Exchange futures market.(Wikipedia: WTI & Brent Crude, (2018)).

Though crude oil futures contracts serve as useful tool for hedging and speculation, it is simultaneously considered to be risky itself because of the potential size and volatility of the underlying. Some famous companies went bankruptcy due to the trading of crude oil futures contracts. For instance, the bankruptcy of China National Offshore Oil Corporation in Singapore due to the failure of trading large volume of crude oil futures contracts. For better discovering the price information and making correct decisions for hedging or speculation. Lots of researchers and studies have focused on analyzing the relation between futures commodity price and spot price. The relation between futures commodity price and spot price for any delivery date is defined as the term structure (Lautier, (2003)).

1.2. Purpose of the paper

The purpose of our paper is to identify how the three key factors (Convenience yield, Inventory level and Volatility) could influence the market trading behaviors. The term structure model will thus be a foundation. The market trading behaviors will be represented by open interest, long & short position held by crude oil traders, long & short position held by money managers. Additionally, we will also test for the interactive influence between those three key factors using the most recent data and compare the result with previous studies. The main reason for choosing those three factors is that they play the most important role in the term structure model and assumed to have very significant influence on market trading behaviors. The data we analyze will be in monthly interval and cover ten years from Jan 2008 to Mar 2018 based on WTI benchmark. We choose to use the data based on WTI instead of Brent Crude for two reasons: Firstly, WTI is based in Oklahoma, US trading hub and its futures contracts are traded on New York Mercantile Exchange, the US financial market has the most important influence over the global financial market and thus WTI benchmark will dominate in providing the crude oil price information globally. Secondly, US is the world´s largest importer, consumer and also one of the largest exporters of crude oil. Therefore, the crude oil trading strategies and other policies of US will influence the supply and demand status of crude oil profoundly and globally. WTI price benchmark, as based in US, will

incorporate and reflect the US crude oil market and policy information, thus providing important price information.

1.3. Main contributions of the paper

The paper will primarily make contributions by developing a three factor model which includes convenience yield, inventory level and price volatility, identifying how these three factors will influence the market trading behaviors by using the most recent data. Even though there are lots of previous studies focusing on those three factors and their effects on price movement and term structure model. Yet no paper have ever focused on how those three factors could influence the market trading behaviors and especially when the trading behaviors are represented by open interest, long & short position held by crude oil traders and money managers. We consider this study field to be very important and interesting, as has been mentioned before that the crude oil futures market is not only dominated by crude oil traders who hold hedging purpose, but also by the money managers who hold speculative purpose today. The empirical results of the paper could provide evidence about how most market participants will react to the change of those three factors. So that when individual market trader anticipates the change of one factor, he could infer how the other market traders will react and thus infer how powerful of long and short position holders could be, similar with the stock market. In addition, our paper will make further contribution by testing and investigating the interactive influence of the three factors by using the most recent data and compare them with previous studies.

1.4. Research Limitations

Our paper mainly focuses on the WTI futures market and all the empirical results are based on the data from WTI futures market. However, there is the other major crude oil futures market as we have introduced before, the Brent Crude. Even though we infer that the effects of those three key factors on the market trading behaviors will be the same in Brent Crude. It is better to conduct a detailed and explicit research based on the Brent Crude futures market as well, so that the empirical results could be more robust and be used later by other researchers who want to focus on the Brent Crude futures market.

1.5. Structure of the paper

The following paper will be organized as follows: Section two will introduce and discuss about the theoretical background, section three will present the data overview, section four

will introduce about the empirical methodology and models, section five will present and analyze the empirical findings, section six will conclude the paper.

2.Theoretical background

This section will introduce some important conceptions and theories in the crude oil futures market, present and discuss previous findings in relating with the interactive influence of the three factors: Convenience yield, inventory level and volatility, and their impacts on market trading behaviors, especially on the trading behaviors of crude oil traders, since they are more impacted by the fundamentals while money managers are more impacted by speculative motivations.

2.1. Open interest

The market trading behaviors could be explained by varieties of variables. For instance, the time to hedge, open interest or the hedging positions. In this paper, we will mainly use open interest and long & short position held by crude oil traders and money managers to represent the market trading behaviors.

Open interest is a popular market approach to measure the flow of the money into the futures market, it is defined as the total number of outstanding contracts which are held by market participants and which have not been settled or closed (Trading charts, (2018)). Because the creation of one future contract involves two sides, the long position and the short position of the contract, therefore, the total open interest will only count on one side of the volume, either the long position volume or short position volume, instead of the sum of the two sides´ volumes.

Ripple & Moosa (2009) give an example about how to count the open interest: when two new traders engage in the market trading activity, one buys the contract, the other sells the contract, the open interest will count on one contract, instead of two.

The conceptions of long & short positions could be easily understood. The total number of contracts held by traders who are obliged to buy the crude oil in the future is defined as the long positions; the total number of contracts held by traders who are obliged to sell the crude oil is defined as the short positions.

2.2. The term structure

The market trading decisions are largely relying on the expectations of the traders together with price information available in the crude oil futures market. Especially towards the latter, traders decide when to hedge and how much to hedge mostly based on the price information derived from the futures market. As has been introduced before that the core model used to discover the price information is the term structure model which is defined as the relation between the futures price and spot price with different maturities (Lautier, (2003)).

Many previous researchers have developed different term structure models and incorporate different factors in the model to identify the relation between futures price and spot price. For instance, Gabillion (1991) constructs a two-factor term structure model which includes spot price of oil and stochastic long-term price of oil as the explanatory variables, convenience yield as the dependent variable determined by the two variables. Liu and Tang (2010) develop a three factor affine general model: spot price, interest price and convenience yield as the independent variables to discover the futures oil price. More distinctive term structure model which differs from affine general model, such as dynamic Nelson-Siegel model developed by Hansen and Lunde (2006), Barunik and Malinska (2015), they assume the crude oil term structure is close to fixed income securities and thus focus on modelling itself to forecast the futures price, instead of the relations between different factors. The term structure models which are mentioned above, they are all aiming at discovering the price movement so that the traders know how to make the correct trading strategies.

2.3. Contango VS Backwardation Status

In the crude oil futures market, Contango and Backwardation are two important conceptions and status. The status where spot price is below the futures price is defined as Contango while the status of spot price exceeding the futures price is defined as Backwardation(Wikipedia: Contango & Backwardation (2018)), in the futures market, Backwardation is more common than the Contango in the relation. Below are graphs presenting the three status of crude oil futures market based on WTI historical spot prices.

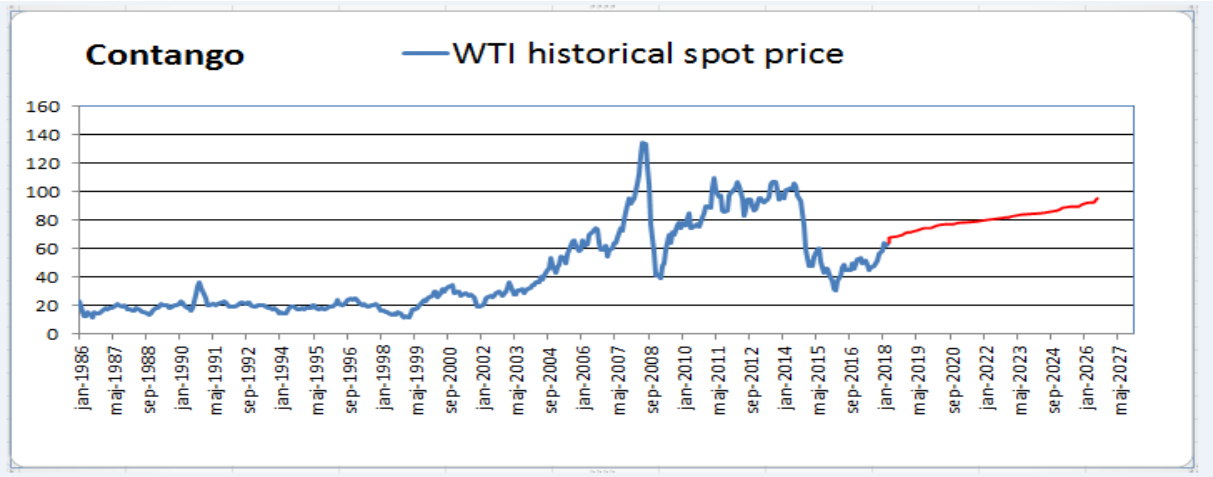

Figure 1: The Contango status of Crude oil market based on the WTI historical spot price.

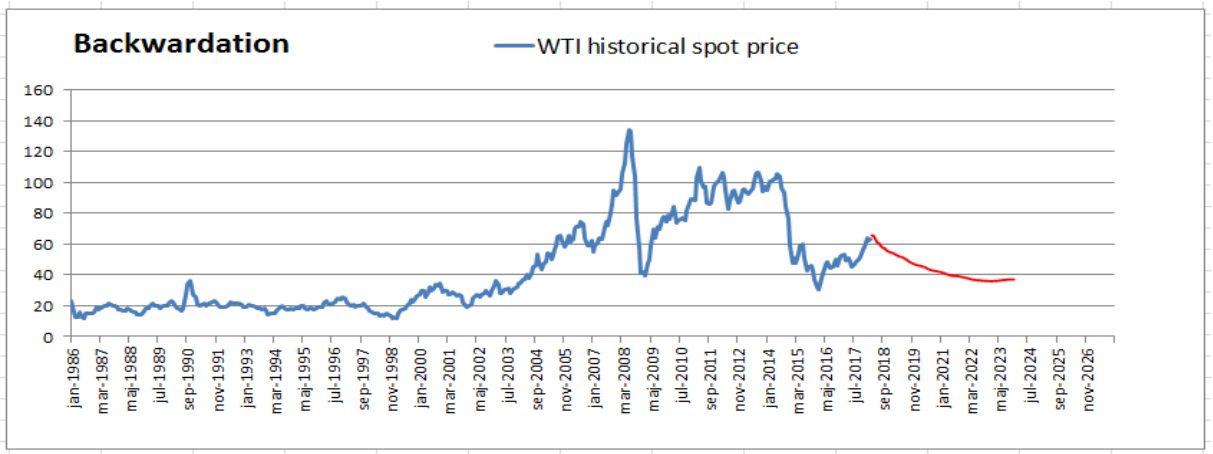

Figure 2: The Backwardation status of Crude oil market based on the WTI historical spot price.

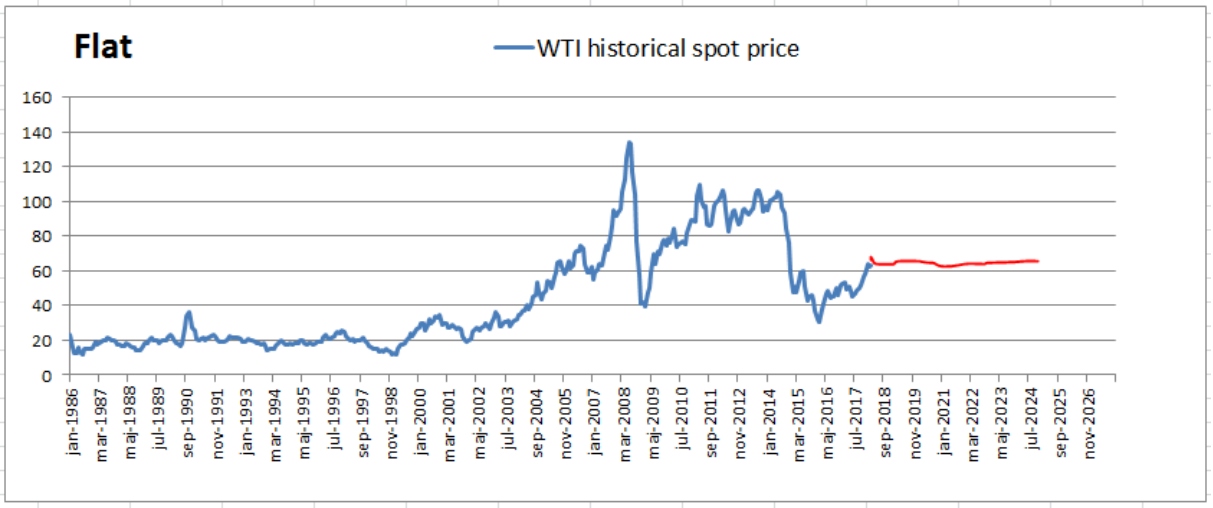

Figure 3: The Flat status of Crude oil market based on the WTI historical spot price.

(Source: WTI Historical Spot Price are collected from U.S. Energy Information Administration (2018) www.eia.gov).

In the crude oil futures market, analysis of Contango and Backwardation is so important that it delivers key message about price movement which will be used by market traders for making trading strategies. Market trading behaviors are different within the different status of the futures market. Horsnell et al (1995) analyze the hedging effectiveness in those three status of futures market which are contango, narrowing and widening backwardations, they come to the conclusion that under status of widening backwardations, the simulated hedges will lead to negative efficiency, short hedge is low while long hedge is high. Therefore, unhedged positions are preferred than hedging positions. Under the status of contango, short hedge is high while long hedge is medium or limited. Therefore, traders tend to hedge more under the status of narrowing backwardations, both short and long hedge are medium (Horsnell et al (1995)).

Charupat & Deaves (2002) studies the hedging strategy of the famous German company Metallgesellschaft which went into bankruptcy due to trading of the crude oil derivatives. They summarize the company´s hedging strategy which mainly uses large quantities of short-term derivatives to hedge the long-term contracts; they develop the model to explain the hedging strategy.

$$\pi_T = c_0 + \sum_{t=1}^{T}[f_t(0) - f_{t-1}(1)] - s_T$$

The model is expressed as the firm´s profit equals the long-term contract price plus the sum of all profits made on the futures contracts less the future spot price (Charupat & Deaves (2002)). The equation could further be written as

$$\pi_T = c_0 + \sum_{t=1}^{T-1}[f_t(0) - f_t(1)] - f_0(1)$$

This model tells that if the futures market is in the backwardation status, using the strategy of the short-term futures contracts to hedge the long-term delivery contracts could make benefits. This strategy will thus decrease the open interest in the futures market since short-term futures contracts will be settled or closed earlier, therefore, we could infer that the open interest will increase under the Contango status when traders prefer long-term delivery contracts. They further propose that if the futures market is in the normal backwardation status which is defined as future expected spot price exceeds futures price, then the larger the extent of normal backwardation, the larger will be the profits. Though, MGRM deems deeply that the

market is in the continuous backwardation in the early 1990s, consequently, they set their hedging strategy heavily on the short-term hedging program and considered to be over-hedged.

2.4. Convenience yield

The definition of convenience yield is firstly proposed by Kaldor (1939) defined as the economic benefits to carry the physical stocks. Further definitions developed later include, Brennan (1958) defines the convenience yield as the benefits from the flow of services that accrues to the owner who actually carries physical commodity, instead of the owner who possesses the derivative contracts for future delivery of that commodity. Heinkel et al (1990) propose a distinctive description of the convenience yield, they regard the convenience yield as the value of the option for stock holders before the end of storage period, and option value is resulted from the capability to sell the commodity for a higher price in the future.

One of the most important and fundamental theories which focuses on the convenience yield is the theory of storage firstly developed by Working(1934), he studies the relation between wheat price spreads to the aggregate U.S. wheat stocks and proposes that the inventory level keeps a negative relation with the convenience yield. More specifically, Working(1949) finds out that convenience yield is jointly affected by the interactive influence of crude oil market supplies and the storage policies of producers. Under the abundant situation of supply by crude oil producers, if the inventory level is still fairly high, convenience yield must be very high enough to exceed the cost of storage. This may due to that crude oil traders expect the futures price will largely exceed the spot price. If the inventory level is relatively low and simultaneously convenience yield is low as well, this may due to crude oil traders expect that the futures price will be less than the spot price. This notion could be a bit confusing with his previous study asserting that the inventory level should be in negative relation with the convenience yield. However, it is not contradictory and it is understandable. The relation has been affected and related deeply with the expectation of crude oil traders. Additionally, Working (1949) explains under the situation of scarce supply of the commodity, convenience yield will be very high and the spot price will thus be very high due to the large demand from the market.

Alquist el.at (2014) develop several models to demonstrate the importance of convenience yield for forecasting the situation of crude oil market. Their paper shows that longer-maturity

convenience yield could help forecast the supply of crude oil in the future as they belong to the forward-looking variables. More explicitly, high convenience yield not only indicates the relative scarcity of today´s crude oil but also forecasts the scarcity of crude oil in the near future. This is consistent with Working (1949) ´s theory. They further explain it is because an increasing convenience yield curve directs that the future inventories are more valued than today´s inventories, which in turn, implies the futures price will thus exceed the spot price. This will lead to Contango status as is defined before. According to Horsnell et al (1995), crude oil traders tend to hedge more under the Contango status. Therefore, if convenience yield increases (decreases), open interest, long & short position volume held by crude oil traders will increase (decreases) as well. In other words, the effects of convenience yield on open interest, long & short position volume held by crude oil traders should be positive according to the theories. Furthermore, they also prove that the term structure of convenience yield provides the information on future crude oil production, global economic activity and the futures price of crude oil. The usefulness of convenience yield in providing the information could also help market participants to forecast the crude oil market and thus make accurate trading strategies and decisions.

Differs from crude oil traders, money managers trade the futures contracts not for the purpose of final delivering of the crude oil, instead, they trade for the purpose of speculation with the expectations that the price or value of the futures contracts will rise or fall. Therefore, price movement of the futures contracts will impact their trading behaviors directly. The increasing of convenience yield implies that the crude oil futures price will exceed the spot price, therefore, the price of futures contracts are expected to rise and vice versa. Based on the motivation for trading futures contracts, money managers tend to hold the long position of the futures contracts and reduce the short position of future contracts under the expectation that the price of futures contracts will increase. In summary, we could infer that convenience yield should impact positively on the long position volume held by money managers while impacts negatively on the short position volume held by money managers.

Other researchers also look deeply into the convenience yield in relation with the market trading behaviors. Gibson & Schwartz (1990) develops two-factor model which includes spot price of crude oil and the stochastic convenience yield to measure the futures price. But they have also additionally showed the result in their model that hedge ratio and convenience yield keeps a negative relation but will decrease in absolute magnitude as maturity increases; the hedge ratio in regarding with the spot price decreases as the maturity of the contract increases.

Their findings are however contradictory with Alquist el.at (2014) and Horsnell et al (1995) ´s conclusion.

2.5. Inventory level

Inventory level is considered to be a core element in influencing the price movement and therefore the market trading behaviors.

Brennan (1958) emphasizes the importance of crude oil inventory as it could improve the efficiency of the gasoline production by avoiding costly production adjustments when supplies are low. The logic behind this notion is that gasoline production relies heavily on the raw material, the crude oil. With abundant inventory of crude oil, energy companies could always adjust the production based on its strategic objectives instead of being restricted of the crude oil supplies from the market, the demand of crude oil in the market could also be mitigated which prevents a sudden increase of the spot price according to demand and supply relation.

Geman & Smith (2013) studies relation between price and inventory level based on the traded metals on the LME, they describe that when the inventory level is low, the spot price will increase due to the large demand and vice versa. Intuitively, if the inventory level follows a decreasing trend, the futures price will be expected to exceed the spot price which leads to the Contango status; if the inventory level keeps increasing in the future, the futures price will be less than the spot price which leads to the backwardation status. Combining with previous theories by Horsnell et al (1995), under Contango status, crude oil traders tend to hedge more, thus we infer that the open interest, long & short positions held by crude oil traders will increase as inventory level decreases. Under backwardation status, unhedged positions are preferred than hedged positions, thus we infer that the open interest, long & short positions held by crude oil traders will decrease. In summary, inventory level should have a negative effect on open interest, long & short positions held by crude oil traders. Furthermore, they also propose that this implication will be less significant in longer maturity futures, because the market participants know that a high price will stimulate the supply in the long term and thus eventually reconstructs the inventory level. They present the evidence as in 2007, when crude oil futures market is in excess demand and a high price, crude oil futures contracts with one month maturity are priced $89 while crude oil futures contracts with 40 or more month maturity are priced at lower price at $76. This is consistent with their explanations.

As has already been introduced in the theory of storage, inventory level has a negative impact on the convenience yield so as to influence the relation between spot and futures price (Working, (1949)). There are further researchers who complement the recognized theory of storage by proposing that the inter-temporal spread between spot and futures price should be a function of expected inventory level, instead of current inventory level. Working´s supply of storage model may work effective under the condition that the expected future inventory level could be estimated by current inventory level (Weymar (1966)). In other words, it implies that market trading behavior will be affected by the expectation of traders as well. Traders will adjust their long & short position volume based on their expectations about inventory level in the future.

The relation between inventory level and spot price volatility is also very important to help explain how the inventory level would influence the trading behavior. Gorton et al (2013) indicates that the hedging positions held by crude oil traders changed directly in regarding with inventory level. When inventory level is low, traders are more willing to enter the futures market and engage in the hedging activity, in other words. Lower inventory level will increase the open interest, long and short positions held by crude oil traders and vice versa. This impact could be explained by the relation between inventory level and price volatility. As the inventory level becomes lower, the spot price will become more volatile so as to push the market traders to enter into the futures market for reducing the price volatility.

The importance of inventory level has also be emphasized by Acharya et al (2007) from the aspect for smoothing the cash flow and avoiding the risk of default. They consider the factors affecting the default risk which include the uncertain demand shocks in future and the costs of external finance. They argue that energy companies could smooth cash flows and deal with uncertainties through mainly two ways: Managing the inventory level or trading in the futures contracts. The role of inventory level is responding the demand shock and directly affecting the spot price, more specifically, they state that an increase in the inventory level will lead to a lower difference between spot price and future spot price, this serves the way to smooth cash flow and reduce the default risk. The role of future contracts could also serve the purpose of smooth cash flow by e.g. going short in the future contracts. The distinct roles of inventory level and trading futures contracts will be magnified when inventory level is low (Acharya et al (2007)). The intuition behind this is that when inventory level is low, its ability to hedge

the default risk will decrease, consequently, energy companies will tend to hedge more using the futures contracts, therefore, we could further expect that the open interest, long & short positions held by crude oil traders should be negatively impacted by inventory level.

Though there is not much paper focusing on how inventory level would influence the trading behaviors of money managers. Many economists have proposed inventory level could prevent speculative pressures from influencing the crude oil price (Medlock, (2013)). However, from the aspect of price movement, the increase of inventory level will decrease the futures price. Therefore, the price of futures contracts are expected to decrease with the increase of inventory level. Money managers tend to decrease the long positions and increase the short positions for the purpose of speculation. In other words, inventory level affects the long positions negatively and affects the short positions positively held by money managers.

2.6. Price volatility

Apart from the inventory level and convenience yield, volatility also serves an important role in the market trading behaviors. Acharya et al (2007) state that the fundamental hedging demand is induced by the incentive to decrease the price volatility and hedge the price risk exposure. Additional purpose is for speculation. Many hedging method analyzed indeed aims at reducing the variance of futures price. Sarungallo and Surya (2014) propose the minimum variance hedging method which targets to minimize the difference between changing of spot price and changing of futures price. Therefore, the price risk exposed to the asset will be reduced together with lower variance. They also state that the changing in the number of contracts will increase if the volatility of the spot price increases, in other words, the market participants will engage more in the hedging activities when volatility increases. Therefore, it is inferred that open interest, long & short positions held by crude oil traders are expected to increase as volatility increases.

Sevi (2015) develops a three factor model which incorporates volatility, inventory level and jumps to measure the convenience yield. His model predicts volatility has very strong power to explain the term structure model which could be used by the market participants. For example, during the high volatility period, the convenience yield is expected to increase, crude oil traders could thus adjust the inventory level and manage the strategic reserves accordantly. This notion has also been proved and analyzed later by Knittel & Pindyck (2016) who state that the increase of the spot prices will stimulate the demand for that commodity and therefore pushing the convenience yield higher. Further studies which identify the

positive relation between price volatility and convenience yield also include recent paper by (Omura et al (2018)), they study the metals base listed on LME and find out that with 10% significant level, a positive relation between realised volatility and convenience yield could be convinced. These previous empirical findings provide us with solid theoretical background and direction when we analyze the relation between convenience yield and price volatility.

Geman & Ohana (2009) has studied the relation between spot price volatility and inventory level based on the analysis of 20 year-database of US oil and natural gas price with inventory level. Their result shows that inventory level and spot price volatility keeps a negative relation. Under the situation of low inventory level, the spot price volatility will increase due to the sudden and large demand by market. This relation has also be mentioned and explained earlier by Telser and Brennan (1958), because abundant inventory allows the holder to react to unexpected supply & demand shocks efficiently and avoid the problem of interruption during manufacturing process. Therefore, mitigate the crude oil price volatility.

The theory of Samuelson effect proposed by Samuelson (1965) is also important relating the price volatility to the crude oil futures market, Samuelson (1965) asserts that the price of the futures contracts will become more volatile when they approach the maturity. Therefore, the spot price volatility will always exceed the future price volatility. He additionally explains this phenomenon as futures price volatility primarily reacts to long term market news while spot price volatility will react to both short and long term news.

It is hard to judge how the price volatility will affect the market trading behaviors of money managers. Because price volatility cannot forecast the increase or decrease of the crude oil price in the future and thus cannot provide information for money managers to make trading strategies. There is either no paper focusing on how price volatility will affect speculations.

2.7. Other factors influencing market trading behaviors.

2.7.1. US dollar value

There are also other factors which will influence the term structure and therefore the market trading behaviors. For instance, the fluctuations of the US dollar value in crude oil market. Crude oil is international-traded and dominated by US dollar, the appreciation(depreciation) of US dollar will make foreign countries spend more or less of their currencies to buy the crude oil. Thus, to the foreign countries, the price of crude oil is actually increasing

(decreasing). Countries which may suffer loss from the fluctuations of US dollar value in crude oil market include largest importers, like China, EU. Japan. Etc. Therefore, US dollar value could have large impacts on the price of crude oil towards Non-US dollar dominated countries. Crude oil consumers from those countries tend to engage more in the hedging activities since they expose to extra currency risks. Bloomberg& Harris (1995) present their empirical findings which show a negative relation between the US dollar value and commodity prices of crude oil in US dollar. The proper explanation could be that if the US dollar appreciates, it will be more expensive for other countries to buy crude oil and therefore the consumer demand will decrease according to the supply-demand relation. The decrease of the consumer demand will then lead to the decrease of the crude oil prices in US dollar. Crude oil traders and money managers will thus adjust their market trading strategies based on the US dollar value and price movement of crude oil. However, Zhang, Fan, Tsai and Wei (2008) find out that this impact tends to hold in the long term, the short term impact is limited on the commodity prices.

2.7.2. Interest rate

The interest rate could also be considered as a factor which influences crude oil price. Basher, Haug & Sadorsky (2010) present their viewpoints: Interest rate has impacts on crude oil price through inflation. Inflation will put pressure on Federal Reserve to increase the interest rate. At the same time, Global investors will seek for investments in other fields, like crude oil during the inflationary period; this will increase the demand for crude oil and thus increase the price. In other words, interest rate will positively influence the crude oil price and therefore affect the market trading behavior.

More specifically, the increase of the interest rate will increase the future crude oil price, which leads to the Contango status. According to Horsnell et al (1995), under the Contango status, crude oil traders tend to hedge more, therefore, we could infer that the open interest, long and short positions held by crude oil traders tend to increase with the increase of the interest rate. The situation is vice versa under the backwardations status.

2.7.3. Crude oil production

Crude oil production impacts the supply & demand relation of crude oil directly. The increase of crude oil production directly increases the supply of the crude oil and vice versa. Based on Working (1949) ´s theory. Under the scarcity of supply, convenience yield will be very high and the spot price will thus be very high due to the large demand from the market. Under

abundant supply, spot price will decrease. Thereby, we could infer that the relation between spot price and futures price will be largely impacted by crude oil production. Market participants will adjust their market trading behavior based on the term structure. The increase of the crude oil production will decrease the crude oil price in the future, thus, leading to the backwardations status. In combining with Horsnell et al (1995) ´s paper, open interest, long and short positions held by crude oil traders tend to decrease as traders prefer unhedged positons under backwardations status. The result will be vice versa under the decreasing trend of crude oil productions.

3. Data Overview

This section mainly describes the raw data and variables which will be used for the empirical findings; the raw data set is based on the West Texas Intermediate (WTI) light and sweet crude oil futures market. The reason why we choose to focus on the WTI crude oil futures market has been described in the introduction part. Furthermore, we will use ten years monthly data from Jan 2008 to Mar2018 due to the availability of the data and ten years monthly data could be considered to provide an accurate empirical result.

3.1. Dependent variables

In order to accurately investigate how the three independent factors (convenience yield, inventory level and volatility) will influence the market trading behaviors, we will rely on five dependent variables in five different models. The five dependent variables are open interest, long position held by crude oil traders, short position held by crude oil traders, long position held by money managers and short position held by money managers which aim to represent the market trading behaviors.

Open interest

Open interest is defined as the total number of outstanding futures contracts which are held by the market participants and have not been settled or closed (Trading charts, (2018)). We will use monthly open interest data of West Texas Intermediate (WTI) futures contracts traded in the New York Mercantile Exchange (NYMEX) from Jan 2008 to Mar 2018. Open interest monthly data is collected directly from the official website of US energy information administration (www.eia.gov).

Long and short position held by crude oil traders

The long position of the futures contracts means the buying of the contracts by market participants with the expectation that the price of the underlying assets will increase and must make the commitment to buy underlying assets in the future. The short position, on the other hand, represents the selling of the contracts by market participants and must make the commitment to sell the underlying assets in the future. The number of long and short position contracts is collected from the official website of US energy information administration (www.eia.gov). We will also use the monthly data from Jan 2008 to Mar 2018 which is consistent with the open interest, so that it could deliver a comparable empirical result.

Long and short position held by money managers

The long and short positions of the futures contracts held by money managers are defined similar with the positions held by crude oil traders. However, the purpose of buying or selling the futures contracts is not for final delivering of the underlying assets. It is instead aiming at making speculative benefits with the expectations of price movement. The money managers who buy the futures contracts at present hold the expectations that the price of the futures contracts will increase; while the money managers who sell the futures contracts hold the expectations that the price of the futures contracts will decrease. We collect the long and short position futures contracts number from the official website of US energy information administration (www.eia.gov). The data is as well ranging from Jan 2008 to Mar 2018.

3.2. Independent variables

As has been described before that the purpose of the paper is to examine how the three factors (convenience yield, inventory level and price volatility) will affect the market trading behaviors. Therefore, we set the three factors (convenience yield, inventory level and price volatility) as the independent variables.

Convenience yield

Convenience yield is an abstract concept defined as the benefits for holding the physical commodity (Kaldor (1939)), it cannot be obtained directly from database. Instead, we need to calculate the monthly convenience yield based on the popular cash and carry arbitrage formula. The formula is defined as:

$$F_{S,T} = Se^{(r-cy)(T-t)}$$

●$F_{S,T}$ is the futures price with T maturity

●T is the maturity period

●S is the spot price

●r is the interest rate

●cy is the convenience yield.

Consequently, we will use the derived formula to calculate the convenience yield, the formula is expressed as:

Cy= r- ((In(Fs,t/S))/(T-t)).

● $F_{S,T}$: Monthly WTI futures price with one months maturity, FS,T can be obtained from the US energy informaiton administration (www.eia.gov).

● T=1: We use the one month maturity WTI futures contract traded on NYMEX.

● *S:* Monthly WTI spot price, which can be obtained from the US energy information administration(www.eia.gov).

● r: Monthly 10-year US government bond yield, which can be obtained from the datastream.

Inventory level

Inventory level of crude oil affects the price movement and market trading behaviors profoundly as has been discussed before in the theoretical background. We use the monthly inventory data excluding SPR from Jan 2008 to Mar 2018 which is consistent with the dependent variable and other independent variables. The reason that we choose to use the inventory level excluding SPR is that: SPR (Strategic Petroleum Reserve) does not commonly involve in the trading of crude oil and therefore will not affect the supply and demand relation significantly. The inventory level excluding SPR is obtained from the official website of US energy information administration (www.eia.gov).

Price volatility

Volatility is a crucial measurement of the total risk of underlying financial assets; it is measured by the standard deviation or variance of returns (Brooks (2014)).The monthly volatility calculation will be based on the daily returns using the daily spot price from Jan 2008 to Mar 2018. We firstly calculate the daily returns as R= Ln(St/St-1)

(t=1, 2, 3…).Monthly volatility equals the standard deviation of one month range daily returns multiplied by the square root of 21. The daily WTI spot price is obtained from the US energy information administration (www.eia.gov).

3.3. Control variables

Interest rate

We consider interest rate as the control variable in our empirical model. The impact of interest rate on the crude oil price has been discussed before. Furthermore, in the cash and carry arbitrage relation, interest rate has been involved as an input to determine the relation between spot price and futures price. Therefore, it is supposed that interest rate may play an important role in impacting the market trading behavior. We will use the monthly 10-year government bond yield from Jan 2008 to Mar 2018 as the proxy of interest rate. Because10-year government bond is considered to be the most representative benchmark and used most frequently as a proxy for other financial analysis. The monthly 10-year government bond yield could be obtained from the datastream.

US exchange rate

US exchange rate has also been considered as a proper control variable since it directly affects the crude oil price towards foreign buyers outside of America. We will use the US dollar index as the proxy of US exchange rate, it measures the value of US dollar relative to a basket of foreign currencies. The index goes up when the value of US dollar increases and goes down when the value of US dollar decreases. The US dollar index is collected from the official website of economic research of Federal Reserve Bank of St. Louis. (https://fred.stlouisfed.org/series/DTWEXM).

Crude oil production

Crude oil production plays a direct and significant role in affecting the supply and demand relation so as to affect the market trading behavior in the crude oil market. The crude oil production data is collected from the US energy information administration (www.eia.gov).

4. Empirical methodology and models.

This section will describe the empirical methodology and models used for testing the relation and analyzing the empirical results. The empirical models are built on the purpose of the paper: As has been described in the introduction part, the paper aims at analyzing how the

three factors (convenience yield, inventory level and volatility) affect the market trading behaviors. The trading behaviors will be represented by five dependent variables, open interest, long and short position held by crude oil traders and money managers. Therefore, we will build five different empirical models with their corresponding hypothesis.

4.1. OLS Application

Ordinary least squares (OLS) will be mainly used to test and analyze the relation between dependent & independent variables since our data is simply time-series data.

We will however firstly test for multicollinearity between independent variables and control variables to see if they hold strong correlation with each other or not, correlation matrix will thus be presented for the test. If R is larger than 0, 8 or smaller than -0, 8, according to Brooks (2014), there exists serious multicollinearity problem and we will have to adjust our model. The other purpose of testing correlation is to investigate the interactive influence between the three key factors and compare them with previous paper.

After testing for multicollinearity, we will run the regression and obtain empirical results through Eviews. We will analyze the results at 10% significant level, if the coefficient shows a positive or negative value at 10% significant level, then we could conclude that the certain factor will have a significant positive or negative impact on the dependent variable.

4.2. Impact on open interest.

The first model is aiming at analyzing how the three factors affect the open interest. We construct the following empirical model and propose the hypothesis based on theoretical background which has been discussed before, some of the dependent, independent and control variables will be taken in the natural logarithm form due to that the numbers are too large.

LN(*Yoi*)=α1+ß1LN(*Inventory level*)+ ß2*Convenience_yield*+ß3*volatility*+δ1*interest_rate*+ δ2 LN (*US dollar index)*+ δ3LN(*Crude oil production*) *+3*

Hypothesis 1: Convenience yield has positive effect on open interest; Inventory level has negative effect on open interest; Volatility has positive effect on open interest.

4.3. Impact on long position held by crude oil traders.

The second model is aiming at analyzing how the three factors affect the long position volume held by crude oil traders. The crude oil traders who hold long position of the futures contracts are mostly crude oil consumers. We construct the empirical model and propose the second

hypothesis based on the theoretical background which has been discussed before as well, similar with the first model, some of the dependent, independent and control variables will be taken in the natural logarithm form due to the large numbers.

LN (Y_{LPT})=α1+ß1LN(*Inventory level*)+ ß2*Convenience_yield*+ß3*volatility*+δ1*interest_rate*+ δ2 LN (*US dollar index)*+ δ3LN(*Crude oil production*) +*3*

Hypothesis 2: Convenience yield has positive effect on long position held by crude oil traders; Inventory level has negative effect on long position held by crude oil traders; Volatility has positive effect on long position volume held by crude oil traders.

4.4. Impact on short position held by crude oil traders.

The third model is aiming at analyzing how the three factors affect the short position volume held by crude oil traders. The crude oil traders who hold short position of the futures contracts are mostly crude oil producers. We construct the empirical model and propose the hypothesis based on the theoretical background which has been discussed before. Some of the dependent, independent and control variables will be taken in the natural logarithm form due to that numbers are large.

LN (Y_{SPT})=α1+ß1LN(*Inventory level*)+ ß2*Convenience_yield*+ß3*volatility*+δ1*interest_rate*+ δ2 LN (*US dollar index)*+ δ3LN(*Crude oil production*) +*3*

Hypothesis 3: Convenience yield has positive effect on short position volume held by crude oil traders; Inventory level has negative effect on short position volume held by crude oil traders; Volatility has positive effect on short position volume held by crude oil traders.

4.5. Impact on long position held by money managers.

The fourth model is aiming at analyzing how the three factors affect the long position volume held by money managers. We construct the empirical model and propose the hypothesis based on the theoretical background which has been discussed before. Some of the dependent, independent and control variables will be taken in the natural logarithm form due to that numbers are large.

LN (Y_{LPM})=α1+ß1LN(*Inventory level*)+ß2*Convenience_yield*+ß3*volatility*+δ1*interest_rate*+ δ2 LN (*US dollar index)*+ δ3LN(*Crude oil production*) +*3*

Hypothesis 4: Convenience yield has positive effect on long position volume held by money managers; Inventory level has negative effect on long position volume held by money managers; Volatility has positive effect on long position volume held by money managers.

4.6. Impact on short position held by money managers.

The fifth model is aiming at analyzing how the three factors affect the short position volume held by money managers. We construct the empirical model and propose the hypothesis based on the theoretical background which has been discussed before. Some of the dependent, independent and control variables will be taken in the natural logarithm form due to that numbers are large.

LN (Y_{SPM})=α1+ß1LN(*Inventory level*)+ß2*Convenience_yield*+ß3*volatility*+δ1*interest_rate*+ δ2 LN (*US dollar index)*+ δ3LN(*Crude oil production*) +*3*

Hypothesis 5: Convenience yield has negative effect on short position volume held by money managers; Inventory level has positive effect on short position volume held by money managers; Volatility has negative effect on short position volume held by money managers.

5.Empirical analysis

5.1. Description of the market trading behaviors.

Open interest

Before we start analyzing how the factors will influence the market trading behaviors in crude oil futures market, it is important to observe and describe the development of trading behaviors in recent 10 years. As has been stated before that the market trading behavior will be mainly represented by the open interest, long and short positions held by crude oil traders and money managers. We use the ten years data from Jan 2008 to Mar 2018 to obtain the general image of trading behaviors.

Open interest is the total number of outstanding contracts aiming at measuring the flow of money into the market. As can be seen from the figure 4, open interest has increased continually during the last ten years, especially after year 2016, open interest has showed significant growth. This trend demonstrates that there are more traders and investors entering into the crude oil futures market accompanying with large flow of the money into the market in the past ten years.

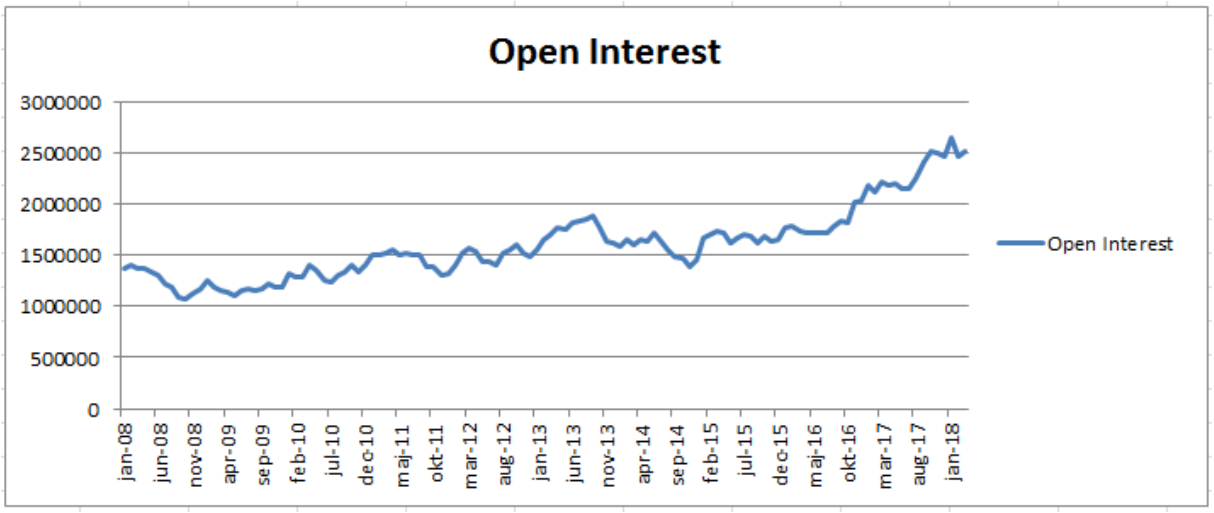

Figure 4: The trend of open interest from Jan 2008 to Mar 2018.

Long and short position held by crude oil traders.

The main crude oil traders are represented by crude oil producers and crude oil consumers. They participate in the futures market for the purpose of lock in the price and final delivery of the crude oil. Figure 5 shows that long and short positions held by consumers and producers tend to move together. This is mainly because long position hedgers need to find short position hedgers with equal and opposite hedging volume (Büyükşahin & Harris, (2009)). Furthermore, the two positions do not show an obvious increase or decrease trend but keep flat generally with minor fluctuations before 2017, then around 2017 there is a sudden increase from the short positions. It is also interesting to observe that at the same period, there is also a sudden increase from the long positions held by money managers. Unlike long and short positions held by money managers, the long position held by crude oil traders have been mostly less than the short position which cause the net position to be negative.

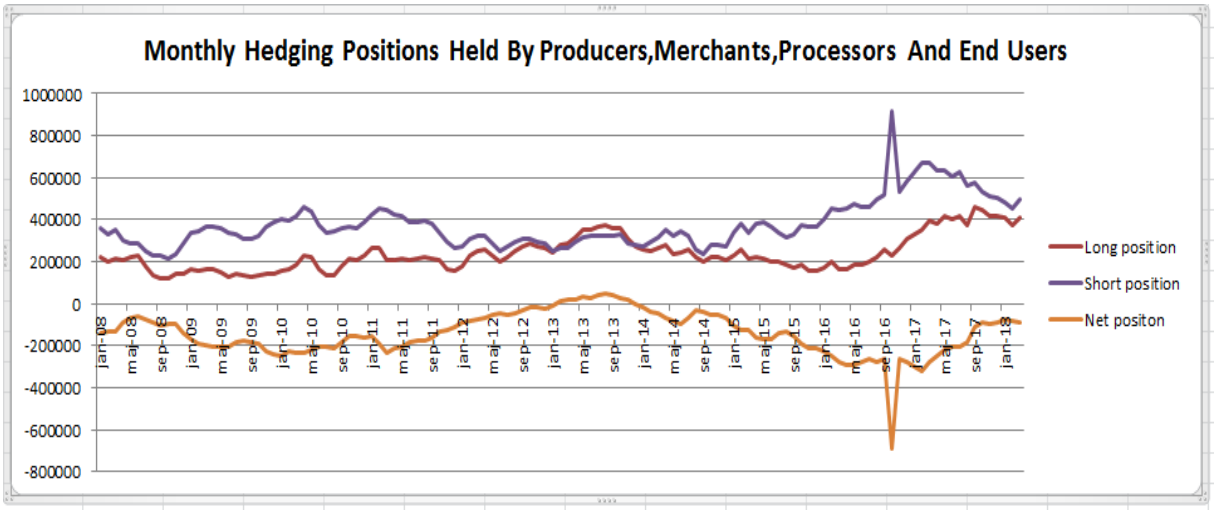

Figure 5: The trend of long and short position held by crude oil traders from Jan 2008 to Mar 2018.

Long and short position held by money managers.

Money managers hold speculative purpose for trading the contracts. It could be observed that long and short positions move almost opposite with each other, which differs of that by crude oil traders. Money managers have continued to go long during the recent years, though often accompanying with large fluctuations. It shows that the power from buying side is growing stronger in general than selling side. Long position volume has almost been larger than short position volume which keeps the net position positive in the last ten years. It could imply that more of the money managers hold the expectations that the price of futures contracts will rise.

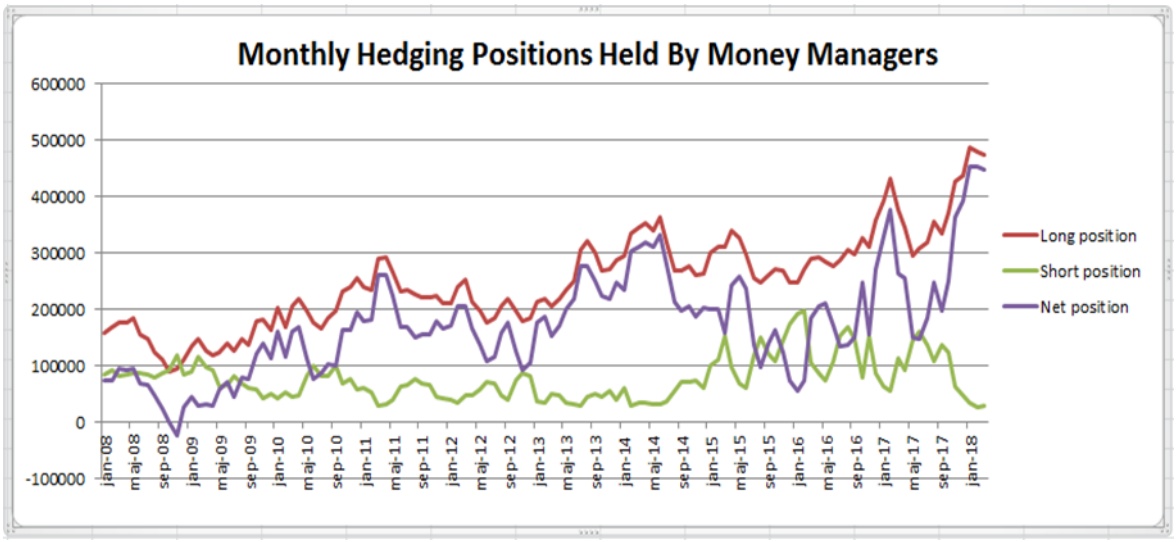

Figure 6: The trend of long and short positions held by money managers from Jan 2008 to Mar 2018.

5.2. The interactive influence of convenience yield, inventory level and volatility.

			Correlation Matrix			
	CONVENIENCE_YIELD	MONTHLY_INVENTORY_LEVEL	MONTHLY_VOLATILITY	CRUDE_OIL_PRODUCTIONS	INTEREST_RATE	US_EXCHANGE_RATE
CONVENIENCE_YIELD	1	-0,5885	0,0622	-0,612	0,9999	-0,432
MONTHLY_INVENTORY_LEVEL	-0,5885	1	-0,014	0,7933	-0,5877	0,8866
MONTHLY_VOLATILITY	0,0622	-0,014	1	-0,2281	0,0648	0,2629
CRUDE_OIL_PRODUCTIONS	-0,612	0,7933	-0,2281	1	-0,6125	0,7294
INTEREST_RATE	0,9999	-0,5877	0,0648	-0,6125	1	-0,431
US_EXCHANGE_RATE	-0,432	0,8866	0,2629	0,7294	-0,431	1

Table 1: Correlation matrix between independent variables and control variables.

The correlation Matrix above shows the correlation among each independent variables and control variables. Based on the theoretical background, there should be correlations between each independent variable and control variables, the purpose of running the correlation matrix is to test if there is strong correlation between independent variables and control variables, so that we could infer the interactive influence between the three independent variables. In addition, If there exists very strong correlations between independent and control variables, we have to adjust the OLS models somehow. If the correlation index shows above 0, 8 or below -0, 8, it implies the correlation is so strong that there exists the problem of multicollinearity and will thus affect the empirical outcomes. From the correlation matrix, we find out that convenience yield and monthly inventory level keep a significant negative relation (-0,5885), this is consistent with the theory of storage by Working (1934) stating that the convenience yield and inventory level holds a negative relation. Since the correlation index is between -0, 8 and 0, 8, there is no serious problem of multicollinearity between those two variables and thus it is not necessary for us to adjust the model.

Based on the previous theories, it is also inferred that the inventory level and volatility should hold a negative relation; the convenience yield and volatility should keep a positive relation. However, our empirical results do not show these two relations to be very significant. The correlation index between inventory level and volatility is -0,014; the correlation index between convenience yield and volatility is 0, 0622. This may due to the volatility could be affected by many other factors, which, in turn will make the problem complex.

Furthermore, we have also tested the correlation between control variables and independent variables in order to eliminate the problem of multicollinearity. The correlation matrix shows that crude oil production holds a significant negative relation with convenience yield (-0,612) and positive relation with monthly inventory level (0, 7933), in other words, if the crude oil production rises, the convenience yield will thus fall down, the inventory level will rise and vice versa. It is in accordance with the theory of storage by Working (1949), Crude oil production has direct effects on the supply of the crude oil in the market. The increase of the crude oil production will increase the supply of crude oil in the market which exceeds the demand. The spot price will fall due to excess supply. Consequently, the inventory level will increase and convenience yield will decrease. While under the situation of scarce supply of the crude oil, inventory level will be tight and the convenience yield will thus be very high. (Working, (1949)). Additionally, we have observed that the crude oil production holds a negative relation with price volatility. However, the correlation index (-0, 2281) does not indicate a significant relation.

The value of the US dollar has showed significant positive relation with the inventory level (0, 8866). This finding is quite interesting since we do not find much paper focused on this field. However, this empirical result could be linked indirectly with Bloomberg& Harris (1995)´s findings, which has been discussed before that there is a negative relation between the US dollar and commodity prices. More in detail, according to Bloomberg & Harris (1995), the increase of the value of US dollar will decrease the spot price of crude oil due to less demand from foreign buyers outside of US. The lower spot price of crude oil will in turn trigger inventory builds up. This could explain why the value of US dollar and inventory level holds a strong positive relation. Even though the correlation between US dollar value and inventory level shows the problem of multicollinearity, we will still incorporate the value of US dollar as the control variable. Because we consider the problem of multicollinearity is moderate and it only affects one independent variable.

The value of US dollar has also showed significant negative relation with the convenience yield (-0,432), this is in accordance with the theory of storage by Working (1949) and in combining with the new finding above. More specifically, Convenience yield keeps a negative relation with inventory level, intuitively, it should also keep a negative relation with the value of US dollar in combining with the new finding that the US dollar value keeps strong positive relation with the inventory level. Therefore, we infer that the value of US

dollar keeps a negative relation with the convenience yield mainly due to the impact of inventory level.

The interest rate shows extreme strong correlation with the convenience yield (0, 9999), this implies an extreme serious multicollinearity problem if we incorporate interest rate in our model. Thereby, we will exclude the interest rate as control variable in the model.

5.3. Impact on open interest

The first model aims at analyzing how the three factors (convenience yield, inventory level and volatility) could influence the open interest. After we have tested for the correlation between independent and control variables, we have decided to remove the interest rate as control variable. Therefore, we rebuild the model as the following:

LN (Y_{OI}) =α1+ß1 Convenience_yield +ß2 LN (Inventory level) +ß3volatility+ δ1 LN (US dollar index) + δ2LN (Crude oil production) +3.

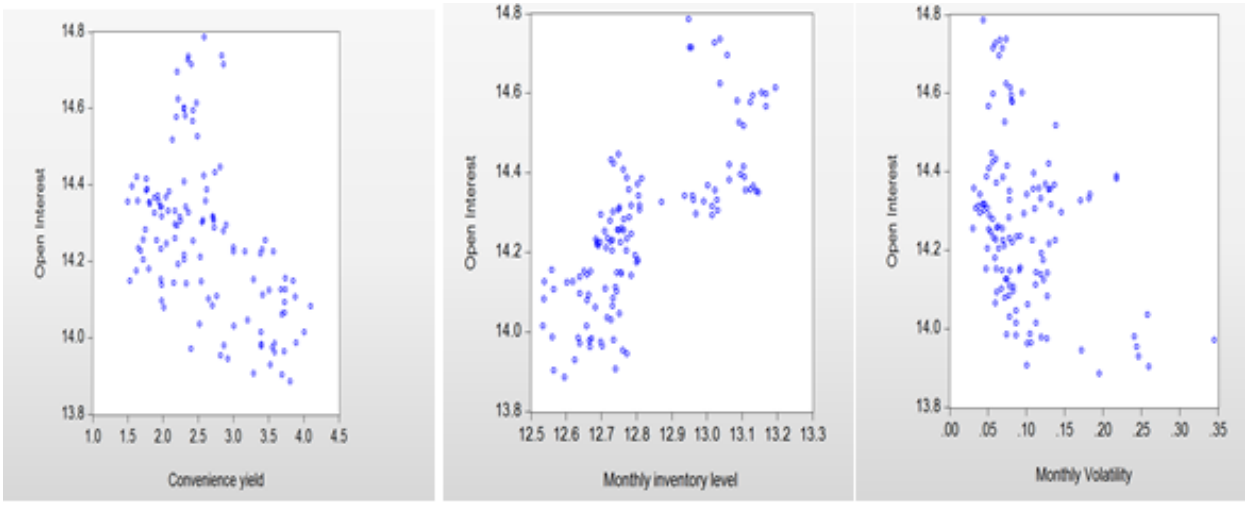

Figure 7: Scatter diagram shows the relation between independent variables and open interest.

The primary purpose of the scatter diagram is for giving a straight impression on the relation between the three independent variables and open interest. From the scatter diagram, we could observe that the convenience yield and volatility tend to have negative effects on open interest while inventory level has positive effect on open interest.

The OLS regression result shows as follow:

Dependent Variable: OPEN_INTEREST
Method: Least Squares
Date: 05/06/18 Time: 12:53
Sample (adjusted): 2 122
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.989961	1.067083	2.801996	0.0060
CONVENIENCE_YIELD	0.035233	0.018566	1.897683	0.0602
MONTHLY_INVENTORY_LEVEL_EXCLU...	0.818521	0.148944	5.495508	0.0000
MONTHLY_VOLATILITY	-0.460932	0.249626	-1.846491	0.0674
CRUDE_OIL_PRODUCTIONS	0.494377	0.077371	6.389693	0.0000
US_EXCHANGE_RATE	-0.833561	0.293336	-2.841666	0.0053

R-squared	0.780485	Mean dependent var	14.26057
Adjusted R-squared	0.770941	S.D. dependent var	0.203346
S.E. of regression	0.097322	Akaike info criterion	-1.773275
Sum squared resid	1.089223	Schwarz criterion	-1.634641
Log likelihood	113.2831	Hannan-Quinn criter.	-1.716970
F-statistic	81.77646	Durbin-Watson stat	0.355816
Prob(F-statistic)	0.000000		

Table 2: OLS regression result which shows how the independent variables impact open interest.

The R-squared which measures the goodness of fit is 0, 7805, the result indicates that the model could quite well explain the observations as it is above 0, 7, according to Brooks (2014).The P-value of F-test shows 0, 0000 which indicates that the model is significant. Therefore, we believe in our model which could deliver a robust empirical result. We test at 10% significant level which means if the P-value of t-test is under 10%, then the independent variable could significantly influence the dependent variable.

As we can see from the regression result, coefficient of convenience yield is 0, 03523 which imply a positive effect on open interest, the corresponding P-value is 0, 0602 which could prove the significance of the relation at 10% level. Therefore, we could conclude from the empirical result that if convenience yield increases, open interest will increase and vice versa. In other words, if convenience yield increases, more investors will choose to enter into the futures market to engage in the trading activities. This result is consistent with our hypothesis and could as well be explained by Alquist el.at (2014) and Horsnell et al (1995)´s theories: High convenience yield not only indicates the relative scarcity of today´s crude oil but also forecasts the scarcity of crude oil in the near future. Consequently, the traders and investors will expect a higher crude oil price in the future due to the scarcity supply of the crude oil and this will lead to Contango status. According to Horsnell et al (1995), under Contango status,

both crude oil traders and money managers will enter into the futures market and thereby, the open interest is expected to rise.

The coefficient of inventory level is 0, 8185 with P-value (0, 0000). The result indicates that the inventory level has significant positive influence on the open interest at 10% significant level. If the inventory level increases (decreases), open interest will consequently increase (decrease). This is however against our hypothesis and theories.

In our theories. Geman & Smith (2013) states when inventory level is low, spot price will increase due to supply & demand relation, a decreasing inventory level will lead to the status that the futures price exceeds the spot price; this is identified as the Contango status. Under Contango status, crude oil traders tend to hedge more (Horsnell et al (1995)). Money managers tend to enter into the futures market and hold the long position of the futures contracts with the expectations that the futures price of the contracts will increase. According to this, inventory level should affect the open interest negatively. This has also been proved by Gorton et al (2013) ´s work that a decreasing inventory level will encourage more investors and traders to enter into the futures market. Acharya et al (2007) as well proposes the same conclusion from the other aspect that when inventory level is low, its ability to hedge the default risk will decrease, energy companies will instead hedge the default risk using the futures contracts. Therefore, a decreasing inventory level will increase the open interest.

In respect with the price volatility, we could observe a significant negative impact on the open interest, coefficient of price volatility is -0, 4609 with P-value to be 0, 0674. This is opposite with our hypothesis and theories. Theoretically, the price volatility should keep a positive impact on open interest, since the fundamental purpose of entering into the futures market is to decrease the price volatility, if the spot price of crude oil becomes more volatile, crude oil traders tend to engage more in the futures market in order to secure the risk exposure (Acharya et al (2007)). Which, in turn, will increase the open interest? However, we have found out there are theories explaining why price volatility keeps a negative relation with the open interest. The starting point differs from previous discussions, they propose that it is not the price volatility which will impact the open interest. Instead, the increase of the open interest will increase the market depth and the liquidity of the futures market, thereby; the price volatility will decrease due to the abundant money in the futures market. (Ripple & Moosa, (2009)).

The control variables all show significant impacts on open interest. Crude oil production positively influences the open interest (0, 4944; 0, 0000) and US dollar value negatively influences the open interest (-0, 8336; 0, 0053). This empirical result implies that by adding those two control variables, we could successfully eliminate the effects of them on the open interest and obtain more accurate empirical results regarding how the independent variables could affect the open interest.

In conclusion, based on our empirical result, the convenience yield and inventory level have significant positive influence on the open interest. If the convenience yield increases, we´d expect an increasing open interest and vice versa; if the inventory level increases (decrease), the open interest will also increase (decrease) though it is against the hypothesis and previous theories. Nevertheless, due to inventory level and convenience yield keep negative relation with each other. When inventory level increases (decreases), we need to consider about its simultaneous negative effect on convenience yield and thus a contradictory effect on open interest. Furthermore, in our result, price volatility has a negative influence on the open interest which is also opposite with our hypothesis and theories, but the negative relation could be explained by other theories from different perspective.

5.4. Impact on long position held by crude oil traders.

The second model aims at analyzing how the three factors (convenience yield, inventory level and volatility) could influence the long position held by crude oil traders. As has been introduced before that we will remove the interest rate in the OLS model, so the model is rebuilt as:

LN (Y_{LPT}) =α1+ß1 Convenience_yield +ß2 LN (Inventory level) +ß3volatility+ δ1 LN (US dollar index) + δ2LN (Crude oil production) +3.

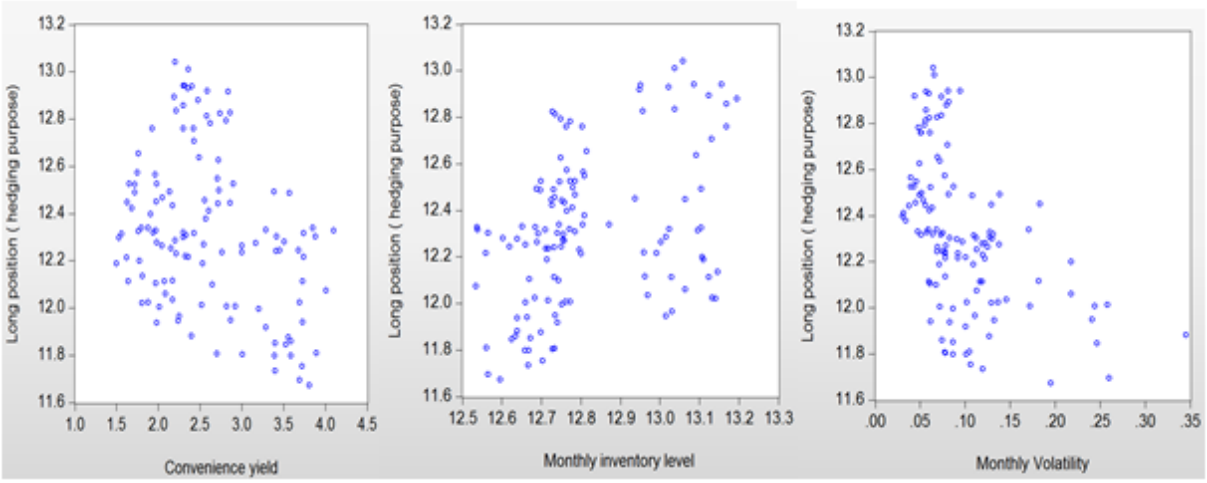

Figure 8: Scatter diagram shows the relation between independent variables and long position held by crude oil traders.

From the scatter diagram above, we could get a general and direct impression that convenience yield may impact the long position held by crude oil traders negatively, inventory level may impact the long position held by crude oil traders positively and volatility may impact the long position held by crude oil traders negatively. Even though the scatter dots do not show the relation to be very significant.

The OLS regression result shows as follow:

Dependent Variable: LONG_POSITION___HEDGING_PURPOSE_
Method: Least Squares
Date: 05/06/18 Time: 12:54
Sample (adjusted): 2 122
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.958171	2.607226	0.751055	0.4542
CONVENIENCE_YIELD	0.035369	0.045364	0.779669	0.4372
MONTHLY_INVENTORY_LEVEL_EXCLU...	0.896696	0.363917	2.464013	0.0152
MONTHLY_VOLATILITY	-1.255339	0.609916	-2.058216	0.0418
CRUDE_OIL_PRODUCTIONS	0.809352	0.189042	4.281329	0.0000
US_EXCHANGE_RATE	-1.890566	0.716713	-2.637829	0.0095

R-squared	0.502742	Mean dependent var	12.31665
Adjusted R-squared	0.481123	S.D. dependent var	0.330109
S.E. of regression	0.237788	Akaike info criterion	0.013442
Sum squared resid	6.502467	Schwarz criterion	0.152076
Log likelihood	5.186772	Hannan-Quinn criter.	0.069746
F-statistic	23.25370	Durbin-Watson stat	0.312354
Prob(F-statistic)	0.000000		

Table 3: OLS regression result which shows how the independent variables impact long position held by crude oil traders.

In our second model, the R-squared is 0, 5027 which implies the model fits the observations well. P-value for F-test is 0, 0000 which indicates the model is significant. Therefore, we could expect a robust empirical result from the model.

Coefficient of convenience yield is 0, 0354 which indicates a positive effect on the long position held by crude oil traders, this is consistent with our hypothesis and theories. However, the P-value is 0, 4372 which is not significant at 10% level. Therefore, we could not make conclusion if the convenience yield has a significant positive effect on the long position held by crude oil traders or not.

Inventory level shows positive impact on the long position held by crude oil traders (0, 8967) at the 10% significant level (0, 0152). The empirical result implies when inventory level increases (decreases), crude oil traders will also increase (decrease) the long position of the futures contracts. This trading activity not only involves newly entering into the futures market, but also buying futures contracts which already listed in the futures market. Similar with the impact on open interest, this empirical result has also challenged the previous paper work, e.g. Gorton et al (2013) and Acharya et al (2007) who assert that inventory level should have negative impact on long position held by crude oil traders.

According to the empirical result, price volatility has a negative impact on the long position held by crude oil traders (-1, 2555) at a significant level (0, 0418). This result has also been contradictory to our theories discussed before. If the spot price of crude oil becomes more volatile, crude oil traders tend to long the position of futures contracts more in the futures market in order to secure the price risk exposure (Acharya et al (2007)). Thereby, price volatility should have a positive influence on the long position held by crude oil traders. However, similar with open interest and based on the theories proposed by (Ripple & Moosa, (2009)). We also infer that the increase of the long position held by crude oil traders will increase the market depth and the liquidity of the futures market, so that price volatility will decrease. In other words, it is not the price volatility which will impact the behaviors of crude oil traders, instead, it is the behaviors of crude oil traders which will influence the price volatility negatively.

The control variables in the model show significant influence over the long position held by crude oil traders. More specifically, crude oil production impacts the long positions

positively(0,8094; 0,0000) and US dollar value impacts the long positions negatively(-1,8906 ; 0,0095). This empirical result indicates that by adding those two control variables so that we could eliminate their effects on long position held by crude oil traders. This is for the purpose of getting an accurate result.

In summary, we do not find a significant positive effect of convenience yield on the long position held by crude oil traders. However, inventory level has a significant positive effect on long positon held by crude oil traders. The increase (decrease) of the inventory level will encourage (discourage) the crude oil traders to hold more long position of futures contracts based on the empirical results which is inconsistent with our theories. The price volatility has a negative influence on the long position held by crude oil traders, which implies that the increase (decrease) of price volatility will discourage (encourage) crude oil traders to hold the long position of futures contracts, though we do not figure out a reasonable explanation based on our previous theories. However, from Ripple & Moosa (2009) `s paper, it seems that the proper reason could be: It is not the price volatility which will negatively impact the long position held by crude oil traders. Instead, it should be the long position held by crude oil traders that will impact the price volatility.

5.5. Impact on short position held by crude oil traders.

The third model aims at analyzing how the three factors (convenience yield, inventory level and volatility) could influence the short position held by crude oil traders. As has been introduced before that we are going to remove the interest rate in our new model. Thus, the OLS model is rebuilt as:

LN (Y_{SPT}) =α1+ß1 Convenience_yield +ß2 LN (Inventory level) +ß3Volatility+ δ1 LN (US dollar index) + δ2LN (Crude oil production) +3.

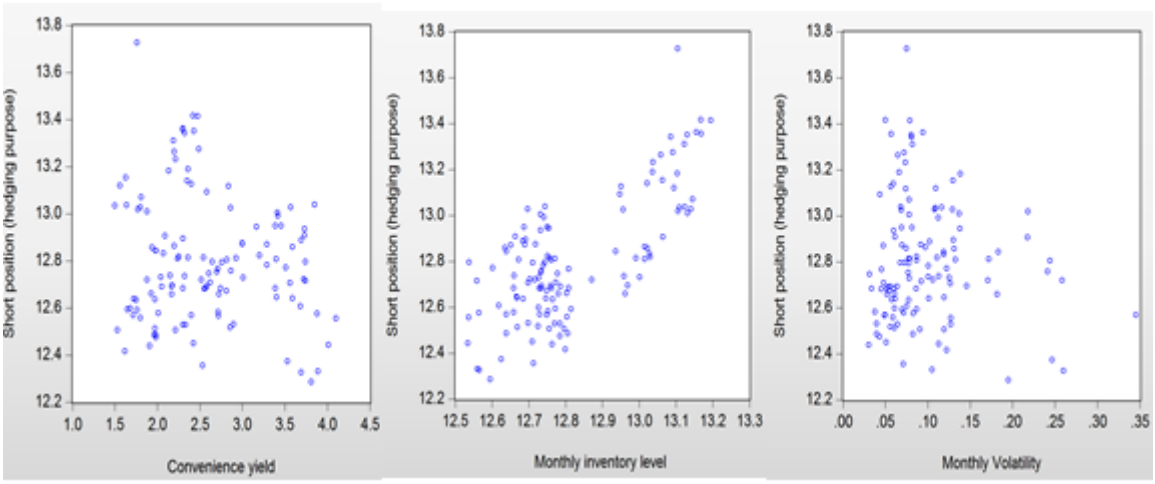

Figure 9: Scatter diagram shows the relations between independent variables and short position held by crude oil traders.

From the scatter graph, we could not observe clear pattern of the effects from convenience yield and volatility on the short position held by crude oil traders. However, we could observe that the inventory level affects short position held by crude oil traders positively and significantly.

The OLS regression result shows as follow:

Dependent Variable: SHORT_POSITION__HEDGING_PURPOSE_
Method: Least Squares
Date: 05/06/18 Time: 12:56
Sample (adjusted): 2 122
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-11.31197	1.539684	-7.346941	0.0000
CONVENIENCE_YIELD	0.171124	0.026789	6.387799	0.0000
MONTHLY_INVENTORY_LEVEL_EXCLU...	2.516812	0.214909	11.71104	0.0000
MONTHLY_VOLATILITY	-0.182651	0.360183	-0.507107	0.6131
CRUDE_OIL_PRODUCTIONS	-0.300209	0.111638	-2.689128	0.0082
US_EXCHANGE_RATE	-1.351250	0.423251	-3.192549	0.0018

R-squared	0.740427	Mean dependent var	12.80060
Adjusted R-squared	0.729142	S.D. dependent var	0.269819
S.E. of regression	0.140425	Akaike info criterion	-1.039978
Sum squared resid	2.267692	Schwarz criterion	-0.901343
Log likelihood	68.91864	Hannan-Quinn criter.	-0.983673
F-statistic	65.60719	Durbin-Watson stat	0.707406
Prob(F-statistic)	0.000000		

Table 4: OLS regression result which shows how the independent variables impact short position held by crude oil traders.

The model shows robust fitness with the observations (R^2=0, 7404), the P-value of F-test (0, 0000) indicates the model is significant. Previous observation of the behaviors of long and short position held by crude oil traders show they tend to move together, this implies that the three independent variables may have the similar effect on short position held by crude oil traders as the long position.

In the model, convenience yield shows a significant positive impact on short positions (0, 1711; 0, 0000), this implies the increase (decrease) of the convenience yield will encourage (discourage) the short position held by crude oil traders. In relating with the theories we discussed before, the increasing convenience yield shows a sign of the scarcity situation of crude oil in the future, this will cause the futures price exceeds the spot price, a status of Contango will thus emerge. Under the Contango status, crude oil consumers tend to hold more futures contracts (Horsnell et al (1995)), which in turn, will also increase the short position volume, because the buying of one futures contract requires the selling of one futures contract for the physical delivery purpose.

Inventory level also shows a significant positive influence on the short positions held by producers (2, 5168; 0, 0000) which is in accordance with the behavior of long position hedgers. This empirical result is as well contradictory with previous theories, similar with the impact on open interest and long position held by crude oil traders.

Price volatility does not show significant negative impact on short position held by crude oil traders (-0, 1827; 0, 6131) in our model. Thereby, we could not make any conclusions on how the price volatility will affect the behavior of short hedgers.

The control variables in the model show significant effects over the short position held by crude oil traders. More specifically, crude oil production impacts the short positions negatively(-0,3002; 0,0082) and US dollar value impacts the short positions negatively(-1,3513 ; 0,0018) as well. This empirical result indicates that by adding those two control variables in this model, we could eliminate their effects on short position held by crude oil traders. Therefore, our model becomes more accurate.

In summary, the model shows that convenience yield will have a significant positive effect on the short position held by crude oil traders. Producers will sell more futures contracts as the convenience yield increases and vice versa, this empirical result is consistent with our hypothesis and theories. Inventory level also shows positive influence significantly on the

short position held by producers which is contradictory with the theories. Furthermore, the price volatility does not show significant effect on the behavior of short position hedgers.

5.6. Impact on long position held by money managers.

The fourth model aims at analyzing how the three factors (convenience yield, inventory level and volatility) could influence the long position held by money managers. As has been introduced before that we will remove the interest rate as the control variable and rebuild our model as the following:

LN (Y_{LPM}) =α1+ß1 Convenience_yield +ß2 LN (Inventory level) +ß3volatility+ δ1 LN (US dollar index) + δ2LN (Crude oil production) +3.

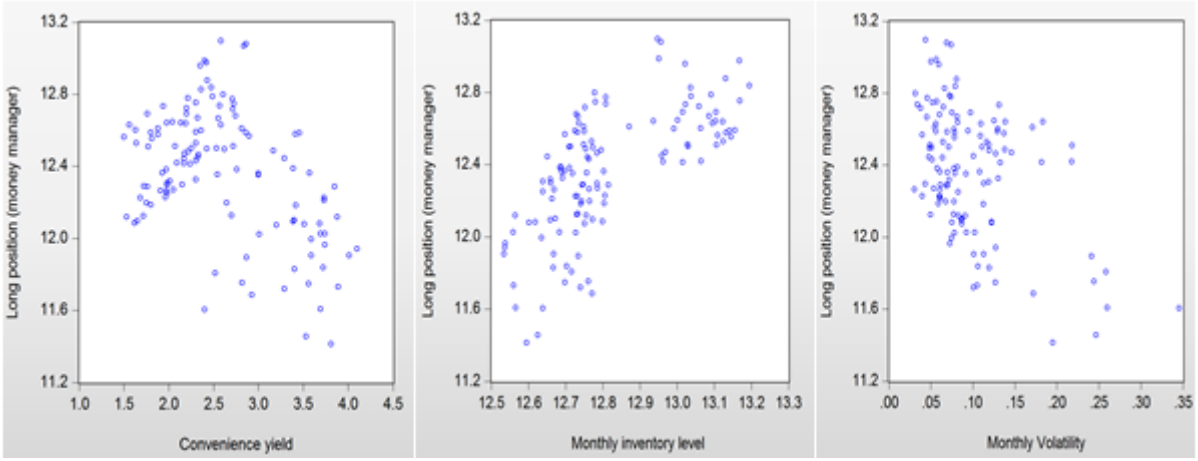

Figure 10: Scatter diagram shows the relations between independent variables and long position held by money managers.

From the scatter diagram, we could observe straightforward that convenience yield and volatility may have negative impacts on long position held by money managers. Inventory level may have positive impact on long position held by money managers. More accurate result will be analyzed using OLS regression.

The OLS regression result shows as follow:

Dependent Variable: LONG_POSITION__SPECULATIVE_PURPOSE_
Method: Least Squares
Date: 05/06/18 Time: 13:02
Sample (adjusted): 2 122
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-5.320170	1.608395	-3.307751	0.0013
CONVENIENCE_YIELD	0.099769	0.027985	3.565109	0.0005
MONTHLY_INVENTORY_LEVEL_EXCLU...	1.280136	0.224500	5.702160	0.0000
MONTHLY_VOLATILITY	-0.901649	0.376257	-2.396368	0.0182
CRUDE_OIL_PRODUCTIONS	1.182968	0.116620	10.14379	0.0000
US_EXCHANGE_RATE	-2.140862	0.442139	-4.842051	0.0000

R-squared	0.828037	Mean dependent var	12.36974
Adjusted R-squared	0.820561	S.D. dependent var	0.346294
S.E. of regression	0.146691	Akaike info criterion	-0.952658
Sum squared resid	2.474607	Schwarz criterion	-0.814024
Log likelihood	63.63583	Hannan-Quinn criter.	-0.896354
F-statistic	110.7499	Durbin-Watson stat	0.791223
Prob(F-statistic)	0.000000		

Table 5: OLS regression result which shows how the independent variables impact long position held by money managers.

Unlike crude oil traders, money managers mainly enter into the futures market for the purpose of speculations. Therefore, their trading behaviors will differ much with that of crude oil traders, as has been showed before in the beginning of section five.

The fourth model shows a high standard of fitness with the data as R-squared to be 0, 8280. The P-value of F-test (0, 0000) also proves our model to be significant.

Our empirical results show that convenience yield has positive influence on the long position held by money managers (0,0998) at a significant level (0,0005). This implies that money managers will go long of the futures contracts as the convenience yield increases and vice versa. Our previous discussions on the theories have also showed that convenience yield impacts positively on the long position volume held by money managers. More specifically, money managers buy and sell the futures contracts based on the expectations of the price movement of the futures contracts. The rise of the convenience yield indicates that the futures price of crude oil will exceed the spot price according to Working (1949) ´s paper. Therefore, the price of the futures contracts will be higher in the future as the convenience yield increases. With the expectation of the increasing futures´ price, money managers will increase the long position of the futures contracts.

The inventory level shows a significant positive impact on the long positions held by money managers (1, 2801; 0, 0000). The empirical result implies that as inventory level increases (decreases), money managers tend to hold(reduce) long position of futures contracts. However, this result is contradictory with the theories we have discussed before. The previous theories all point to that inventory level should affect the long position held by money managers negatively.

Price volatility shows a significant negative effect on the long position held by money managers. This finding is interesting, theoretically speaking, price volatility does not provide information about price movement, in other words, it cannot predict increase or decrease of the crude oil price in the next stage. Thereby, cannot affect the trading behavior of money managers. However, we may also infer that it is not the price volatility which will affect the behavior of money managers, instead, induced from the paper of Ripple & Moosa (2009) that open interest will impact price volatility through market depth and liquidity. We also assume that the long position held by money managers will influence the price volatility negatively.

The control variables in the model show significant effect on the long position held by money managers. The result shows that crude oil production impacts the long position held by money managers positively(1,1830; 0,0000) and US dollar value affects the long position negatively(-2,1409 ; 0,0000). Similar with previous models, this result proves the usefulness of adding the two control variables for eliminating their effects on long position held by money managers.

In conclusion, with our significant empirical results, we could say that convenience yield affects the long position held by money managers positively which is consistent with our theories. Inventory level also shows a positive influence on the long position held by money managers which is contradictory with previous studies. Price volatility affects the long position held by money managers negatively. Our results have provided very useful empirical evidence on predicting how the money managers will react with the change of the three factors.

5.7. Impact on short position held by money managers

The fifth model aims at analyzing how the three factors (convenience yield, inventory level and volatility) could influence the short position held by money managers. As has been introduced before that we will exclude the interest rate as the control variable in our model. So that our model is rebuilt as the following:

LN (Y_{SPM}) =α1+ß1 Convenience_yield +ß2 LN (Inventory level) +ß3volatility+ δ1 LN (US dollar index) + δ2LN (Crude oil production) +3.

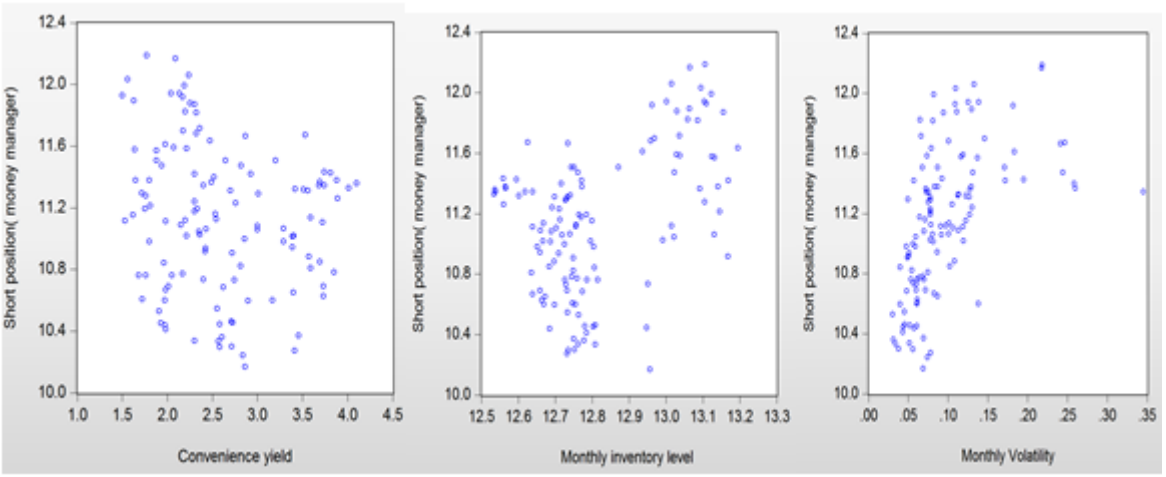

Figure 11: Scatter diagram shows the relations between independent variables and short position held by money managers.

From the scatter diagram, we could not describe or conclude how convenience yield or inventory level will impact the short position held by money managers since the scatter dots are quite disperse. Though, we could observe a clear positive pattern on how the volatility will impact the short position by money managers.

The OLS regression result shows as follow:

Dependent Variable: SHORT_POSITION__SPECULATIVE_PURPOSE_
Method: Least Squares
Date: 05/06/18 Time: 13:03
Sample (adjusted): 2 122
Included observations: 121 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.569101	3.556550	-0.722358	0.4715
CONVENIENCE_YIELD	-0.036244	0.061881	-0.585712	0.5592
MONTHLY_INVENTORY_LEVEL_EXCLU...	0.625493	0.496424	1.259998	0.2102
MONTHLY_VOLATILITY	2.946676	0.831994	3.541702	0.0006
CRUDE_OIL_PRODUCTIONS	-0.687874	0.257875	-2.667471	0.0087
US_EXCHANGE_RATE	2.648178	0.977677	2.708643	0.0078

R-squared	0.561370	Mean dependent var	11.14353
Adjusted R-squared	0.542299	S.D. dependent var	0.479457
S.E. of regression	0.324370	Akaike info criterion	0.634450
Sum squared resid	12.09981	Schwarz criterion	0.773084
Log likelihood	-32.38423	Hannan-Quinn criter.	0.690755
F-statistic	29.43599	Durbin-Watson stat	0.713135
Prob(F-statistic)	0.000000		

Table 6: OLS regression result which shows how the three independent variables impact short position held by money managers.

Our last model shows a good fitness with the observations as R-squared to be 0, 5613. The model is also significant with P-value for F-test to be 0, 0000. Therefore, our empirical model is considered to be accurate as to deliver the final empirical results.

From the OLS regression table, the coefficient of convenience yield does not show significant positive effect on the short position held by money managers. Since the P-value is quite high (0,5592). Therefore, we could not make any conclusion on how the convenience yield will impact the behaviors of money managers who go short of the futures contracts. Theoretically, as the convenience yield increases, the futures´ price will exceed the spot price. In other words, money managers tend to hold the expectations that the price of futures contracts will increase in the future and therefore go long of the futures contracts instead of going short. The volume of short position held by money managers is expected to decease as the convenience yield increase.

The P-value for inventory level is also high (0,2102) which keeps us from making the conclusion that inventory level affects the short position held by money managers positively (0,6255). In relating with our theories, we expect a positive effect of inventory level on the short position by money managers. Because the increase of the inventory level will lead to the decrease of the crude oil price in the future. Therefore, we expect the price of the futures contracts will decrease as the inventory level increases. With the expectation that the price of futures contracts will decrease, money managers will go short of the futures contracts instead of going long. Therefore, the short positon held by money managers will increase as the inventory level increases. This implies a positive effect on the short position held by money managers.

We find out that price volatility has a positive influence on the short position held by money managers (2, 9467, 0, 0006). Which implies that as price becomes more volatile, money managers tend to increase the short positon of the futures contracts and vice versa. Though theoretically speaking, the price volatility cannot predict the price movement in the next stage and will not affect explicitly on the short position held by money managers.

The two control variables in the model have shown significant effect on the short position held by money managers. More specifically, crude oil production impacts the short position held by money managers negatively(-0,6879; 0,0087) and US dollar value affects the long

position positively(2,6482 ; 0,0078). Similar with previous models, this result also proves the usefulness of adding the two control variables which could make the empirical results more accurate.

In summary, we could only find out that price volatility has significant positive effect on the short position held by money managers. While the impacts from convenience yield and inventory level are not significant according to the P-value.

6.Conclusion

The paper has investigated the interactive influence between the three key factors: convenience yield, inventory level and price volatility by using the recent ten years monthly data. Our empirical results have been robust and consistent with the Working´s theory (1934, 1949) that convenience yield and inventory level keeps a negative relation. However, comparing with other theories which state convenience yield and price volatility should keep positive relation; while inventory level and price volatility should keep negative relation. Our results do not provide significant and robust correlation index to support the theories, though it indeed shows the positive relations between convenience yield and price volatility; negative relations between inventory level and price volatility.

Our empirical models have mostly delivered significant and robust results on how the three key factors could influence the market trading behaviors represented by five variables. To summarize, convenience yield and inventory level will impact open interest, long and short position held by crude oil traders and long position held by money managers positively, however, due to the negative relations between convenience yield and inventory level, we suppose there exists a contradictory effect in influencing the behaviors of crude oil traders and money managers. Limited by the purpose of our paper, we do not further and deeper analyze how this contradictory effects will influence the market trading behavior by crude oil traders and money managers. However, we suggest this topic could be an interesting research field for further studies. Price volatility impacts the open interest, long and short position held by crude oil traders, long position held by money managers negatively, though the effect on short position held by crude oil traders is not significant. The negative impacts are not consistent with the theories. However, we also infer that it is not the price volatility which will influence the market trading behaviors. Instead, it is the market trading behaviors that impact the price volatility negatively through increasing or decreasing the market depth and liquidities, so that

price volatility will increase or decrease accordantly (Ripple & Moosa (2009)). We also consider this field to be important and interesting, thereby, we suggest further researches and studies on the relation between price volatility and market trading behaviors.

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Appendix A

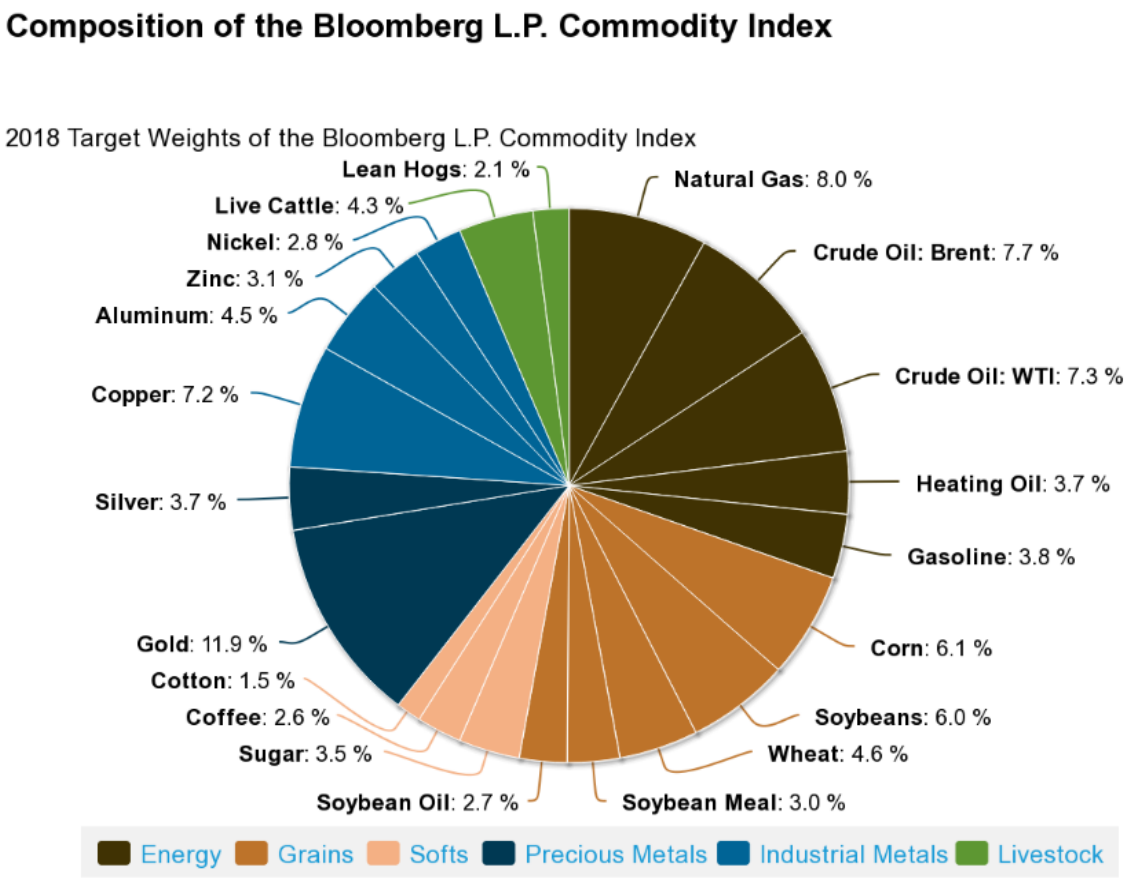

Figure (12): Composition of the Bloomberg L.P. Commodity Index. Source: Bloomberg.L.P, published

Appendix B

	Convenience yield	Inventory level	Price volatility
Open Interest	0,0352	0,8185	-0,4609
	(0,0602)	(0,0000)	(0,0674)
Long position held by crude oil traders	0,0354	0,8967	-1,2553
	(0,4372)	(0,0152)	(0,0418)
Short position held by crude oil traders	0,1711	2,5168	-0,1827
	(0,0000)	(0,0000)	(0,6131)
Long position held by money managers	0,0998	1,2801	-0,9016
	(0,0005)	(0,0000)	(0,0182)
Short position held by money managers	-0,0362	0,6255	2,9467
	(0,5592)	(0,2102)	(0,0006)

Table (7): Regression result on how the three key factors: convenience yield, inventory level and price volatility could impact on market trading behaviors. The significant level is at 10%.