

# **Risk Premium on Crude Oil Futures Prices**

by

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## **Abstract**

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This paper tests the risk premium on crude oil future prices in the US market. The history data on five crude oil spot prices and one crude oil future are collected through the period 2011 to 2013. To examine the risk premium on crude oil future prices based on the sample, this paper employs the cost of carry model. Meanwhile, OLS and GLS are the major regression used in this research. The results of the empirical study show that the risk premium on crude oil future prices is positive. This paper concludes that if the spot price grows, the potential profit to invest in crude oil futures is optimistic.

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# **Chapter 1: Introduction**

## **1.1 Purpose of study**

Crude oil is one of the most important energy in the world. The price of the crude oil will affect the development of the economy and the trend of the financial market. Crude oil market is also the largest international trade market, and any price change of the crude oil will affect the international energy market. In that situation, the price change of the crude oil gives a big signal to the market. Many investors, financial analysts will pay great attention to the price, return and risk of the crude oil. To avoid the price risk, an important method is taking the futures price contract for hedging. From that reason, it needs to analyze the risk of the crude oil future contract hedging for the investors and financial analysts. This paper will focus on the risk premium of the crude oil future prices.

From the discussion above, the main idea of the paper is to estimate the risk premium of the crude oil futures price and test the relationship between the risk premium and spot price. The results will tell the investor if they invest in the crude oil futures prices, how risky of their investment in the different level of return. In that situation, investors will choose whether they invest in futures crude oil market depends on their risk tolerance. James D. Hamilton and Jing

Cynthia Wu researched the paper that “if arbitrageurs care about the mean and variance of their futures portfolio, then hedging pressure from commodity producers or index-fund investors can give rise to an affine factor structure to commodity futures prices.”

## **1.2 Background**

The derivative markets become popular during the 1980s, and still in a huge growth trend from the past three decade. *The Economist* magazine has reported that as of June 2011, “the over-the-counter (OTC) derivatives market amounted to approximately \$700 trillion, and the size of the market traded on exchanges totaled an additional \$83 trillion”. The commodity derivative market is an extremely important part of the derivative market and is also the earliest application in derivative markets which includes futures, options and forwards contract. For example, farmers use the futures contract to sell corn, wheat and fruit became a traditional business way for several centuries because farmers can use the futures contract to hedge their price risks. During the recent years, there are many commodities used in the derivative markets. The commodity which focuses on this paper is crude oil.

Crude oil is “a naturally occurring, unrefined petroleum product composed of hydrocarbon deposits. Crude oil can be refined to produce usable products such as gasoline, diesel and various forms of petrochemicals”. (Investopedia)

Therefore, crude oil is simply the largest commodity trade in the international trading market and belongs to the energy market. The energy is a rare resource in the world especially for crude oil. Many useful things need oil such as power, gas, and gasoline. From this reason, the demand of crude oil increased significantly during the recent years. Many investors, oil companies, government trade crude oil in the market. Investors can make the profit as they trade the oil in the market, the oil companies' performance depends on the amount of oil they owned and the government need oil to develop their new technologies and army.

As the crude oil comes in the financial market, the oil price, return and risk will be more concentrated in people's mind. Moreover, as the price of the oil changes quickly and significantly, many investors will trade the crude oil in the derivative markets. "The crude oil derivatives market constitutes the most liquid commodity derivatives market. In December 2011, WTI and Brent crude oil futures accounted for 51.4% of dollar weight in the S&P GSCI commodity index. Nearly 900,000 futures and options contracts trade on WTI every day". (Peter Christoffersen)

In the derivatives market, many investors and brokers will use the futures or forward contract to trade the crude oil because the crude oil price is so volatile, sometimes change only for a minute and second.



Futures crude oil contract means the contract for the crude oil price can be ensured, the investors will not care about the volatile of the price because when the buyer and seller sign a futures oil contract and make sure the futures price, the contract will not be changed unless one party cancel the contract or do not have enough cash to support their margin account. However, the futures contract is still risky and even more risky than the commercial contract because as the contract being signed and ensure the future price to buy or sell, and then the contract will not be changed until the maturity for delivery. For that reason, if the buyer chooses a futures price contract higher than the spot price of the crude oil, when the price goes down, it increases the risk for the buyer because the buyer still needs to buy the crude oil in the futures price in the contract, on the opposite, sellers will become riskier because they should sell the crude oil in the futures price contract. In that sense, any wrong prediction of the price will get more risky or suffer a big loss for investors. However, the price is the hardest to predict in the financial market because any events happen will change the price especially for the oil. For example, as Iran announced to block Hormoz Strait led the potential warfare with the US, the oil price increase in a significant trend.

Another risky thing is the margin when investors use the futures contract, as the buyer long a futures contract, if the price decrease lower than a point, investors should add the cash to their margin account, as they do not have enough margin or cannot borrow enough cash into margin account, all of the contract will be

cancelled by the counter party and the margin buyer paid will never come back because the buyers lose their futures contract.

For the risk of the futures market, some investors will accept the high risk, because higher risk will have higher return. Some investors will accept nearly zero risk which is risk free. Therefore, this paper will focus on the risk of crude oil futures prices and try to give the method to figure out the risk premium of the crude oil futures prices then test them.

## **Chapter2: Literature Review**

### **2.1 How crude oil price affect economy**

The crude oil is the most important energy in the world. Any fluctuation of crude oil price will give a signal to the world economy situation. If the oil falls into the floor, the economy and the financial crisis will come. Many investors and economy specialist will pay more attention to the crude oil prices. They will forecast the price to the future then hedging the risk and also get the result of the economy situation by the past crude oil prices.

From the monthly report of the Deutsche Bundesbank(2012, JUN), the crises of the 1970s led the economic breakdown that will reduce the oil supply as a result of events such as war and recession. However, the rising trend of demand on oil increases the oil price. Ever since the severe crises of the 1970s and early 1980s, if not earlier, the price of crude oil has been regarded as one of the main determining factors of fluctuations for economy levels. In the 1990s, temporary price increases were repeatedly occasioned by supply-side factors, such as the Gulf War and the decreasing of OPEC oil production quotas because of the Asian crisis. In 2011, global oil consumption was divided nearly 50-50 between these two groups of countries; ten years earlier, the industrial countries had occupied for 60%. The emerging economies' hunger for energy is widely seen

as one of the key drivers of the gradual but continuous oil price rise between 2003 and 2008.

From all the oil price change during 1970s to 2011s, any events which affect the oil price then will affect the world economy situation. The crude oil is related to the economy and the financial market. So this paper first review the important consequence in the crude oil and tell the reader why interested in crude oil prices.

## **2.2 The volatility of crude oil prices**

Crude oil price changes every second. Some important messages related to the crude oil will affect the price significantly such as the war in the energy countries, the policy change in the main oil export countries, the demand for the oil in developed countries. Moreover, some other information announced by the oil company and government will also change the oil price. In that situation, the crude oil price is so volatile which gives the investor and financial analyst hard to predict the future price. According to McKay, P. A. (2004, Jun 29), from the other hand, other recent developments have helped to reduce the oil price. In Iraq, flow circuit repairs have activated the country's exports after earlier attacks had stopped production. Elsewhere, a strike by Norwegian oil workers has ended, and producers announced that country's production recovered to normal

yesterday. Also, the Organization of Petroleum Exporting Countries has announced to increase production, especially for Saudi Arabia in particular saying it will meet any output shortfalls.

From the topic of crude oil price payoff by Al Bawaba (2010, Feb 07), crude oil prices fell immediately in the second half of January, moving closer to the \$70 per barrel (pb) level. After achieving the \$80 pb mark on January 11th, the price of Kuwait Export Crude (KEC) fell by \$9 to \$71 pb by the 26th. Two factors seem to have been the reason for the fall. First, the rising risk aversion across global markets saw a big change to the US dollar, which traditionally puts a bumper on crude prices. Secondly, the announcement of new measures to prevent the growth of credit in China raised concerns of slower oil demand; China has accounted for 40% of the growth in global oil demand in recent years. The fallen 9 dollars for the crude oil price illustrated the crude oil price can be changed in a large range by the events happen across the international market. Finally, the events happened hit the market every day lead the volatile of crude oil prices.

### **2.3 Risk premium of crude oil future prices**

From the discussion above, crude oil is an important energy which will give the signal to the economy trend. Therefore, the crude oil price is so volatile. In that

situation, the most important part of the crude oil prices is risk. For the significant change of crude oil prices, the investors will pay great attention to minimize the risk and maximize their profit. So investors will try to get what kind of risk they should face, the risk they can accept, and the accurate amount of risk premium.

In 1994, Moosa, I. A. and Al-Loughani, N have researched in the market efficiency and unbiased issues on crude oil future markets. They examined the relationship between crude oil spot prices and future prices. For the result, the futures crude oil prices are neither unbiased nor efficient for spot prices. Furthermore, a GARCH-M (1,1) model reveals the existence of a time-varying risk premium.

According to Considine, T. and Larson, D. F. (2001), they tested the risk premiums on crude oil by the stochastic model in econometric. The traditional theory of storage developed by Kaldor (1939), Working (1934), Brennan (1958), and Telser (1958) defined the marginal storage cost by the expected future spot price less the current spot price. Pindyck (1994) provided some systematic econometric evidence linking the convenience yield with the stock-to-sales ratio for several commodities. The main idea is testing the relationship between convenience yield and an option value to the price of crude oil. The empirical findings provide strong support to the existence of risk premiums and convenience yield. The risk premiums rose sharply with greater price volatility

and help explain why prices for immediate sales often exceed prices for future delivery.

There is a popular relationship between the construction of highway and cost of crude oil which is researched by Damjanovic, I., & Zhou, X. (2009), many constructions especially for the highway need crude oil, so the price of crude oil is the risk for the construction on the highway. Therefore, the price of crude oil will directly affect the contractors gain and loss. Avoiding the risk is the main request for the contractors, the paper will focus on investigating the evidence of behavior and test the expected change in oil prices (the difference between the futures and spot price) and the implied volatility in the oil market affect the price of bid items for contracts without price adjustment clauses.

According to Strumpf, D. (2011, Dec 14), the investors use the popular method to bet on the crude oil price by exchange-traded fund, which offers exposure to the ebbs and flows of raw-material prices by using pooled money to buy and sell commodity futures. For the futures market, the delivery price in the future later will be higher delivery sooner, many oil ETF investors have been forced to get their profit every month.

From the Ewald, C., Nawar, R. and Siu, T. K. (2013, 06), the paper study the performance of how to minimize the risk of futures and options crude oil price by hedging strategies. According to Haase, M., & Zimmermann, H. (2013), risk premiums of commodity futures are directly related to the physical scarcity of commodities. For this purpose, the authors propose a simple decomposition of spot prices into a pure asset price plus a scarcity related price component. This replaces the traditional convenience yield that results from an imperfect no-arbitrage relationship of the term structure of commodity futures prices. The empirical tests confirm that two separate commodity-specific risk premiums affect the pricing of crude oil futures contracts: a net hedging pressure premium and a scarcity premium.

## **2.4 Objective**

From all of the review, it divides into three main parts. First, explain the importance of the crude oil energy and how they drive the economy trend. Second, tell the reader the volatile of the crude oil price changes, in other words, how quickly and immediately the crude oil price will change by some events enter in the market. Depending on the two parts before, finally review the risk premium of the crude oil prices. After review all the models of the risk premium on crude oil, the researchers tried to test the relationship of the spot prices and the futures prices on crude oil, however, the research is not completed. In this paper, I will try to estimate the relationship between the risk premium on crude



oil futures and spot price of crude oil by using the cost of carry model to get the risk premium of crude oil price then test them.

## **Chapter3: Methodology**

### **3.1 Data Source**

To calculate the risk premium of the crude oil future prices, this paper collected the data from the US crude oil market because the US oil market is one of the most representative crude oil markets all over the world. This paper chose five represented crude oil companies. The daily future prices of crude oil employed in this paper are picked from the NYMEX. All the original data, including the spot price, the futures price, the interest rate, the storage cost and the daily risk free rate are collected in the US market during the period 2011 to 2013.

### **3.2 Model**

The model applied in this paper is the cost of carry model. From the review of the risk premium on crude oil future prices, Keynes (1930) introduced the Normal Backwardation. This is the basic of the risk premium on crude oil future prices. The model uses the future price at maturity  $T$  compared to the expected future spot prices. In other words, use the difference between them to get the risk premium of crude oil.

$$E(\varnothing) = E(S_T) - f_0(T)$$

$$E(S_T) = S_0 + S + iS_0$$

$$f_0(T) = (S_0 + S)e^{(r-c)t}$$

$E(\varnothing)$ : The risk premium of the crude oil price which is calculated by the expected spot price minus the futures price of crude oil at an ensure time because the different from the spot price and futures price is the profit if buying the crude oil futures contract.

$E(S_T)$ : The expected spot price of crude oil which can be combined with the spot price at time 0 plus the cost of storage and the interest forgone.

$F_0(T)$ : The futures price of the crude oil at maturity T. This is what we called the cost of carry model to get the futures price of the commodity. From this formula, the main idea is to get the futures price of the crude oil at different maturity then compare to the futures contract price in the market, therefore also need to test the formula.

$S_0$ : the spot price of the crude oil which is also the price of crude oil which traded in the market at time 0.

$S$ : the storage cost of the crude oil. As crude oil is the commodity, so need to storage the oil which will cost the money.

$iS_0$ : the interest forgone of the crude oil. If forgone to hold the crude oil, the investor will get the interest of holding the crude oil.

$r$ : the risk free rate of the crude oil, from this model, this paper uses the continues compounded rate

$c$ : the convenience yield, it is the premium earned by the holding of the crude oil in short supply.

$T$ : time at the maturity date

As the paper chose five representative companies, so we use the panel data to combine the spot of five companies together. Therefore, the regression will be more accurate. In order to estimate the relationship between the risk premium of crude oil and spot price, this paper employed the methodology of panel OLS.

### **3.3 Hypothesis**

To test the relationship between the risk premium and spot price, we have three hypotheses: positive relationship, negative relationship and no relationship. For the positive relationship, as the spot price of crude oil increased in the market, the risk premium will also increase. For the negative relationship, as the spot price of crude oil rose, the risk premium decreased. Another hypothesis is that there is no relationship between the risk premium and the spot price, in that sense, no one will care about the spot price of crude oil.

$H_0$ : There is a positive relationship between risk premium and the spot price of crude oil

$H_1$ : There is no relationship between risk premium and the spot price of crude oil

$H_2$ : There is a negative relationship between risk premium and the spot price of crude oil

The reason why to use the hypothesis and test the relationship between risk premium and spot price is that investors can use the test results to make their decision to whether buy futures, sell futures or buy the spot price. If the relationship is positive, it will suggest investors to buy the crude oil futures to make profit. However, if the relationship is negative, investors should sell the crude oil futures or only buy the spot price because once the spot price increased, the profit of futures became negative. In addition, if the result shows no relationship between them, investors should not care about the spot price and futures price.

## Chapter 4: Results Analysis

### 4.1 Data summary

According to table 1, we found 3650 observations from the market; however, we can only use 2525 of them to run the regression. “Spotlastor~e” represents the spot price of the crude oil of 5 companies, which are Alaska North Slope, Bakken UHC, USGC Sour Index, Bonoto Sour, Eugene Island; “futureslas~e” represents the futures prices of crude oil; and “yield” represents the interest rate.

In order to get the best result of the risk premium of the crude oil futures prices, both spot price and futures prices are the most important factors to consider with. Additionally, the risk premium is based on the following regression

$$E(\phi) = E(S_T) - f_0(T)$$

Also, the interest rate is applied to get the expected futures spot prices, which is calculated as the following:

$$E(S_T) = S_0 * (1+i)$$

After running the regressions, we got the following results: (1) the maximum and minimum values of the spot prices are 127.99 and 63.69, respectively, and the

standard deviation and mean values of which are 10.58896 and 105.8615, respectively; (2) the maximum and minimum values of the futures prices are 113.93 and 75.67, respectively, and the standard deviation and mean values of which are 7.875517 and 94.62338, respectively; (3) the maximum and minimum values of the interest rate are 3.737 and 1.1, respectively, and the standard deviation and mean values of which are 0.7906297 and 2.087347, respectively. The following table summarizes the results.

Table 1: Data Summary

Variable	Obs	Mean	Std. Dev.	Min	Max
spotlastpr~e	2525	105.8615	10.58896	63.69	127.99
futureslas~e	2525	94.62338	7.875517	75.67	113.93
yield	2525	2.087347	.7906297	1.1	3.737

The expected futures spot prices are calculated by the spot price time the interest rates and then add back the spot prices. Additionally, the risk premium of the crude oil future prices is subtracted from the futures prices. As discussed before, the risk premium is a very important factor for investors to make the decisions.

After running the regression, even the risk premium is highly volatile, the average of the results is positive; therefore, risk lover and neutral investors may want to invest in crude oil futures because there is an existence of potential profit within the crude oil futures. The maximum and minimum values of the risk premium are 33.04732 and -26.26449, respectively; the standard deviation and mean values of which are 8.712599 and 13.46258, respectively. The following table shows the detailed results of the regression.

Table 2: Expected future spot price and risk premium

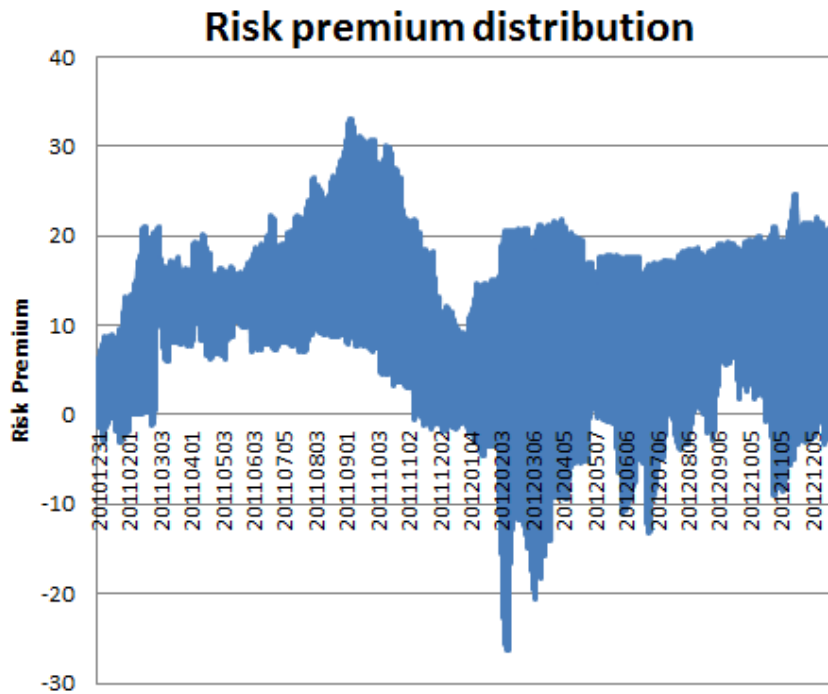
Variable	Obs	Mean	Std. Dev.	Min	Max
spotlastpr~e	2525	105.8615	10.58896	63.69	127.99
futureslas~e	2525	94.62338	7.875517	75.67	113.93
riskpremuim	2525	13.46258	8.712599	-26.26449	33.04732
yield	2525	.0208735	.0079063	.011	.03737

Also, the figure below graphically illustrates the distribution of the risk premium.

Most of them are positive in the sample period of 2011 to 2013.



Figure 1: Risk Premium Distribution



## 4.2 Regression Results

### 4.2.1 Fix effect regression

The regression fixed effect regression of risk premium against spot prices shows that there is an existence of encouraging relationship between the two. The coefficient is 0.321514, which means one unit change in spot prices will influence the risk premium by 0.321514 units. Also, the t value of 5.86 from the regression illustrates that the coefficient is statistically significant at the 95% confidence level. However, the standard deviation is nearly 5% which means

the diversified risk for investing in crude oil is extremely low. Moreover, there is an existence of the positive effect of crude oil spot prices upon the risk premium. At the 95% confidence level, the relationship between the spot prices and the risk premium will always be positive.

The R square of 0.5133 illustrates that the regression can explain nearly 51% of the whole market for two years sample. The higher the spot prices in the market, the higher the risk premium in the market. The investor may want to participate in crude oil futures with high spot prices to get the profit. The following is the detailed results of the regression.

Table 3: Fixed Effect Regression

```
. xtreg riskpreuim spotlastprice, fe robust
```

```
Fixed-effects (within) regression      Number of obs   =    2525
Group variable: code                  Number of groups =     5

R-sq:  within = 0.2289                 Obs per group:  min =    505
      between = 1.0000                   avg   =    505.0
      overall  = 0.5133                   max   =    505

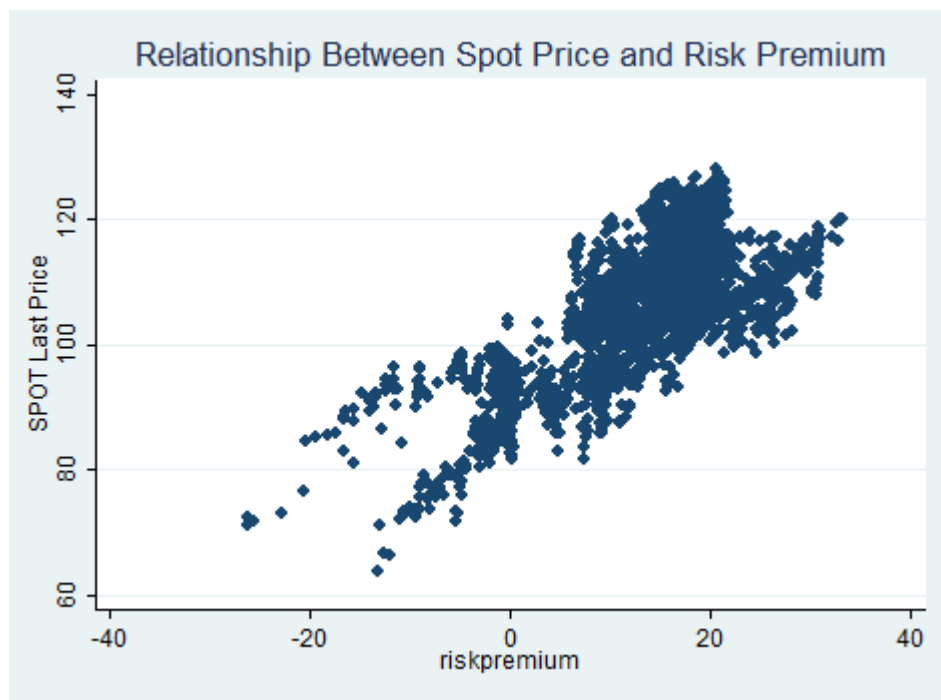
                                F(1,4)           =    34.35
corr(u_i, Xb) = 0.6200                Prob > F       =    0.0042
```

(Std. Err. adjusted for 5 clusters in code)

riskpreuim	Robust		t	P> t	[95% Conf. Interval]	
	Coef.	Std. Err.				
spotlastprice	.321514	.0548558	5.86	0.004	.16921	.473818
_cons	-20.57338	5.807114	-3.54	0.024	-36.69651	-4.450246
sigma_u	5.1167805					
sigma_e	4.9081643					
rho	.52080071 (fraction of variance due to u_i)					

Also, the following figure of the relationship between the spot prices and the risk premium proves the same results analyzed above. From the figure below, most of the observations of the risk premium lying within the range between 0 and 40 units of profit.

Figure 2: The relationship between the spot prices and the risk premium



#### 4.2.2 Random effect regression

Random effect is another regression applied for the panel data. The results of the random effect regression show that the coefficient of the spot prices is 0.59, which interprets the relationship between the spot prices and the futures prices

is positive under the model. Also, the z value of 4.34 proves that the coefficient is statistically significant at 95% confidence level. However, the standard deviation largely increases to 13.58543% under the random effect model. The regression results prove that as the crude oil spot prices increase, the risk premium in the market also rises. Therefore, there is an existence of potential profit for investors.

Moreover, the R square under the random effect model stays the same as the fixed effect model used above, 51.33% of R square intercepts that the regression explains nearly half of the observations. The following table is the detailed results of the regression.

Table 4: Random effect results

```

Random-effects GLS regression           Number of obs   =   2525
Group variable: code                   Number of groups =     5

R-sq:  within = 0.2289                 Obs per group:  min =    505
      between = 1.0000                  avg   =   505.0
      overall = 0.5133                  max   =    505

corr(u_i, X) = 0 (assumed)             Wald chi2(1)    =   18.83
                                           Prob > chi2     =   0.0000

```

(Std. Err. adjusted for 5 clusters in code)

riskpreuim	Coef.	Robust Std. Err.	z	P> z	[95% Conf. Interval]	
spotlastprice	.5895152	.1358543	4.34	0.000	.3232456	.8557847
_cons	-48.94439	15.7444	-3.11	0.002	-79.80284	-18.08594
sigma_u	0					
sigma_e	4.9081643					
rho	0	(fraction of variance due to u_i)				

## Chapter 5: Conclusion

From above discussions and analyses, the risk premium plays an important role for the derivative markets, especially for futures markets. Investors can figure out the risk and decide whether to invest in the futures market depending on their risk tolerance.

This paper focuses on calculating the risk premium on crude oil future prices and tests the regression from risk premium and spot price. According to literature review, this paper illustrates the importance of the risk premium, how other researchers make their researches and propose my main idea for this paper. From the model, I choose the main commodity futures model which is the cost of carry model to forecast the risk premium and run the regression to test the relationship between risk premium and spot price.

In addition, this paper uses the fixed effect and the random effect method to run the regression. Both of the results get the positive relationship between two factors which is also 95 percent statistically significant during 2011 to 2013. Finally, the conclusion after estimation is that if the spot price is higher, the potential profit to invest in crude oil futures is optimistic.

All in all, the risk premium has an important research trend and can be developed more deeply in the future.

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