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Dan Zhang[a,b,*], Arash Farnoosh[b], Zhengwei Ma[a]

a China University of Petroleum(Beijing),18 Fuxue Road ,Changping Disrict ,102249 Beijing,China

b IFPEN, IFP School, 232 Avenue Napoléon Bonaparte, 92852 Rueil-Malmaison, France

***Corresponding author.**

Email address: danzhang.424@gmail.com (Dan zhang); arash.farnoosh@ifpen.fr (Arash Farnoosh)

ma_zhengwei@163.com (Zhangwei Ma)

Abstract:

Based on the examination of price discovery between Shanghai crude oil futures and spot market, this paper explores whether the introduction of Shanghai crude oil futures can play a stabilizing role in the spot market, alleviating the impact of the financial cycle risk on the crude oil market from March,2018 to December, 2019. The results show that there is only a uni-directional relationship of spot price to futures price, and spot plays a leading role in price discovery. The risk of financial cycle will increase the volatility of spot price, and the introduction of crude oil futures market can increase the impact of financial cycle on spot market. The additional research on the microcosmic mechanism of Shanghai crude oil futures indicates that crude oil futures market mainly influences the spot market fluctuation through the behaviour of traders: speculation increases price volatility in the spot market, which is more pronounced in the high volatility of financial cycle as oppose to hedging transaction.

Key words: Shanghai crude oil futures; Price discovery; Stabilization; Financial cycle

Introduction

Chinese crude oil futures, the first international futures product from China, were officially listed on the Shanghai International Energy Exchange (INE) on March 26, 2018. In the past two years, Shanghai crude oil futures have shown the characteristics of smooth operation and expanding trading scale. In the first half of 2020, the average daily trading volume of crude oil futures in Shanghai was about 18 thousand lots and the average daily position was about 120 thousand lots, increasing by 3% and 286% respectively from the same period last year. Shanghai crude oil futures have become the third largest crude oil futures after WTI and Brent crude oil futures in terms of trading volume.

Launching of Shanghai crude oil futures contract is not only beneficial to meet the demand of oil companies to hedge against the risk of international oil price fluctuation, but also to ensure the stability of oil prices in China, which is of great significance to the energy security and economic development. Since the introduction of Shanghai Crude oil futures contracts, many scholars have payed attention to this new energy futures market. As the third largest crude oil futures market in the world, it is of great significance to evaluate the operating efficiency of this futures market, which is also the aim of our study.

The main contributions of this paper are as follows: First, Shanghai crude oil futures market is a new international crude oil futures market, and the research on the price discovery of this futures contract is not comprehensive enough. Here we conduct the analysis by information share approaches. Result shows that crude oil spot market does more contribution during the price discovery and there is only a one-way leadership of spot price to futures price. Second, this study introduces the financial cycle variable and explores if Shanghai crude oil futures play a stabilizing role in spot price in the framework of financial cycle volatility risk. Our research fills the void and finds that after the introduction of crude oil futures in China, spot price volatility decreased significantly. At last, according to the market contagion theory, price linkage between the futures market and spot market is mainly affected by investors behaviour. In the decision-making process, investors will not only analyse the investment target market, but also refer to the relevant market price, which can effectively reduce the cost of the information captured by the investors (King and Wadhwani, 1990). Hence, in this work we discuss the influence of traders' behaviour in futures market toward the volatility of spot price to reveal the microcosmic mechanism between the futures and spot markets.

The remainder of this paper is organized as follows: Section 1 provides a description of the related studies in this domain; Section 2 discusses the methodology used in the paper. Section 3 describes the data and variables used in the empirical analysis. Section 4 presents the empirical results to explain the relationship between Shanghai crude oil futures market and spot market in terms of price discovery and stabilization in the framework of financial cycle risk. In addition, a robustness test is provided at the end of this section. Finally, section 5 concludes the paper.

1. ***Review of Literature***

Crude oil futures have two basic functions: price discovery and risk transfer (Working,1948). The essence of the price discovery function of futures markets hinges on whether new information is reflected first in changed futures prices or in changed spot prices (Irwin, 1933). In theory, the futures market has the characteristics of low cost, high leverage and high liquidity, therefore the price discovery function of futures markets leads price changes in spot markets more often than the reverse (Garbade and Silber,1983).

A large body of empirical literature support this view. For example the study of Schwarz and Szakmary (1994) strongly proved that futures dominate in price discovery in all three petroleum product markets: crude oil, heating oil and unleaded gasoline. In the case of WTI, the contribution of the futures market has been increasing, especially between 2003 and 2008 and then again after the start of 2009 (Silverio and Szklo, 2012). There are many scholars whose research conclusions are contrary to this conclusion. Quan (1992) takes two step testing procedure to prove that the crude oil futures market does not play an important role in price discovery; Wang and Wu (2013) reveal that the leadership between crude oil spot and futures prices is different at different time scales by multi-frequency analysis. There exists an alternate lead–lag structure instead of a dominance between the futures and spot market in the case of WTI (Shao et al.,2019).Therefore, different research perspectives and subjects will lead to different results in terms of price discovery. However, most studies focus on the efficiency of the WTI and Brent crude oil markets, and few of them focus on the crude oil futures markets for other Asian (or emerging and developing) countries.

What is the price discovery progress between Shanghai crude oil futures market and spot market? Ji and Zhang (2019) document interestingly stylized facts of the new crude oil futures market (INE) in China. Wang et al. (2019) use the R/S analysis, multifractal detrended fluctuation analysis (MF-DFA), and multifractal spectrum to analyse the fractal characteristics of the INE crude oil market. From the results of Yang et al (2020) who just used one-year data of INE crude oil futures, they concluded that INE crude oil futures can reflect the fundamental information of spot market effectively.

Furthermore, the influence of crude oil futures on spot prices volatility is also an important embodiment of the operating efficiency of futures market. Several economists have studied the relationship between futures trading and price variability of spot market by comparing price volatility in a period of no futures trading and a period of active futures trading. Hieronymus (1960) and Gary (1963) concluded that futures market can play a stabilizing role in the spot price while Johnson (1973) demonstrated that futures trading has no effect on prices. Cox (1976) believed that future trading can alter the amount and improve the quality of information reflected in expected price so that the spot market works more efficiently thanks to hedging and speculation. Because the Shanghai crude oil futures contract was listed recently, its function of stabilizing the spot market needs further verification. Li et al（2020） investigate dynamic correlations between Chinese crude oil futures and spot prices of OPEC and Oman, as well as the hedging effectiveness, finding that the correlations and hedging effectiveness of Chinese crude oil futures and spots are quite strong. Zhang, Di and Farnoosh (2021) also find that the listing of Shanghai crude oil futures establishes an effective hedging tool for oil importers and refineries.

After the financial crisis in 2008, the characteristics of international energy market financialization are becoming increasingly prominent (Ji and Fan, 2010; Kolodziej et al., 2014). Salim Lahmiri (2017) also finds strong evidence of chaotic dynamics in both Brent and WTI volatilities after international financial crisis.

Based on Brent crude oil spot and futures daily prices, Chen and Zeng (2011) discuss the property of oil price during financial crisis and find that stochastic cointegration relationship does exist between oil spot and futures prices. As a kind of commodity, the financial attributes of crude oil are becoming more and more obvious (Zhang, 2017). Yang et al (2021) investigated the impact of five global financial market uncertainty on the price dynamics of Shanghai Crude oil futures and find China's crude oil futures volatility, including intraday volatility and its components, moves tightly with all the global financial uncertainties. Crude oil price volatility is cyclical (Naini et al., 2017). Therefore, the risk of financial cycle volatility also affects crude oil prices. As the financial cycle evolves, the sentiment of market participants will change as risk premium (Laborda and Olmo, 2014). With the impact of sentiment, futures market participants adjust their positions (Baker and Wurgler, 2006; Nayak,2010). The constant change of trading volume leads to the continuous change of price. The adjustment process of trading volume and position in futures market increases the market depth and then improve the efficiency of price discovery of futures market (Bessembinder and Seguin,1993). However, the empirical research in this area especially the relationship between financial cycle and crude oil price is still blank.

2. *Methodology*

2.1. Information share approaches

In existing studies, the evidence on the relationship between spot and futures prices is always revealed based on causality tests or cointegration tests (Crowder and Hamed,1993; Silvapulle and Moosa,1999; Bekirosa and Diks 2008). Here we expand the analysis by information share approaches. Information share model is established by Hasbrouck (1995) to evaluate the contribution of each market to the common effective price. Information share model is based on cointegration relationship, and then vector error correction model (Vector Error Correction, VEC) which is needed to be established. Given a finite length of time, there is an equilibrium price for a relevant asset in different markets, which is described by a common component of different market prices (Gonzalo and Granger, 1995), so that the contribution of each market to the common factor can be measured, and the contribution percentage of each market is called information share. A summary of the analytical methods is provided as follows:

Assume $y1_t$ and $y2_t$ denote the logarithmic price sequence of crude oil spot and crude oil futures respectively. If there is a cointegration relationship (the vector form of the cointegration relationship is Yt=(y1t,y2t))between the spot and futures markets, then the VEC model is expressed as:

$$\Delta Y_t = \alpha\beta Y_{t-1} + \sum_{j=1}^{k} \varphi_j \Delta Y_{t-j} + e_t \qquad (1)$$

Where α is the error modified coefficient; e_t is residual with the mean of zero. The residual sequences are uncorrelated, and their covariance matrix is：

$$\text{Tt}\quad \text{P} = \begin{bmatrix} {\sigma_1}^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & {\sigma_2}^2 \end{bmatrix} \qquad (2)$$

Where, ${\sigma_1}^2$, ${\sigma_2}^2$ are variances of information e_{1t} 、 e_{2t}, respectively. And ρ is the correlation coefficient.

The information share model is to decompose the variance of the common factor and define the price discovery according to the variance contribution of the information of each market to the common factor. The key is to break down the impact of shocks to each market and analyse the contribution of each market to shocks. When there is a simultaneous correlation between the information items of two markets, Cholesky decomposition can be used to eliminate the simultaneous correlation between information. When market one is in the first variable, the calculated information share is its upper limit; when it is in the last variable, the calculated information share is its lower limit. The average of the upper and lower limits is its average share of information (Yan and Zivot,2010)

Lower limit of information share of Market1:

$$IS_{1max} = \frac{(\alpha_2\sigma_1 - \alpha_1\sigma_2\rho)^2}{\alpha_2^2\sigma_1^2 - 2\rho\alpha_1\alpha_2\sigma_1\sigma_2 + \sigma_2^2\alpha_1^2} \qquad (3)$$

Upper limit of information share of Market1:

$$IS_{1min} = \frac{\alpha_2^2\sigma_1^2(1-\rho^2)}{\alpha_2^2\sigma_1^2 - 2\rho\alpha_1\alpha_2\sigma_1\sigma_2 + \sigma_2^2\alpha_1^2} \qquad (4)$$

2.2. Exponential Generalized Auto Regressive Conditional Heteroskedasticity （EGARCH）

After studying the price discovery function of crude oil futures market and spot market, we will further explore the influence of Shanghai crude oil futures market and financial cycle fluctuation on spot price volatility. Through the relevant tests, it is found that the return rate of Daqing crude oil spot has a significant ARCH effect. There is a characteristic of volatility clustering. Therefore, this paper chooses the GARCH model which can characterize the volatility clustering phenomenon to carry on the research. Moreover, the research of Bekiros and Diks (2008) indicated that crude oil spot and futures returns may exhibit asymmetric GARCH effects. Considering the influence of positive and negative coefficients of variance equation of GARCH model on volatility, we choose the EGARCH model established by Nelson (1991) as the main model:

$$R\_DQ_t = \alpha + \beta R\_DQ_{t-4} + \mu_t \tag{5}$$

$$\mu_t = \sigma_t \varepsilon_t \tag{6}$$

$$\ln({\sigma_t}^2) = \omega + \lambda_1 \ln({\sigma_t}^2) + \lambda_2 \left|\frac{\mu_{t-1}}{\sigma_{t-1}}\right| + \lambda_3 \frac{\mu_{t-1}}{\sigma_{t-1}} + \sum_1^k \theta_i x_{it} + \sum_1^j \varphi_i z_{it} + \sum_1^m \sum_1^n \phi_i x_{mt} x_{nt} \tag{7}$$

Equation (5) is the mean equation. According to the AIC-SIC criterion, the fourth-order lag term of Daqing crude oil spot yield is selected for autoregressive. Equation (6) is the variance equation. μ_t is the residual, and ε_t is the white noise process. λ_1 is the GARCH coefficient, which represents the shock of the previous information on the rate of return. λ_2 is the ARCH coefficient, which represents the shock of the new information on the rate of return. λ_3 measures the asymmetry of the rate of return. In the variance equation, x_{it} is the core explanatory variable， z_{it} is the controlled variable, and the last term is the interaction between explanatory variables.

3. Data and Variables

3.1. Data and period examined

The main research objects of this paper are Shanghai crude oil futures price and China crude oil spot price, among which China spot crude oil price is measured by Daqing crude oil spot price. The range of Shanghai crude oil futures sample is from March 26,2018 to December 31,2019, and Daqing crude oil spot sample is from January 1,2015 to December 31,2019. The sample range of credit, credit /GDP, housing boom index, and M2, needed to construct the financial cycle index, is the quarterly frequency data from March 2000 to December 2019. [1] The credit, credit/ GDP data are from the BIS database and the rest is from the WIND database. [2],[3]

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[1] M2: M2 is a measure of the money supply that includes cash, checking deposits, and easily convertible near money, it is a broader measure of the money supply than M1, which just includes cash and checking deposits.

[2] BIS: Bank for International Settlements. Its mission is to serve central banks in their pursuit of monetary and financial stability, to foster international cooperation in those areas and to act as a bank for central banks. www.bis.org

[3] WIND: is Chinese leading provider of financial data, information and software services.

3.2. Variables explanation

In this paper, Shanghai crude oil futures price and Daqing crude oil price are selected as indicators to study price discovery. Daqing Oilfield is the largest oil field and the most important source of crude oil in China. In the Daqing Oilfield, the registered prospecting right area is about 266,000 square kilometres, the prospective oil resources are more than 14 billion tons, the proven reserves are more than 6.5 billion tons, and the annual growth of oil reserves exceeds 100 million tons for five consecutive years. [4] The price of Daqing crude oil is generally used to represent the price of Chinese crude oil in the world, and its price level basically represents the overall price level of Chinese crude oil (Wei and Lin,2007). In the price stabilization study, the explained variables are the return rate of Daqing crude oil futures, and the explanatory variables are divided into core explanatory variables and exogenous control variables. As we do research in the framework of the time series, here we use the log difference value for the rate of return, which follows normal distribution and can validate the constant variance assumption of the statistical model that we use later. The core explanatory variables include the variable of whether introduce futures or not, financial cycle fluctuation, speculation and hedging of crude oil futures. Exogenous control variables include the yuan-dollar exchange rate, the weekly effect variable, and the yield of WTI (West Texas Intermediate).

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[4] Data from the official website of Daqing oil field:

http://dqyt.cnpc.com.cn/dq/yqkt/fwjs_common.shtml

3.2.1. Financial cycle volatility variables

The financial system has its own laws of cyclical fluctuations, and such fluctuations will have an impact on the fluctuations of the real economy (Mendoza and Terrones, 2012). As the lifeblood of industry, crude oil is closely related to the real economy, so it is of great value to bring the fluctuation variable of financial cycle into the research scope. In terms of the measurement of the financial cycle, two kinds of indicators are mainly used, the first category is devoted to the investigation of credit indicators; the second category synthesizes the volatility variables of the financial cycle by considering various indexes, such as interest rate, asset volatility, stock price, real estate price and so on (Eickmeier et al., 2014; Borio, 2014). Based on Borio's method of constructing financial cycle index combined with the available research in China (Fan et al.,2017;Zhu and Huang,2018), this paper synthesizes financial cycle with the indicators of Credit to non-financial sector from all sectors, Credit to non-financial sector from all sectors/GDP, National housing boom index and M2.

The financial cycle is a longer-term volatility force, generally 8-30 years, so we expand the period of sample used to construct the financial cycle to 2000-2019. After standardizing each index based on the data of the first quarter of 2000, we use the frequency filtering method to obtain single periodic fluctuations, and then take the arithmetic average of four single filtering indicators as financial cycle risk indicators. If the financial cycle risk is greater than the average interval, we define it as financial cycle high volatility state and vice versa. Finally, we set financial cycle variable as dummy variable：high volatility state of 1 and low volatility state of 0. Figure 1 depicts the high and low volatility state of the financial cycle, which is compared with the incremental data of social financing scale. As the below figure shows, when the increment of social financing scale is negative which means the scale of social capital flow is small, the financial cycle is basically in a low volatility state.

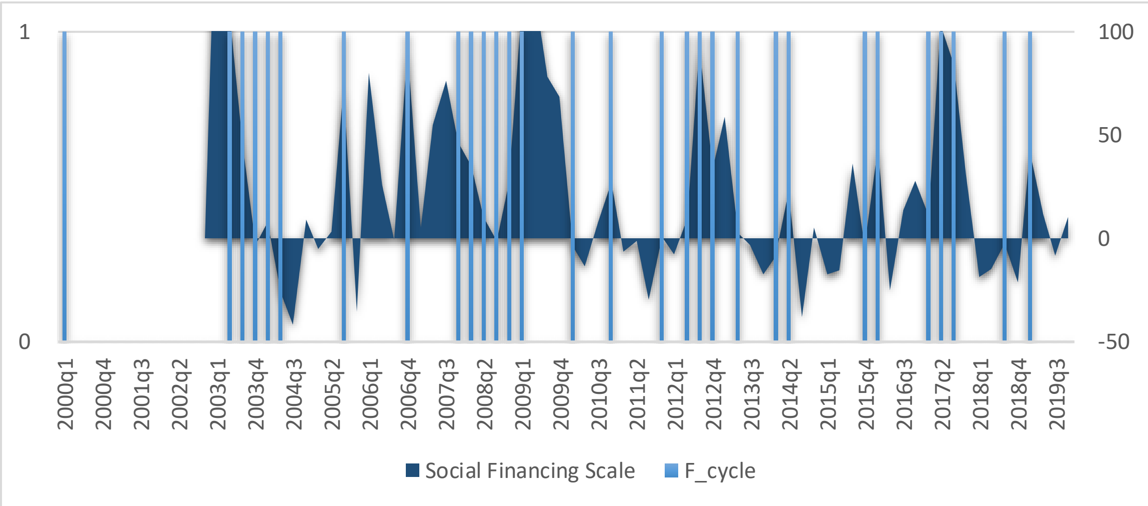


Figure 1. High and low volatility state of the financial cycle

3.2.2. Agent variables of speculation and hedging

In the classical study, it is generally assumed that the speculative traders of futures earn the risk premium through frequent trading, which constantly impact the spot price (Perk,1976). Speculators trade derivatives without risk exposure and thus they are outright position-takers , this group of traders includes the so-called day traders who hold their positions for less than one trading day(Lucia and Pardo,2010), so we can use the daily turnover volume as the agent variable of speculative activity. In the contrast, futures hedgers hold futures contracts until maturity so we can use position volume as hedging agent variable (Kim,2005; Bohl et al.,2013) .

3.2.3. Control variables

To control the influence of other factors on the fluctuation of crude oil, the exogenous control variables introduced in this paper include the exchange rate of RMB to US dollar, the weekly effect variable, and the yield of WTI. Available literature shows that the dollar exchange rate has a significant impact on futures and spot price fluctuations (Zhang Dayong and Ji Qiang,2018). The benchmark price of crude oil on the international market has always been based on three kinds of crude oil futures prices: WTI, Brent, Dubai. Besides, there is a stable crude oil market in the United States, which is directly linked to US dollar and Brent crude oil prices have been accompanied by changes in WTI crude oil prices for most of the time with little deviation from WTI. Therefore, in this paper we choose the yield of crude oil and the exchange rate of RMB to US dollar as control variables.

Table 1. Variables explanation.

Variable	Variable	Variable Meaning

		Name	
Price Discovery	Price of Shanghai Crude Oil Futures	Ln_INE	Ln(Daily settlement price of INE futures contracts)
	Price of Daqing Crude Oil	Ln_DQ	Ln(Daily Price of Daqing Crude Oil)
	Log Yield of Shanghai Crude Oil Futures	R_INE	(Ln_INE$_{t}$- Ln_INE$_{t-1}$)*100%
	Log yield of Daqing crude oil	R_DQ	(Ln_DQ$_{t}$- Ln_DQ$_{t-1}$)*100%
Price Stabilization	Variable of whether introduce Shanghai Crude Oil futures or not	Launch	Take 1 after the launch of crude oil futures and 0 before the launch
	Financial cycle volatility variables	F_cycle	Take 1 for high and 0 for low
	Agent variable if speculation of crude oil futures	Spe	Ln(Daily turnover of crude oil futures)
	Agent variable if hedging of crude oil futures	Hed	Ln(Daily position of crude oil futures)
	Log yield of WTI futures	R_WTI	(Ln_WTI$_{t}$-Ln_WTI$_{t-1}$)*100%
	Exchange rate	Exchge	RMB to US dollar
	Week effect variables	Week _i	Take 1 when it is in the corresponding week day and 0 at other times

3.3. Descriptive statistics

Descriptive statistics of Daqing crude oil price and yield, Shanghai crude oil futures price and yield, turnover and position are reported in Table2. Moreover, Descriptive statistics are carried out respectively on the spot data of the whole sample and half sample (before and after the futures are introduced). Because Logarithmic price scales are better than linear price scales at showing less severe price increases or decreases, we conduct log transformation of spot and futures prices. It can measure all variables in a comparable metric, thus enabling evaluation of analytic relationships amongst two or more variables despite originating from price series of unequal values. It can be seen from the table that after the introduction of futures, the standard deviation of logarithmic price and yield of crude oil spot is obviously reduced. The mean of turnover volume is larger than the position volume, which means that the proportion of speculator who trade more actively than hedgers in the market is larger. The skewness of turnover and position is negative which presents characteristics of leptokurtosis and fat-tail.

Table 2. Descriptive statistics

Variable	Ln_DQ			R_DQ			Ln_INE	R_INE	Spe	Hed
	Full Sample	Before launch of INE	After launch of INE	Full Sample	Before launch of INE	After launch of INE	Full Sample	Full Sample	Full Sample	Full Sample
Mean	3.900	3.790	4.102	0.042	0.040	0.045	6.135	-0.002	12.361	10.362
Maximum	4.343	4.151	4.343	13.102	13.102	8.501	6.392	7.050	13.464	10.991
Minimum	2.995	2.995	3.730	-11.823	-11.823	-7.637	5.873	-7.891	9.646	8.044
Standard Deviation	0.244	0.225	0.112	2.517	2.748	2.025	0.083	1.685	0.542	0.388
Skewness	-0.872	-0.870	-0.168	0.262	0.322	-0.047	0.328	-0.398	-1.159	-2.252
Kurtosis	3.765	3.757	2.463	5.526	5.241	4.770	3.268	4.769	5.713	10.411

4. Empirical Results

4.1. Price discovery of Shanghai crude oil Futures market

The linear cointegration relationship between the time series to be tested must be guaranteed before using the information share model. A E-G two-step method is used to test the cointegration relationship between variable sequences in this paper (Engle & Granger, 1987). As shown in Table 3, the ADF test proves that the price of Daqing crude oil is not stationary with the price of Shanghai crude oil futures contract. However, the residual sequence obtained by the linear regression of these two variables is stationary, indicating that there is a cointegration relationship between the price of Daqing crude oil and the price of Shanghai crude oil futures. From the last line of the table, it can be seen that the residual sequence is stationary at a significant level of 1%, which means that there is a long-term cointegration relationship between China's crude oil spot market and futures market.

Table 3. The results of ADF tests.

Variable	Test type(c,t,k)	Value of ADF	Conclusion
Ln_DQ	(0,0,1)	0.082	Non-stationary
Ln_INE	(0,0,1)	0.349	Non-stationary
R_DQ	(0,0,1)	-15.121***	stationary
R_INE	(0,0,1)	-15.919***	stationary
(Ln_DQ, Ln_INE ）	(0,0,1)	-3.742***	stationary

(c,t,k) is the type of tests. A parameter c, t,k indicates whether the unit root test equation included a constant, trend and lag. *,** and *** represent t test values significant at 10%,5% and 1% significance levels, respectively.

VECM model is established based on cointegration. In this study, the optimal lag order of the VECM model is 2 according to the AIC-SIC criterion. Table 4 shows the parameter estimation results of the VECM model. Here LD.ln_DQ and L2D.ln_DQ mean the first order difference and second order difference of ln_DQ respectively. The results show that when the market deviates from the long-term equilibrium, the error correction coefficient of the spot is 0.03, and the error correction coefficient of the futures is 0.05, and the gap between the two is small, indicating that the speed of deviation from the adjustment is generally equal. Through the short-term lag coefficient following, results can be obtained: In the spot formula, the impact of previous futures price and spot price on the current spot price is not significant; In the futures formula, the coefficient of spot lag term and futures lag term are significantly not zero, indicating that both spot and futures price will affect the volatility of futures price. At the same time, according to the numerical judgment, the previous spot price has a positive impact on the current futures price, while the previous futures price has a negative impact on the current futures price.

Table 4. The parameter estimation results of the VECM model.

	_CE1	LD.ln_DQ	L2D. ln_DQ	LD.ln_INE	L2D.ln_INE
D_Ln_DQ	0.0303**	-0.0324	-0.0784	0.0135	-0.0207
	(0.0135)	(0.0674)	(0.0671)	(0.0611)	(0.0604)
D_Ln_INE	-0.0541***	0.1347**	0.1314*	-0.1871**	-0.1901**
	(0.0146)	(0.0730)	(0.0727)	(0.0662)	(0.0654)

Note: The superscripts"***""**""*"indicate the degree of significance associated with rejection of null hypothesis at the level of 1%, 5% and 1% respectivelyThe standard error is in the parentheses (similarly hereinafter).

Table 5

Information share of crude oil spot and futures market.

	Cov(DQ,INE)	ρ	α_{DQ}	${\sigma_{DQ}}^2$	Upper limit	Lower limit	Average information share
Spot Market	0.000307	0.6518	0.0303386	0.000435	99.65%	63.26%	81.45%
Futures Market	0.000307	0.6518	0.0541053	0.00051	36.74%	0.35%	18.54%

The last column of table 5 shows the average share of information share in the spot and futures markets, and the data show that the spot market of crude oil has made a major contribution to the price discovery of crude oil, reaching 81.45%. In summary, crude oil spot plays a leading role in the change of crude oil spot and crude oil futures price. In addition to using the information share model to estimate the contribution of crude oil futures and spot to long-term price changes, the VAR model and Granger causality analysis are also used to explore the current short-term dynamic characteristics of this period. The Granger causality test results are shown in Table 6. This result is consistent with the conclusions obtained using the information share method. Indeed, we can conjecture that spot contribute more to price discovery at the opening hours because they are able to disseminate price information faster than in futures markets.

Table 6. The results of Granger causality.

H0	Observation	P value	Conclusion

R_DQ is not the Grange cause of R_INE	392	0.062	reject
R_INE is not the Grange cause of R_DQ	392	0.485	Cant' reject

4.2. Price stabilization of Shanghai crude oil futures market

In order to explore the function of Shanghai crude oil futures to stabilize the spot and the difference of the stability function of crude oil futures market under the background of financial cycle fluctuation, we added the dummy variable of futures and the financial cycle fluctuation variable on the basis of the main model. The specific model is as follows:

$$\ln({\sigma_t}^2) = \omega + \lambda_1 \ln({\sigma_t}^2) + \lambda_2 \left|\frac{\mu_{t-1}}{\sigma_{t-1}}\right| + \lambda_3 \frac{\mu_{t-1}}{\sigma_{t-1}} + \sum_1^4 \theta_1 Week_{it} + \theta_2 Exchge + \theta_3 R\_WTI + \varphi_1 Launch_t + \varphi_2 F\_cycle_t + \tau Launch_t * F\_cycle_t \quad (8)$$

The core explanatory variable regression results are reported in table 7. Model (1)(3)(4) show that the coefficient of *Launch* is significantly negative, indicating that the launch of shanghai crude oil futures has played a stabilizing role in the price fluctuation in the spot market. The crude oil futures market can provide fair price information for the spot market, thus reducing the large fluctuation of the spot price.

Model (2) shows that the coefficient of financial cycle fluctuation is significantly positive, indicating that under the high fluctuation state of financial cycle, the scale of social capital fluctuates frequently and the stability of spot price of crude oil decreases. On the other hand, the financial attribute of crude oil is verified to a certain extent. Model (3) shows that after adding the variable *Launch* on the basis of (2), the high volatility state of the financial cycle does not significantly aggravate the volatility of the spot market, implying that after the launch of the shanghai crude oil futures contract, the high volatility state of the financial cycle won’t aggravate the fluctuation of spot market any more . Furthermore, model (4) includes the variable *Launch* F_cycle* , the coefficient of interaction term is significantly positive, meaning that the launch of Shanghai crude oil futures plays a positive role during the process of the financial cycle exacerbating the spot market volatility. Under the high fluctuation state of financial cycle, social capital flows more frequently, and the introduction of Shanghai crude oil futures contract is helpful for traders to carry out long/short trading more conveniently, thus exacerbating the fluctuation of crude oil price (Simpson and Ireland,1985).

Table 7. The Regression Results of Oil Futures Contract Introduction and Financial Cycle Risk on the Stability of Spot Market.

	(1)	(2)	(3)	(4)
Launch	-0.0650**		-0.0556*	-0.1049**
	(0.0274)		(0.0299)	(0.0421)
F_cycle		0.0442**	0.0289	-0.0177

		(0.0224)	(0.0257)	(0.0331)
*Launch**				0.1763**
F_cycle				(0.0846)
Exchge	-0.0107	-0.4544	-0.1232	-0.0916
	(0.3245)	(0.2939)	(0.3569)	(0.4015)
R_WTI	0.0291***	0.0323***	0.0303***	0.0326***
	(0.0072)	(0.0073)	(0.0073)	(0.0074)
$Week_{1t}$	0.4285***	0.4455***	0.4462***	0.3892**
	(0.1656)	(0.1690)	(0.1686)	(0.1693)
$Week_{2t}$	-0.0156	-0.0251	-0.0155	-0.0378
	(0.1456)	(0.1447)	(0.1457)	(0.1459)
$Week_{3t}$	0.2743**	0.2781**	0.2798**	0.2504**
	(0.1241)	(0.1243)	(0.1253)	(0.1273)
$Week_{4t}$	0.6380***	0.6449***	0.6468***	0.6075***
	(0.1763)	(0.1770)	(0.1773)	(0.1818)

4.3. Market investors and Financial cycle

The above research proves that the launch of crude oil futures market can effectively alleviate the fluctuation of crude oil price. This paper will further study the internal mechanism of futures market affecting the spot market. The behaviour of different types of traders in the futures market may be one of the micro causes of influencing the spot market. We introduce agent variables of different trading behaviour of crude oil futures participants into the model, and add the interaction term combined with financial cycle and trader behaviour variables to examine the effect of trader behaviour on crude oil price fluctuations on different financial cycle fluctuations state. The variance equation is set as follows:

High volatility state of the financial cycle:

$$\ln({\sigma_t}^2) = \omega + \lambda_1 \ln({\sigma_t}^2) + \lambda_2 \left|\frac{\mu_{t-1}}{\sigma_{t-1}}\right| + \lambda_3 \frac{\mu_{t-1}}{\sigma_{t-1}} + \sum_1^4 \theta_1 Week_{it} + \theta_2 Exchge + \theta_3 R\_WTI + \varphi_1 Hed_t + \varphi_2 Spe_t + \tau Hed_t * F\_cycle_t \quad (9)$$

Low volatility state of the financial cycle：

$$\ln({\sigma_t}^2) = \omega + \lambda_1 \ln({\sigma_t}^2) + \lambda_2 \left|\frac{\mu_{t-1}}{\sigma_{t-1}}\right| + \lambda_3 \frac{\mu_{t-1}}{\sigma_{t-1}} + \sum_1^4 \theta_1 Week_{it} + \theta_2 Exchge + \theta_3 R\_WTI + \varphi_1 Hed_t + \varphi_2 Spe_t + \tau Hed_t * (1 - F_{{cycle}_t}) \quad (10)$$

The core explanatory variable regression results are reported in table 8. The coefficient of hedging variable of crude oil futures is significantly negative in regression results of model (5) to (6), which indicates that the hedging transaction of crude oil futures inhibits the fluctuation of crude oil spot market. On the contrary, the regression results obtained from model (6) to (10) shows that the coefficient of speculative trading of crude oil futures is significantly positive, which indicates that the speculative trading of crude oil futures increases the fluctuation of crude oil price. These conclusions are consistent with the study of Etienne and Irwin (2015), saying that speculative trading is a kind of noise in futures market, which will create bubbles in the spot market so that increases the volatility of crude oil price.

Models (7) and (8) introduce the interaction terms of high volatility financial cycle and agent variables of hedging and speculation, respectively. The results show that the interaction term coefficient between the hedging and the high volatility financial cycle is significantly positive, indicating that the stabilization effect of hedging behaviour on the fluctuation of crude oil price is restrained. Nevertheless, interaction term coefficient between the speculation and the high volatility financial cycle is positive and significant at 1% level, which means that the high fluctuation state of the financial cycle intensifies the influence of speculative trading on the fluctuation of the spot market, and the market speculation is more active under the high fluctuation state. Models (9) and (10) introduce the interaction terms of low volatility financial cycle and agent variables of hedging and speculation, respectively. The interaction term coefficient between the hedging and the low volatility financial cycle is significantly negative and the interaction term coefficient between the speculation and the low volatility financial cycle is negative as well as. On the low fluctuation state of the financial cycle, volatility of futures prices does not provide investors with sufficient opportunities for speculation so that investors prefer hedging to speculative trading. As a result, the effect of hedging trading on the stability of spot market volatility is more significant. On the high fluctuation state of financial cycle, the activity of social capital flow is enhanced, and the market speculators occupy the dominant position. The speculators adjust their positions frequently, thus exacerbating the price fluctuation in the crude oil market.

Table 8. Regression of the impact of crude oil futures traders and financial cycles on spot market stability.

	(5)	(6)	(7)	(8)	(9)	(10)
Hed	-0.0061**	-0.1826*	-0.3281	-0.3127	-0.2361	-0.3126
	(0.0026)	(0.0974)	(0.3019)	(0.3006)	(0.2996)	(0.3006)
Spe		0.1472*	0.7372***	0.7249***	0.7373***	0.7995***
		(0.0814)	(0.2326)	(0.2329)	(0.2326)	(0.2278)
*Hed*F_cycle*			0.0920***			
			(0.0322)			
Spe F_cycle*				0.0745***		
				(0.0265)		
Hed(1-F_cycle)*					-0.0920***	
					(0.0322)	
Spe (1-F_cycle)*						-0.0745***
						(0.0265)
Exchge	-0.0136	-0.0936	1.6000	1.6561	1.5999	1.6573
	(0.3247)	(0.3585)	(3.4194)	(3.4181)	(3.4194)	(3.4183)
R_WTI	0.0290***	0.0337***	0.0678***	0.0666***	0.0678***	0.0666***
	(0.0072)	(0.0077)	(0.0190)	(0.0190)	(0.0190)	(0.0190)
$Week_{1t}$	0.4277**	0.4141**	0.1288	0.1299	0.1288	0.1302
	(0.1655)	(0.1639)	(0.2835)	(0.2836)	(0.2836)	(0.2837)
$Week_{2t}$	-0.0166	-0.0154	-0.0928	-0.0886	-0.0929	-0.0883
	(0.1456)	(0.1460)	(0.2893)	(0.2883)	(0.2894)	(0.2883)

$Week_{3t}$	0.2736**	0.2451**	-0.0113	-0.0101	-0.0112	-0.0099
	(0.1240)	(0.1240)	(0.2692)	(0.2691)	(0.2692)	(0.2691)
$Week_{4t}$	0.6375***	0.6131***	-0.0231	-0.0232	-0.0231	-0.0231
	(0.1763)	(0.1781)	(0.2022)	(0.2026)	(0.2022)	(0.2026)

4.4. Robustness Test

In this paper we mainly carry on the robustness test by using other similar empirical methodology, changing the core agent and controlled variables, changing the sample interval and so on. Firstly, we conducted the Common Weighted Factor (CFW) of Gonzalo and Granger (1996) (Appendix 1). and received the same results as Hasbrouck measure that the Chinese crude oil spot market contributes more than Shanghai crude oil futures market in the price discoverySecondly, the controlled variable logarithmic yield of WTI crude oil futures are replaced by logarithmic yield of Brent crude oil futures(Appendix 2), and the outcome of the analysis is exactly like the previous case: the spot price leads the futures price, and the crude oil futures can play a stabilizing role of the spot market price. In addition, we also tried to change the selection of speculative agent variables and hedging agent variables. We take the ratio of turnover volume and position volume as a speculative index and unpredictable position volume as a hedging index to investigate the influence of investors' trading behaviour on spot fluctuation in futures market (Appendix 3). The results show that the coefficient of speculation agent variable is significantly positive, and the coefficient of hedging agent variable is significantly negative, which is consistent with the results of the previous argument. Therefore, the previous conclusions are robust. As the financial cycle fluctuation variable is an important variable of this study, we change the period of the sample (credit, credit / GDP, national housing boom index, M2) which was used to compose the financial cycle fluctuation variable. Although the time span has been reduced from 20 to 10 years(Appendix 4), the obtained financial cycle fluctuation state is roughly similar In summary, the conclusions of this study are robust.

5. Conclusions and Policy Implications

In this paper, we provide a comprehensive empirical analysis on the efficiency of Shanghai crude oil futures market based on price discovery and stabilization. We take Shanghai crude oil futures and Daqing crude oil spot as the main research subjects and apply information share model and EGARCH model. Given that crude oil price is also affected by the financial cycle risk, we constructed financial cycle volatility variable by the method of Borio (2014)and added it into the study to explore the effect of crude oil futures on the spot market in terms of stability under the framework of financial cycle fluctuation. Moreover, we discussed the traders' behaviour during the process of price discovery and stabilization and compared their different influences on the different financial volatility state (high and low).

This study contributes to the literature on relationships between the spot and futures markets in several ways. In particular, the empirical evidence shows that by the end of 2019, there was a uni-directional relationship between Shanghai crude oil futures market and spot market. The spot market contributes more in the progress of price discovery which is consistent with the results of Yan (2019) who utilize the Shanghai

Crude oil futures and Oman crude oil spot as the research subjects. To be specific, the price discovery function of Shanghai crude oil futures to market needs to be further improved. However, as explained by Kawaller et al.(1998), the lead or lag relationship between futures and spot market will change at any time point depending on market participants' perception of new information.

Additionally, Shanghai crude oil futures can play a stabilizing role in the spot market since its introduction. Taken the financial cycle volatility risk into consideration, results imply that high volatility in the financial cycle can exacerbate volatility in the crude oil spot market and futures trading enhances the impact of the financial cycle on spot price volatility. That is because the launch of crude oil futures provides a more convenient trading context for traders involved in the oil market. Traders' behaviour is a very important factor that influence the futures market and consequently helps to stabilize the spot market (Bohl and Salm,2011). Our work also proves this view in the case of Shanghai Crude oil futures. Speculation in futures market will increase the price volatility of spot market as oppose to hedging. In other words, Shanghai crude oil futures stabilize the spot market by trader's trading behaviours. On the high volatility state of the financial cycle, the market sentiment is high and the social capital flows more frequently. Consequently, the speculative trading becomes more dominant than the hedging trading in the futures market and subsequently the effect of hedging on oil price volatility would be restrained. In contrast, on the low volatility state of the financial cycle, hedging can play a better role in stabilizing spot prices.

These conclusions, apart from offering a much better understanding of the operating efficiency of Shanghai crude oil futures market, may have important implications for helping the regulators to optimize the design of futures contract in Shanghai Crude oil futures and guide them to take different market supervision measures on traders' behaviours under different financial cycles. For example, they may be useful in future research to quantify the influence of the trader structure in futures market. Of course, there are also some limitations in our empirical analysis. When we study the Shanghai Crude Oil market, we just limit it in the context of China. In fact, all international oil prices will also play very important roles in the price discovery process. Additionally, there are lots of other ways to establish the indicator of financial cycle. Our focus was the credit index which could indicate the market vitality. We suppose that with application of various methods of measuring financial cycle, the performance of futures markets will bring more information for policy makers.An interesting subject for future research is the difference of price relationship between Shanghai and other international crude oil futures markets. As presented, on different states of financial cycle, different trader behaviours in futures market play different roles in stabilizing the spot price. Therefore, during the process of the price discovery and stabilization, more factors can be taken into consideration to make the research more comprehensive and objective. In addition, we could also think about the possibility of the significant IS variations along the trading day. For example, the price contributions of the spot market at the end of the day may be higher than those of the Shanghai futures market because the spot market is far more liquid, which needs to be proven further.

Appendix

Appendix 1. Common Weighted Factor model information share for international crude oil markets

	lag.max=120	lag.max=60
Futures market	0.3905452	0.2223949
Spot Market	0.6094548	0.7776051

Appendix 2. Robustness Test of Price stabilization of Shanghai Crude oil futures

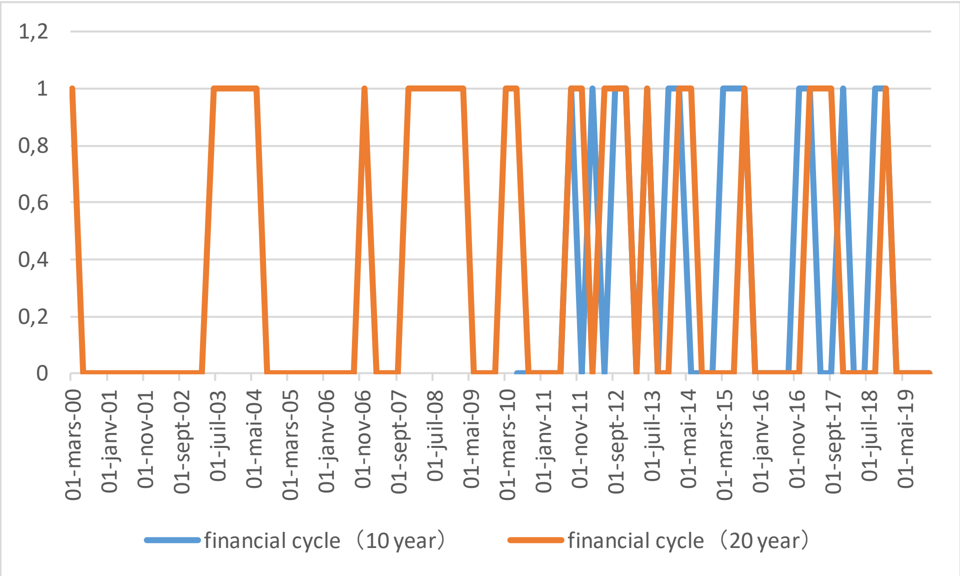
	(1)	(2)	(3)	(4)
Launch	-0.0644606** (0.0267221)		-0.0559221* (0.0289676)	-0.103885** (0.0412919)
F_cycle		0.0414482** (0.0216896)	0.0263981 (0.0249362)	-0.0174925 (0.0319904)
Launch *F_cycle*				0.1647225** (0.0833196)
Exchge	-0.0185101 (0.3172782)	-0.4509811 (0.2901479)	-0.1236757 (0.3494434)	-0.1016106 (0.3931513)
R_Brent	0.0234548*** (0.0074762)	0.0266844 *** (0.0074905)	0.0245306*** (0.0075449)	0.0250495*** (0.007604)

$Week_{1t}$	0.4399853*** (0.1635043)	0.4572123*** (0.1668569)	0.4583608 *** (0.1660583)	0.4035538 ** (0.1655194)
$Week_{2t}$	-0.0084923 (0.1474445)	-0.0141807 (0.1464662)	-0.0077248 (0.1476184)	-0.0303418 (0.1476457)
$Week_{3t}$	0.2776036** (0.1232661)	0.2800268** (0.1232066)	0.2830073 ** (0.1241306)	0.2555247 ** (0.1257145)
$Week_{4t}$	0.6509468 *** (0.1740184)	0.6593233 *** (0.1738974)	0.6598697 *** (0.1745773)	0.6237383*** (0.1784601)

Appendix 3. Robustness Test of the impact of crude oil futures traders and financial cycles on spot market stability

	(5)	(6)	(7)	(8)	(9)
Hed (unpredictable position volume)	-0.0223317 *** (0.0073601)		-0.0003216 (0.0308847)	- 0.0258338 (.0372755)	-0.0032565 (0.0340254)
Spe (turnover volume /position volume)		0.1256507 *** (0.0256121)	0.1256586 *** (0.0257041)	0.1289903 *** (0.029447)	0.1003626 *** (0.0291609)
*Hed*F_cycle*				0.1259324 *** (0.1422938)	
Spe F_cycle*					0.0460369 ** (0.0240779)

Appendix 4. Different time span to construct Financial cycle



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Declaration of interest

Declarations of interest: none

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