Research on The Volatility of Crude Oil Futures and Portfolio Decision In China: Based on The Perspective of Crude Oil Industry Chain

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Abstract—Each link of the industrial chain is closely connected, and its upstream and downstream through a variety of price fluctuation transmission paths, showing spillover effects. Perspective based on the crude oil industry chain in China's oil futures market price fluctuations conduction effect as the research subject, by VAR model, the empirical analysis in almost three years in Chinese crude oil futures market, WTI crude oil futures market, and asphalt, polypropylene, purified terephthalic acid industry chain downstream the three mean spillover effect between the futures market. The conclusions of this study show that: Firstly, WTI price fluctuation has a positive transmission effect on INE; Secondly, WTI oil futures market yield has a significant positive transmission effect on the downstream markets of the three industrial chains; Third, the downstream markets of the three industrial chains have extremely weak transmission effects with different positive and negative directions.

Keywords—Crude oil futures, The industrial chain, Spillover effect, The VAR model

1. Introduction

The dynamic relationship between oil price volatility and other financial markets has been well studied. However, from the perspective of industry chain, to study the spillover effects of crude oil futures market in China is a new Angle of view, this article considers the crude oil futures market, WTI crude oil futures market in China and downstream of the industrial chain of crude oil futures market in our country, based on crude oil industry chain under the perspective of China's oil futures market research to provide a more comprehensive research train of thought.

For crude oil, crude oil futures market at home and abroad industry chain downstream effects of futures market price volatility transmission between the in-depth study has important practical significance, can further improve the domestic futures, spot market management and trading mechanism, and to enhance the overall efficiency of the industrial chain of crude oil futures market in China has important reference value and significance.

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2. Theoretical Foundation and Literature Review

2.1 Study on the transmission effect of price fluctuation among different oil markets

Hou Yiru and Wang Lun et al. (2021) [1] studied the price data of the INE, WTI and Brent crude oil futures markets, constructed BEKK-GARCH model to study the price causality and spillover effect among the three crude oil futures markets. It is found that the price of WTI and Brent crude oil futures is an important factor affecting the price of INE crude oil futures. Wang Liang and Li Bishao et al. (2021) [2] used the BEKK-MGARCH model to study the price volatility spillover effect and its persistence between Chinese crude oil futures and international crude oil futures, and found that there was a significant and continuous two-way information transmission phenomenon between INE, WTI and Brent, and GARCH volatility spillover was the main one.By combining theory and demonstration, Meng Yanli (2020)[3] constructed the BEKK-GARCH model VAR model, and analyzed the mean value and volatility spillover effect among INE, the international benchmark crude oil futures market represented by WTI and the downstream futures market of the crude oil industry chain. It is found that Chinese crude oil futures market has initially had the function of price discovery and conducted a certain transmission to the downstream futures market through cost transmission/demand pulling.

2.2 Study on the internal relationship between crude oil futures and other financial markets

Zou Wenhui and Chen Yanzhen(2022)[4]constructed a time-varying Copula-CoES model to study the interdependence and extreme risk spillover between Shanghai crude oil futures and six major Asian stock markets before and after the epidemic. The study found that the correlation between Shanghai crude oil futures and Asian stock markets was weak, but stronger than that between WTI/Brent and Asian stock markets, and the correlation between the two increased after the epidemic.Based on the monthly data of the US Federal funds rate and the WTI crude oil futures price index from January 2016 to January 2022, Ma Xiaoqing(2022)[5] constructed the bivariate VAR (2) model and empironally analyzed the relationship between the changes of the US federal funds rate and the WTI crude oil futures price by using the Johansen co-integration test, impulse response and variance decomposition.Zhang Dayong and Ji Qiang (2018)[6] made a pioneering quantitative analysis of the risk spillover relationship between INE and international benchmark crude oil, RMB exchange rate and Shanghai Stock Index , and found that China's crude oil futures were closely related to the information of international benchmark crude oil, but relatively weakly related to the stock market and exchange rate market.

3. Research Design

3.1 Data Selection and Processing

This paper uses the Flush Financial data terminal to select the closing price data of daily INE, WTI, asphalt, polypropylene PP, refined terephthalic acid PTA futures price index in the time span from March 26, 2018 to March 26, 2022. To a certain extent, it avoids the influence of large price fluctuations caused by the replacement of the main contract, and the daily data can reflect the relationship between variables more accurately than the monthly/quarterly data. Secondly, in order to ensure the validity of the five groups of time series samples, the data with

inconsistent dates and no transactions or unqualified data were removed, and the 730-day valid sample data were finally obtained, and the above five groups of series were approximately regarded as continuous time series. Due to financial market price data, the frequency range is small, at the same time in order to eliminate the phenomenon of different variance of financial time series to observation data more smooth, eliminate multicollinearity and heteroscedastic sample data error problem, in this paper, the groups of data are difference treatment, after taking logarithm yield on behalf of the five group of returns on the market.

$$R_{i,t} = \ln\left(\frac{P_{i,t}}{P_{i,t-1}}\right) = \ln(P_{i,t}) - \ln(P_{i,t-1}) \quad (1)$$

In the above equation (1), i is 1,2,3,4,5 to represent INE, WTI, asphalt, polypropylene PP and refined terephthalic acid PTA futures market respectively; t is denoted as time, representing the time sequence of the sample; $P_{i,t}$ (i= 1,2,3,4,5) respectively represent the specific values corresponding to INE, WTI, asphalt, polypropylene PP and refined terephthalic acid PTA futures prices; $R_{i,t}$(i=1,2,3,4,5) represents the return rate of the futures market after the logarithmic difference of the five markets, To facilitate the distinction, R_{INE}, R_{WTI}, R_{LQ}, R_{PP} and R_{PTA} represent the return rate of crude oil futures market, WTI crude oil futures market, asphalt futures market, polypropylene PP futures market and refined terephthalic acid PTA futures market respectively.

3.2 Descriptive Statistics of Correlated Series Return

Table 1 Descriptive statistical results of time series of returns in different futures markets

	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
Mean	0.000138	0.000145	2.62E-05	-8.56E-05	-9.22E-05
Median	0.000755	0.000852	-0.00012	0.000600	0.001345
Maximum	0.107584	0.109001	0.067065	0.063779	0.202137
Minimum	-0.11202	-0.10502	-0.08507	-0.07336	-0.48790
Std.Dev	0.024083	0.021401	0.013249	0.016000	0.039520
Skewness	-0.08981	-0.01625	-0.19124	-0.23278	-3.21050
Kurtosis	5.632165	6.698792	8.792443	5.285480	46.68185

According to the statistics in Table 1 above, the mean values of the five groups of variables R_{INE}, R_{WTI}, R_{LQ}, R_{PP} and R_{PTA} are all close to 0. It can be seen that the market returns of the five groups of variables fluctuate around the mean value. Look from the standard deviation, purified terephthalic acid PTA futures market yields most volatile, fine and WTI crude oil futures market return volatility are larger, polypropylene PP futures market yields the volatility of The Times, minimum yield fluctuation, asphalt LQ futures market shows the PTA, fine, WTI these three crude oil futures market data discrete, the risk is bigger, The market data of polypropylene PP and asphalt LQ futures are relatively stable and the risk is small. In terms of skewness, the skewness coefficients of the five groups of variables were all less than 0, with negative deviation, showing the statistical characteristics of left-skewed distribution (left tail curve lengthening). In terms of kurtosis, the kurtosis coefficients of the five groups of variables are all greater than 3, indicating that they all have significant statistical characteristics of "sharp peaks and

thick tails". In addition, the J-B test statistics of the five groups of variables are all much higher than 3, which further rejects the null hypothesis that the sample variables obey normal distribution, that is, the five groups of time series variables do not conform to the characteristics of normal distribution.

4. Empirical Test and Model Construction

4.1 ADF Unit Root Stationarity Test

To avoid spurious regression, testing the stationarity of data (i.e., whether there is a unit root in time series) is the basis for establishing VAR model. In this paper, the ADF unit root test is used for empirical analysis through the statistical software Eviews10.0. The test results are shown in Table 2:

Table 2 Unit root ADF test results

variable	*ADF test t value*	*10% level*	*5% level*	*1% level*	*Results*
R_{INE}	-25.3371	-1.61640	-1.94125	-2.56813	steady
R_{WTI}	-29.2801	-1.61640	-1.94125	-2.56813	steady
R_{LQ}	-24.9296	-1.61640	-1.94125	-2.56813	steady
R_{PP}	-25.6511	-1.61640	-1.94125	-2.56813	steady
R_{PTA}	-24.7052	-1.61640	-1.94125	-2.56813	steady

As can be seen from Table 2, the t values of ADF test of R_{INE}, R_{WTI}, R_{LQ}, R_{PP} and R_{PTA} five groups of price index time series are -25.3371, -29.2801, -24.9296, -25.6511, -24.7052, respectively. All of them are less than the critical level of 1%, 5% and 10%, indicating that the five series of R_{INE}, R_{WTI}, R_{LQ}, R_{PP} and R_{PTA} are stationary, which can reject the null hypothesis that the time series is stationary.

4.2 Determination of Lag Order

In this paper, the VAR model of yield series of INE, WTI, asphalt, polypropylene PP and refined terephthalic acid PTA futures market is established as follows:

$$Y_t = \mu + \prod_1 Y_{t-1} + \prod_2 Y_{t-2} + \ldots\ldots + \prod_n Y_{t-n} + u_t,\ u_t \sim IID(0,\ \Omega) \tag{2}$$

In the above equation (2), Y_t represents the column vector of order n*1, $\boldsymbol{\mu}$ represents the column vector of constant term of order n*1, $\prod_n$ represents the parameter matrix of order n*n, and u_t represents the error vector (there is no autocorrelation). The mean value of the error term is zero, and the covariance matrix is a positive definite matrix of n*n. In order to determine the optimal lag order of VAR model, "majority principle" can be adopted. If more than half of the selection criteria (LR, FPE, AIC, SC, HQ criteria) point to the same lag period, the lag can be selected as the optimal lag order. Therefore, the first-order lag period is selected as the optimal model expression.

Table 3 Table of selection criteria for lag order of VAR model

Lag	*LogL*	*LR*	*FPE*	*AIC*	*SC*	*HQ*
0	9370.4	NA	4.45e	-25.764	-25.733	-25.75*
1	9389.6	38.136	4.52e*	-25.77*	-25.85*	-25.675
2	9407.4	34.994	4.61e	-25.728	-25.381	-25.594
3	9431.1	46.30*	4.63e	-25.725	-25.220	-25.530
4	9449.8	36.335	4.71e	-25.707	-25.045	-25.452

4.3 Establishment of VAR Model

According to the previous determination of the optimal lag order of the VAR model, the VAR (1) model with lag order 1 is established for estimation, and the estimation results are as follows:

Table 4 VAR (1) model estimation result

	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
R_{INE} (-1)	-0.01264 (0.0531) [-0.2376]	0.17743 (0.0871) [2.0352]	0.001214 (0.04734) [0.0256]	-0.038240 (0.02932) [-1.3044]	-0.038141 (0.03522) [-1.0829]
R_{WTI} (-1)	0.03034 (0.0225) [19.3]***	-0.08156 (0.0370) [-2.2043]	0.015316 (0.02009) [9.76]***	0.015548 (0.01244) [3.24]***	0.006730 (0.01495) [6.45]***
R_{LQ} (-1)	0.10700 (0.0647) [-1.652]*	-0.11927 (0.10616) [-1.1236]	0.061612 (0.05765) [1.06874]	0.034201 (0.03570) [0.95809]	0.028817 (0.04289) [0.67193]
R_{PP} (-1)	0.016840 (0.0784) [0.2147]	0.055485 (0.12850) [0.4317]	0.096698 (0.06978) [1.38568]	0.064890 (0.04321) [1.50170]	0.127127 (0.05191) [2.44875]
R_{PTA} (-1)	0.00862 (0.0720) [0.1197]	0.034251 (0.11811) [0.2900]	-0.046628 (0.06414) [-0.7269]	-0.025512 (0.03971) [-0.6423]	0.048596 (0.04771) [2.018]**
R_{INE} (-1)	0.00013 (0.0008) [0.1541]	-0.00010 (0.00146) [-0.0734]	0.000137 (0.00079) [0.17301]	2.58E-05 (0.00049) [0.05261]	-7.97E-05 (0.00059) [-0.1353]
R_{WTI} (-1)	0.00862 (0.0720) [0.1197]	0.034251 (0.11811) [0.2900]	-0.046628 (0.06414) [-0.7269]	-0.025512 (0.03971) [-0.6423]	0.048596 (0.04771) [2.018]**
C	0.00013 (0.0008) [0.1541]	-0.00010 (0.00146) [-0.0734]	0.000137 (0.00079) [0.1730]	2.58E-05 (0.00049) [0.05261]	-7.97E-05 (0.00059) [-0.1353]

Note: Standard errors in ( ) & t-statistics in [ ]

From the analysis of empirical results of the VAR (1) model in Table 4, it can be concluded that:

- the yield of crude oil futures market in China lag WTI crude oil futures market is affected significantly, suggesting that China's oil futures market has with the international crude oil market, but because of the crude oil futures market in China is in a relatively passive disadvantage,

inevitably under international benchmark crude futures market earnings changes produce certain impact; At the same time, the asphalt futures market has a certain negative impact on the downstream futures varieties, and the other futures markets have no significant impact.

- Represented by asphalt futures, polypropylene PP futures and refined terephthalic acid PTA futures market, the return rate of Chinese crude oil downstream futures market was positively affected by WTI lag period return rate, but not significantly affected by the return rate of Chinese crude oil futures market, which indicated that, to some extent, Our crude oil futures market's industry depth and its close degree with downstream futures market are still not mature, and our crude oil futures have not shown its core role in the whole downstream industry chain price conduction system.

However, VAR model only indirectly affects some financial indicators. Therefore, it is necessary to further study this problem by combining Granger causality test impulse response function and variance decomposition.

4.4 Stationarity Test

The AR root diagram of the stationarity test result of VAR model is shown in Fig. 1. The reciprocal of all root modes is less than 1 in the unit circle, indicating that the VAR model constructed in this paper is relatively stable.

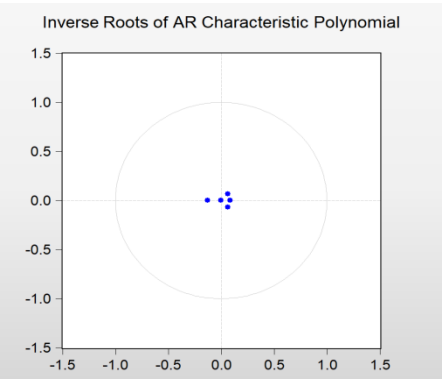

Fig. 1. Unit circle test

4.5 Granger Causality Test

Considering that VAR model itself does not focus on distinguishing the direction or degree of mutual guidance among economic variables, Therefore, this paper will adopt Granger causality test to explore the "causal relationship" between the yield series of INE crude oil futures market, WTI crude oil futures market, asphalt futures market, polypropylene PP futures market and refined terephthalic acid PTA futures market.

Granger causality test is based on the theory of statistical method with variable sample data to estimate the stationary time series data between variables, the test results only represent statistical sense "granger causality", doesn't mean the inevitable cause-and-effect relationship between economic variables, nor as determined or block according to the causal relationship be-

tween variables, therefore, Granger causality test is often used in the empirical analysis of financial time series. The test requires the mathematical expression of the estimated regression as follows:

$$y_t = \sum_{i=1}^{p} \lambda_i y_{t-i} + \sum_{j=1}^{q} \eta_j x_{t-j} + u_{1t} \quad (3)$$

$$x_t = \sum_{i=1}^{p} \alpha_i x_{t-i} + \sum_{j=1}^{q} \beta_j y_{t-j} + u_{2t} \quad (4)$$

In the above equations(3) and (4), Y_t and X_t respectively represent the current value of variable y and variable x, λ_i, η_j, α_i and β_j represent the regression coefficient, X_{t-i} and Y_{t-j} respectively represent the lag i and j order values of variables x and y, U_{1t} and U_{2t} represent the error term.

Table 5 Granger causality test results

Number	***Null Hypothesis:***	***Obs***	***F.Statistic***	***Prob.***	***Results***
1	WTI does not Granger CauseINE	730	4.38628	0.036	reject
2	INE does not Granger CauseWTI		2.04047	0.151	not reject
3	LQ does not Granger Cause INE	730	3.99272	0.646	not reject
4	INE does not Granger Cause LQ		0.00077	0.977	not reject
5	PP does not Granger Cause INE	730	0.67327	0.4122	not reject
6	INE does not Granger Cause PP		1.35789	0.244	not reject
7	PTA does not Granger CauseINE	730	0.67888	0.410	not reject
8	INE does not Granger CausePTA		0.12633	0.722	not reject
9	LQ does not Granger CauseWTI	730	0.60568	0.436	not reject
10	WTI does not Granger Cause LQ		0.56630	0.042	reject
11	PP does not Granger CauseWTI	730	0.91460	0.3392	not reject
12	WTI does not Granger Cause PP		1.60200	0.026	reject
13	PTA does not GrangerCauseWTI	730	1.27667	0.258	not reject
14	WTI does not GrangerCausePTA		0.21218	0.045	reject
15	PP does not Granger Cause LQ	730	1.50320	0.220	not reject
16	LQ does not Granger Cause PP		0.00657	0.935	not reject
17	PTA does not Granger Cause LQ	730	0.18904	0.663	not reject
18	LQ does not Granger CausePTA		0.69576	0.404	not reject
19	PTA does not Granger Cause PP	730	0.75551	0.385	not reject
20	PP does not Granger CausePTA		6.53302	0.210	not reject

By analyzing the results of Granger causality test in Table 5 above, it can be concluded that:

- As can be seen from sequence number 1 and 2, In terms of the relationship between WTI and INE, the mean spillover effect between INE and WTI has a certain asymmetry. The return rate of WTI crude oil futures market is the unidirectional granger cause of the return rate of INE in our crude oil futures market, and the change of WTI return rate to the change of INE return rate is unidirectional. The fine oil futures market is still in the receiver information, China's oil futures

market price fluctuations of WTI futures market yields no impact to guide, to further reveal the WTI crude oil futures market accounted for a dominant position in the global crude oil futures market, China's crude oil pricing power no significant impact on the international crude oil futures market, The discourse power of Chinese crude oil is still in a disadvantageous position, which has no strong effect on the price interaction of international crude oil futures market.

- As can be seen from the serial number 3 to 8, the fine and the relationship between the downstream of the futures market in China, at present, China's oil futures market and the downstream no significant interactions between the futures market, crude oil futures market in China for the yield of the futures market guide weaker downstream, further illustrate oil futures is still at the stage of development in our country, crude oil futures market is not mature enough, It has little influence on the downstream futures of the industrial chain.

- As can be seen from the sequence number 9 to 14 that the relationship between WTI and Chinese downstream futures market shows that the rate of return of WTI crude oil futures market is Granger cause of our downstream futures market at present, and it shows that WTI crude oil futures market is the main reason to guide the trend of yield of main chemical industry futures market in China. However, INE does not play an obvious role in guiding the yield of crude oil downstream futures market, which further highlights the pivotal position of WTI in the global crude oil futures market.

- As can be seen from the serial number 15 to 20, the three kinds of crude oil in terms of the relationship between the industry chain downstream of the futures market, shows that industry chain downstream of the three kinds of futures market yields between horizontal is not each other, the granger cause of influence was not significant between each other, that the industry chain downstream weak link between futures market in our country, between the industry chain downstream transverse correlation degree is low, The industrial chain still needs to be further improved.

In conclusion, there is unidirectional Granger causality between WTI return rate and INE return rate, and the return rate of WTI crude oil futures market is also the unidirectional Granger cause among the downstream markets of asphalt futures, polypropylene PP futures and refined terephthalic acid PTA futures. This suggests that in the international crude oil futures market in China is still in a relatively weak disadvantage, crude oil futures market in China through their own futures yield changes have a significant impact on the international crude oil futures market, and to some extent, reflects the maturity of crude oil futures market in China is low, the price weathervane effect is not obvious, for downstream futures varieties of guide is not significant.

4.6 Impulse Response Function Analysis

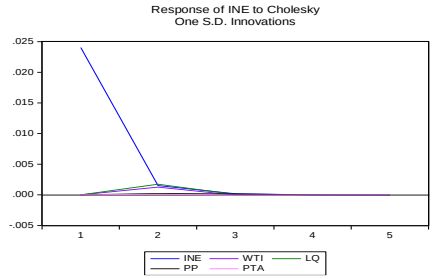

Fig. 2. INE impulse response analysis diagram

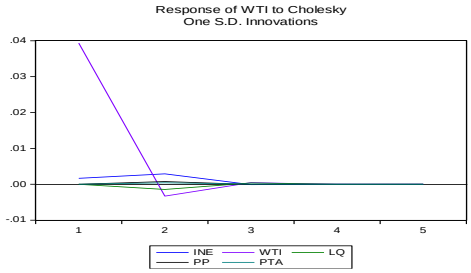

Fig3. WTI impulse response analysis diagram

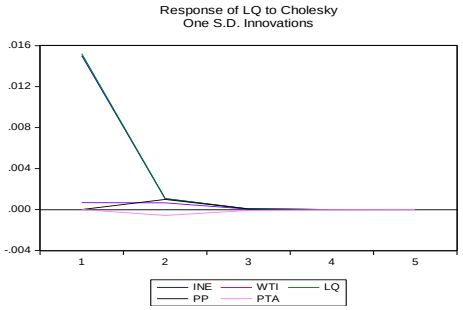

Fig4. LQ impulse response analysis diagram

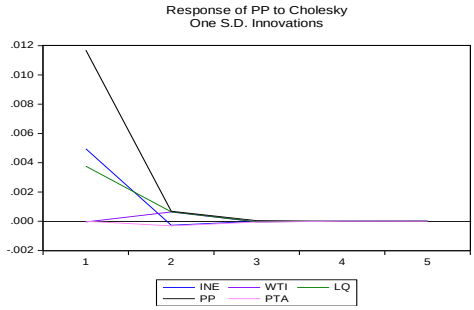

Fig5. PP impulse response analysis diagram

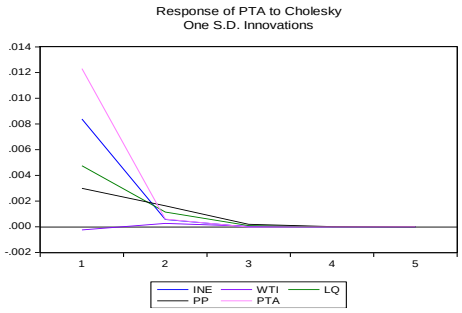

Fig6. PTA impulse response analysis diagram

To sum up, all five groups of variables have the largest impact on themselves, and all of them are under the strongest positive impact in the first period, and tend to zero after reaching stability in the third period. It indicates that the impact of variable changes on itself is positive and can generally last until the third day, and tends to zero after the third period, that is to say, the impact gradually disappears after the third period.

- On the relationship between WTI and INE, WTI has a positive effect on the yield of INE in Chinese crude oil futures market.

- For the relationship between INE and our country downstream futures market, INE has a slight positive conduction effect to our country downstream futures market.

- The relationship between WTI and our country's downstream futures market has a significant positive conduction effect.

- For the relationship between the downstream futures markets of the three crude oil industry chain, there is a very weak transmission effect between each other, and the positive and negative directions are not necessarily.

In general, the influence of the above pulses on VAR (1) model will disappear with the passage of time, thus indicating that the VAR (1) model constructed in this paper is stable.

4.7 Variance Decomposition

Variance decomposition is used to obtain the importance of the impact of different structural shocks from a quantitative perspective (percentage). The main purpose of variance decomposition is to analyze the contribution degree of endogenous variables to the forecast variance.

Table 6 INE variance decomposition results

Period	***S.E.***	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
1	0.02403	100.000	0.00000	0.00000	0.00000	0.00000
2	0.02418	55.2034	43.2729	0.51315	0.00848	0.00192
3	0.02418	55.1981	43.2731	0.51394	0.01242	0.00235
4	0.02418	55.1980	43.2731	0.51399	0.01242	0.00236
5	0.02418	55.1980	43.2731	0.51399	0.01242	0.00236
6	0.02418	55.1980	43.2731	0.51399	0.01242	0.00236
7	0.02418	55.1980	43.2731	0.51399	0.01242	0.00236

Table 7 WTI variance decomposition results

Period	***S.E.***	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
1	0.02403	10.1803	89.8196	0.00000	0.00000	0.00000
2	0.02418	10.7113	89.1092	0.13231	0.03586	0.01128
3	0.02418	10.7116	89.0998	0.14103	0.03599	0.01148
4	0.02418	10.7117	89.0996	0.14107	0.03605	0.01148
5	0.02418	10.7117	89.0996	0.14107	0.03605	0.01148
6	0.02418	10.7117	89.0996	0.14107	0.03605	0.01148
7	0.02418	10.7117	89.0996	0.14107	0.03605	0.01148

Table 8 LQ variance decomposition results

Period	***S.E.***	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
1	0.02403	18.0984	29.3377	50.5638	0.00000	0.00000
2	0.02418	18.1946	29.1529	50.3733	0.21297	0.07130
3	0.02418	18.1981	29.1515	50.3718	0.21382	0.07294
4	0.02418	18.1981	29.1515	50.3718	0.21382	0.07296
5	0.02418	18.1981	29.1515	50.3718	0.21382	0.07296

Period	*S.E.*	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
6	0.02418	18.1981	29.1515	50.3718	0.21382	0.07296
7	0.02418	18.1981	29.1515	50.3718	0.21382	0.07296

Table 9 PP variance decomposition results

Period	*S.E.*	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
1	0.02403	0.00111	13.9785	8.06262	77.9576	0.00000
2	0.02418	0.23140	13.9050	8.22992	77.5779	0.05570
3	0.02418	0.23242	13.9044	8.23043	77.5754	0.05727
4	0.02418	0.23244	13.9044	8.23042	77.5754	0.05728
5	0.02418	0.23244	13.9044	8.23042	77.5754	0.05728
6	0.02418	0.23244	13.9044	8.23042	77.5754	0.05728
7	0.02418	0.23244	13.9044	8.23042	77.5754	0.05728

Table 10 PTA variance decomposition results

Period	*S.E.*	R_{INE}	R_{WTI}	R_{LQ}	R_{PP}	R_{PTA}
1	0.02403	0.02407	27.7589	8.90356	3.52660	59.7868
2	0.02418	0.05118	27.3738	9.25060	4.49440	58.8299
3	0.02418	0.05187	27.3688	9.25222	4.50773	58.8192
4	0.02418	0.05187	27.3688	9.25222	4.50773	58.8192
5	0.02418	0.05187	27.3688	9.25222	4.50773	58.8192
6	0.02418	0.05187	27.3688	9.25222	4.50773	58.8192
7	0.02418	0.05187	27.3688	9.25222	4.50773	58.8192

Through the impulse response function and variance decomposition, we concluded that:

- First, the yield rate of crude oil futures market in China is more affected by itself and WTI international benchmark crude oil futures market, and with the increase of periods, the impact force is gradually weakened and tends to be stable.

- Second, the contribution of WTI crude oil futures market to the INE yield rate of our crude oil futures market is relatively large, reaching 43.2731%. Except for the WTI crude oil futures market, the contribution of the yield rate of our crude oil futures market to itself has been stable after the fourth period, reaching 55.1980%. However, the contribution of our crude oil downstream futures market to the rate of return of INE in our crude oil futures market tended to stabilize was very weak.

- Third, in the downstream futures market of the crude oil industry chain, asphalt futures market, polypropylene PP futures market and refined terephthalic acid PTA futures market all contribute the most, followed by WTI crude oil futures market, accounting for 29.1515%, 13.9044% and 27.3688% respectively.

5. Research Conclusion and Suggestion

5.1 Main Research Results

Based on the perspective of the crude oil industry chain, this paper takes the transmission effect of price fluctuations in the crude oil futures market as the research topic, and the mean spillover effect of the crude oil futures market to the downstream futures market as the empirical research object. Based on the VAR model, this paper conducts in-depth research and draws the following conclusions:

- First, WTI yield is the one-way Granger cause of INE yield change, but INE yield change has a small impact on the return of WTI crude oil futures market.
- Second, the mean spillover effect between INE and WTI is asymmetric to some extent. Further research shows that WTI yield changes have a one-way mean spillover effect on INE yield changes
- Third, the rate of return of Chinese crude oil futures market is not granger reason for the rate of return of asphalt futures, polypropylene PP futures, refined Purified terephthalic acid PTA futures market, but WTI crude oil futures market is granger reason for the changes of rate of return of varieties of Chinese crude oil downstream futures market.

5.2 Policy Suggestion

5.2.1 Suggestions for the development of Chinese crude oil futures market and industry chain related enterprises:

- First, relevant enterprises should actively assist the financial departments of the government to formulate more efficient monetary, financial and economic policies.
- Second, the crude oil futures market in our country emphasizes the plurality of main bodies and enhances the market activity.
- Third, Chinese crude oil futures market should continue to accelerate the reform, stimulate the market vitality, further optimize and improve trading rules and supporting facilities, accelerate the introduction of settlement price trading mechanism.

5.2.2 Relevant recommendations to the government:

- Firstly, the government should pay close attention to the impact of important global commodities on the overall economic development of China and guard against the sudden occurrence of financial risks.
- Second, we should actively develop new green alternative energy sources and reduce our dependence on crude oil. Due to the progress and development of social civilization, human beings have an increasingly urgent need for clean energy.

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