Study on the influence of international oil price on domestic oil price by APT-ECM

Ziyuan Liu¹,²,³, Yu Wang¹,²,⁴,⁵, Shiwei Xu¹,²,³,⁴, Shengwei Wang¹,²,³, Denghua Li¹,²,⁴ and Han Zhou¹,²,⁴

¹Agricultural Information Institute of CAAS, Beijing, 100081
²Beijing Agricultural Monitoring & Early Warning Engineering Technology Research Center, Beijing 100081
³Key Open Laboratory of Intelligent Agricultural Early Warning Technology & System of CAAS, Beijing 100081
⁴Key Laboratory of Agricultural Information Service Technology of the Ministry of Agricultural and Rural Affairs, Beijing 100081
⁵Corresponding author’s e-mail: wangyu06@caas.cn

Abstract. Based on the monthly data of soybean, soybean oil and soybean meal prices in China and the United States from 2006 to 2020, this paper applied the asymmetric error correction model (APT-ECM) to analyze the influence of international oil price on domestic oil price before and after Sino-US trade friction. The results show that: 1) the influence of international domestic soybean price on domestic soybean price is significant before and after Sino-US trade friction, while the influence of domestic price on international price is insignificant; 2) the impact of international soybean oil price on domestic soybean price is stable in the early stage but fluctuates evidently in the latter stage; 3) domestic soybean oil price is exposed to insignificant impact of international soybean oil price.

1. Introduction

Food safety constitutes the key for China to promote rural revitalization comprehensively and advance the modernization of agriculture and rural areas. Being the largest oil crop worldwide and the important source of plant protein, soybean plays an important role in China’s grain and oil system as well as in food safety, and is regarded as an important trade agricultural product of the world. Since the frequent trade frictions between China and the United States, as an important trade product between the two countries, soybean has been the focus of attention. Despite several policies promulgated by the Chinese government to revitalize domestic soybean industry, the current situation that China mainly relies on imported soybean will not be fundamentally changed in a short time. The bilateral trade between the United States and China, the two largest economies of the world, has been exposed to constant frictions. In 2017, the US National Security Strategy Report officially positioned China as the “strategic competitor” and a “revisionist state”, and launched “301 investigation” against China in August. From March to December 2018, the United States and China had imposed additional 25% tariffs on their exported products, with a trade volume of approximately USD 600 billion and 233 billion respectively. In June 2019, the US announced additional 25% punitive tariffs on a special list of commodities valued USD 300 billion [1]. In January 2020, the US and China officially signed the phase-1 economic and trade agreement to gradually exclude the procurement of the commodities on
which additional tariffs were imposed [2]. Since the agricultural product policy of the new Biden administration is still unknown, the future of soybean trade is still in the dark. The changes of the trade policies of the US and China exert significant influence on the prices of soybean, soybean oil and other oil products.

On one hand, only a few countries could satisfy China’s demand on soybean import, while the US has been one of the important exporters. Sino-US trade friction would result in the price rise of products in soybean-related industries [1]. Considering the market power in international trade, large trading countries have the power to influence international market price [3], and exert significant influence on the trade prices of soybean products in the international market [4]. They can guide the flow of agricultural product resources including soybean in the international market and therefore firmly control the international market prices of relevant oil products. However, according to some other studies, the narrower import channels will lead to the increase of the soybean oil cost and reduce China’s dependence on imported soybean [2]. The feed cost of animal husbandry and fishery may be driven up due to the higher prices of soybean meal and its substitutes; and in this way, the influence of the trade friction will be extended to other agricultural products.

On the other hand, as a land-intensive product, soybean assures food safety to a certain extent [5], but the high dependence of China on the import of soybean as an oil product leads to the mutual price transmission between international and domestic soybean. According to domestic and foreign literatures, the existing research methods can be divided into two types: linear model and nonlinear model, among which the linear model is widely used. The TAR model, VAR model and variance decomposition and MS-VAR model etc. all prove that the soybean trade between the US and China will lead to nonlinear price transmission [6] While the ARIMA model and the error correction GRAPH model realize the prediction of soybean price transmission based on time series [7]. Li Y used the APT-ECM model to study the characteristics of price transmission between American soybean and domestic soybean, and between domestic soybean and domestic soybean oil and soybean meal [8]. In respect of the rate of return of oil product prices, the effective risk assessment on the cross-border trade of oil products can be conducted by combining the GARCH model family and VAR method [9]; and Sino-US trade friction will bring strong negative impact on the bilateral trade value added [10]. The elasticity analysis of the AIDS model (import demand model) shows that this negative impact is caused by the gap between supply and demand caused by the imposition of tariffs [11]. Some scholars adopted the general equilibrium trade model and WIT-SMART model to simulate the trade diversion effect and abatement effect of the trade dispute and demonstrated the complementary characteristics of soybean and its by-products between the US and China. In recent years, the deep learning method represented by LSTM neural network has been gradually applied in the research field of futures soybean price transmission [12], especially with good predictive ability for extreme value prediction after price transmission.

Compared with the existing literatures, this paper has two main contributions and innovations. First, scholars mostly studied the price transmission effect from the perspective of "point-to-point" [13], while the research content on the impact of other international oil by-products on the price fluctuation of domestic oil products was still less. Second, existing studies often separated the relationship between endogenous and exogenous factors in the soybean pressing industry chain, such as the impact of Sino-US trade friction on each link of the oil processing industry chain [14]. On the basis of existing research, this paper creatively intends to utilize the asymmetric price transmission model with dual factors (APT-ECM) and variance decomposition and consider the trade friction as an external factor to study, in both temporal and spatial approaches, the influence of international oil price on domestic oil price under the conditions of different Sino-US trade policies, in order to scientifically understand the status and influence of domestic soybean market in international trade [15]. The results show that 1) international soybean price exerts significant influence on domestic soybean price, while the domestic price exerts insignificant influence on international price; 2) the influence of international soybean oil price on domestic soybean price is stable in the early stage and fluctuates significantly in the latter stage, even showing reverse effects in two stages; 3) international soybean oil price has
insignificant influence on domestic soybean oil price. It takes a longer time for domestic soybean oil and soybean meal prices to return to normal due to international soybean oil trade barrier, which lengthens the operation cycle of domestic oil industry chain.

2. Conceptual framework and data description

2.1. Data description

The data of domestic oil price mainly came from Dalian Commodity Exchange. The closing forward prices of soybean No. 2 (for oil), soybean oil and soybean meal were adopted, and the monthly unit price of domestic oil (yuan/kg) was calculated based on the closing trading amount and volume. The domestic soybean price, domestic soybean oil price and domestic soybean meal price were respectively denoted by CH_LS, CH_LO and CH_LP, and, after index processing, denoted by DCH_LS, DCH_LO and DCH_LP. The time interval was from January 2006 to December 2020. The data of international oil price came from CBOT Chicago Mercantile Exchange (CME), which adopted the closing forward prices of soybean and soybean oil and calculates the monthly unit price of international oil (yuan/kg) based on the closing trading amount, trading volume and real-time exchange rate. The international soybean price and international soybean oil price were respectively denoted by US_IS and US_IO, and, after index processing, denoted by DUS_IS and DUS_IO. The time interval was from January 2006 to December 2020.

2.2. Research definition

According to research needs, the research objectives were defined as follows: 1) the influence of international soybean price on domestic soybean price before and after Sino-US trade friction, i.e. the transmission between DUS_IS and DCH_LS; 2) the influence of international soybean oil price on domestic soybean price before and after Sino-US trade friction, i.e. the transmission between DUS_IO and DCH_LS; 3) the influence of international soybean oil price on domestic soybean oil price before and after Sino-US trade friction, i.e. the transmission between DUS_IO and DCH_LO and; 4) the influence of international soybean oil price on domestic soybean meal price before and after Sino-US trade friction, i.e. the transmission between DUS_IO and DCH_LP.

The “301 investigation” in August 2017 was considered as the demarcation point, by which Sino-US trade friction was divided into two stages, i.e. before Sino-US trade friction (Stage 1) and after Sino-US trade friction (Stage 2). Details are as follows:

Stage 1 (200601-201708): relatively stable low tariff;
Stage 2 (201709-202012): fluctuating high tariff.

2.3. Model

This paper applied the asymmetric error correction model (APT-ECM) to study the influence of international oil price on domestic oil price. In the price transmission mechanism, APT-ECM could not only build the impulse response function to analyse the short-term dynamic impact of different variables in different environments [16], but also examined the correction mechanism and speed for the evolution of the research object from the disequilibrium to long-term equilibrium and further determine the long-term fluctuation trend of the impact and whether any asymmetry in price transmission during price changes. The basic expression of this model is as follows:

$$
\Delta y_t = \alpha_0 + \sum_{j=1}^{N_1} \beta_{1,j} \Delta y_{t-1,j} + \sum_{j=1}^{M_1} \beta_{2,j} \Delta y_{t-1,j} + \sum_{j=1}^{N_2} \beta_{3,j} V^+ \Delta y_{t-1,j} + \sum_{j=1}^{M_2} \beta_{4,j} V^- \Delta y_{t-1,j} + \sum_{j=1}^{M_2} \beta_{4,j} V^- \Delta x_{t-1,j} + \mu_t
$$

(1)

In Formula (1), $\Delta y_t$ stands for the market price change of oil crop $y$ in the $t$ period, $\Delta x_t$ indicates the dependent variable that influences crop $y$ in the $t$ period, and $V^+$ and $V^-$ suggest the dummy
variable of price rise and fall respectively, i.e. the positive and negative transmission of the unit price change.

In the short run, the price follows the short-term trend based on times series. Hence:
\[
\sum_{j=1}^{N} \beta_{1,j}^+ + \sum_{j=1}^{N} \beta_{2,j}^- = 1
\]  
(2)
\[
\sum_{j=1}^{N} \beta_{3,j}^+ + \sum_{j=1}^{N} \beta_{4,j}^- = 1
\]  
(3)

X and its j-period-lagged data can well describe the fluctuation of y in a certain period, while the lag period j can be determined in accordance with AIC.

In the long run, the co-integration of the dummy variable V and the residual shall be considered, thus to further determine the influence of the long-term fluctuation of y price. Where \( y_i \geq y_{i,t-1}, x_i \geq x_{i,t-1}, V^+ = 1 \); where \( y_i < y_{i,t-1}, x_i < x_{i,t-1}, V^- = 0 \); and where \( y_i < y_{i,t-1}, x_i < x_{i,t-1}, V^- = 1 \). \( \text{ecm}_{t,i} \) is the residual of the estimate of the long-term equilibrium equation that reflects the variable co-integration, i.e. [17]:
\[
\text{ecm}_{t,i} = y_{t,i} - \beta x_{t,i}
\]  
(4)

The residual can be decomposed into the negative price impact and negative price impact, to further clarify the asymmetric direction of price transmission.

Then we will examine the null hypothesis \( H_0 \):
\[
\beta_{1,i}^- = \beta_{2,i}^+
\]  
(5)
In Formula (5), i is less than any value in set M, N;
\[
\beta_{3,i}^+ = 0
\]  
(6)
In Formula (6), i is greater than N;
\[
\beta_{4,i}^- = 0
\]  
(7)
In Formula (7), i is greater than M, \( \delta^+ = \delta^- \).

If \( H_0 \) is rejected, it proves the significant asymmetric effect in the transmission from international oil price to domestic oil price.

Based on the regression of the lag terms of time series \( y_t \) and \( x_t \) that present the co-integration relationship, the casual relation between the two, i.e. whether one variable is the Granger cause of the other variable, can be determined, in order to examine and explain the influence of the international and domestic oil price transmission mechanism.

2.4. Basic hypotheses
First, since the target data is the forward price (the market’s estimated oil price in the future), Hypothesis 1 is required:

The settlement price of the forward market is the delivery price of soybean in stock;

Second, as China’s import volume of soybean meal is relatively smaller than that of soybean and soybean oil, Hypothesis 2 is required:
The international soybean meal price shows insignificant transmission effect against domestic oil price;

Third, as Sino-US trade friction is mainly manifested in the high tariff barrier and the influence of the tariff policy on price shows certain time lag, Hypothesis 3 is required to reduce the model order and prevent over-modeling:
The price in t period is subject to the impact of the price in t-1 period, the expected price in t period, prices of relevant products in t period and the random disturbance variable.
Table 1. Lag order test table (E-G Co-integration Test).

| Lag | LogL  | LR   | FPE  | AIC   | SC    | HQ    |
|-----|-------|------|------|-------|-------|-------|
| International soybean – domestic soybean | 2    | 473.3319 | 18.8892 | 2.53E-06 | -7.3644 | -7.067 | -7.2270 |
| International soybean oil – domestic soybean | 3    | 413.6834 | 19.9366 | 6.95E-06 | -6.7582 | -6.331 | -6.2112 |
| International soybean oil – domestic soybean oil | 3    | 371.6045 | 16.7887 | 1.19E-05 | -5.8004 | -5.668 | -4.9675 |
| International soybean oil – domestic soybean meal | 3    | 556.3723 | 45.5479 | 3.97E-06 | -6.8677 | -6.702 | -6.7087 |

Note: This table is prepared based on the calculation results

3. Impact of international oil price on domestic oil price

This paper performed ADF stationarity test and E-G co-integration test based on the domestic oil price and international oil price in both Stage 1 and Stage 2, and determines their lag order respectively. The first-order difference of the original two sets of data (first set: DDCH_LS, DDCH_LS and DDCH_IO; second set: DDUS_IO, DDCH_LO and DDCH LS) was adopted for the stationarity test, and they were found integrated of order one, suggesting the possibility to establish a co-integration relationship between the variables. Then E-G co-integration test was conducted against the two sets of data and discovers the long-term co-integration relationship between these sets. According to Akaike information criterion (AIC) and Schwarz Criterion (SC), the lag order of international soybean to domestic soybean was 2; the lag order of international soybean oil to domestic soybean is 3; the lag order of international soybean oil to domestic soybean oil was 3; and the lag order of international soybean oil to domestic soybean meal was 3 (see Table 1).

3.1. Study on the influence of international soybean price on domestic soybean price

According to the short-term regression estimation (Table 2), the international soybean price transmission with 1-period lag shows insignificant negative impact, suggesting the small impact of the fall of international soybean price on domestic soybean price and the insignificant difference in the price of the transmission chain before and after Sino-US trade friction. But the international soybean price transmission with 1-period lag shows insignificant positive impact, which each rise of 1 unit of international soybean price compared to the previous period leads to a rise of 0.0155 unit of domestic soybean price, which increases to 0.0209 unit after the trade friction; and it shows that the rise of international soybean price exerts 25% positive influence on domestic soybean price under Sino-US trade friction. It shows that the short-term price self-adjustment ability of the domestic soybean market is not balanced. After the Sino-US trade friction, the market "bottom" price is relatively stable, but the ability to calm down the high price is weak.

According to the long-term regression estimation (Figure 1), in Stage 1, the impact of each 1 unit change of the international soybean price on the domestic soybean price is exposed to strong positive effect in the first 5 periods and shows less volatility and gradually reaches zero in the next 10 periods. The influence lasts for 15 periods. Then the negative effect arises, which causes a negative change of about 0.01 unit, maintains stable for 4 periods and gradually approaches zero afterwards. In Stage 2, the domestic soybean price fluctuates more significantly with a change of approximately 0.04 unit, then sharply decreases and finally approaches zero after 15 periods of decline. Compared to Stage 1, Stage 2 shows a lag of two periods and presents stronger positive influence of price fluctuation in the range of negative effect. It indicates that under the impact of international soybean prices, Sino-US trade frictions have extended the time for domestic soybean prices to recover to a stable level. To a certain extent, the panic of domestic soybean market on price rise will be enhanced.
### Table 2. Spatial APT-ECM model regression results for the influence of international oil price on domestic soybean price before and after sino-us trade friction.

| Variable | Stage 1 | Stage 2 |
|----------|---------|---------|
|          | DDUS IS and DDCH LS | DDUS IO DDCH LS | DDUS IS and DDCH LS | DDUS IO DDCH LS |
| $R^2$    | 0.6993 | 0.0302 | 0.5770 | 0.0899 | 0.4622 | 0.0326 | 0.3911 | 0.0875 |
| $ecm_{t-1}$ | -0.0065 | 0.0572 | 0.0032 | 0.2774 | -0.0966 | 0.0452 | -0.0361 | 0.2033 |
| $ecm_{t-2}$ | -0.0155*** | 0.6644 | -0.5392*** | 0.7902 | -0.0209*** | 0.7002* | -0.5643*** | 0.5936 |
| DDUS IS | 0.1709*** | -0.0387 | - | - | 0.1619*** | -0.0560* | - | - |
| DDUS IS | 0.2657*** | 0.0932 | - | - | 0.2645** | 0.1122* | - | - |
| DDCH LS | 0.2672 | -0.3443 | 0.6679*** | -0.5243 | 0.3425 | -0.3562 | 0.6635*** | -0.1985 |
| DDUS_IO | - | 0.3982* | -0.0803 | 0.4256** | 0.1035 | 0.2747** | -0.0074 | 0.4886*** |
| DDUS_IO | - | - | 0.3966*** | 0.1332 | - | - | 0.1834*** | 0.1266 |
| DDUS_IO | - | - | -0.1292** | -0.0032 | - | - | -0.1889** | -0.0026 |
| $C$      | 0.0001 | 0.0002 | 0.0002 | 0.0008 | 0.0001 | 0.0009 | 0.0002 | -0.0002 |

### Table 3. Mixed APT-ECM model regression results for the influence of international oil price on domestic soybean oil price before and after sino-us trade friction.

| Variable | Stage 1 | Stage 2 |
|----------|---------|---------|
|          | DDUS IO and DDCH LO | DDUS IO DDCH LP | DDUS IO and DDCH LO DDUS IO DDCH LP |
| $R^2$    | 0.3490 | 0.0655 | 0.6579 | 0.1083 | 0.2333 | 0.0992 | 0.6399 | 0.0703 |
| $ecm_{t-1}$ | 0.0554 | 0.2321 | 0.0598 | 0.1883 | 0.0572 | 0.2430 | 0.0479 | 0.1332 |
| $Ecm_{t-1}$ | -0.1980 | 0.5655** | 0.1168 | 0.6882*** | -0.1990* | 0.3934** | -0.0001 | 0.4464*** |
| DDUS IO | 0.2299*** | -0.0091 | 0.4739*** | -0.1366 | 0.1922** | -0.1366 | 0.3945*** | -0.0091 |
| DDUS IO | 0.3264*** | 0.0099 | 0.4906*** | 0.1442 | -0.2313*** | 0.6635 | 0.4930*** | 0.1132 |
| DDUS IO | 0.0077 | -0.0349 | 0.0609 | -0.1994 | -0.0381 | -0.0048 | 0.1033 | -0.1420 |
| DDCH LO | 0.1679** | -0.0333 | - | - | 0.2134** | -0.0432 | - | - |
| DDCH LO | -0.0078 | 0.0155 | - | - | -0.0039 | 0.1965* | - | - |
| DDCH LO | -0.1933** | -0.0024 | - | - | -0.1704** | -0.0101* | - | - |
| DDCH LP | - | - | -0.1778** | 0.1191 | - | - | -0.1886** | 0.0430 |
| DDCH LP | - | - | 0.1512* | 0.2428 | - | - | 0.1633 | 0.2294 |
| DDCH LP | - | - | -0.0931* | 0.1922 | - | - | -0.1002** | 0.1388 |
| $C$      | 0.0003 | 0.0004 | 0.0001 | 0.0003 | 0.0016 | -0.0002 | 0.0001 | -0.0009 |

3.2. Study on the influence of international soybean oil price on domestic soybean price

According to the short-term regression estimation (Table 2), the international soybean oil price transmission with 1-period lag shows insignificant negative impact on domestic soybean price, suggesting the small impact of the fall of international soybean oil price on domestic soybean price and the insignificant difference in the transmission chain before and after Sino-US trade friction. Also, the international soybean oil price transmission with 1-period lag shows no insignificant positive impact, which each rise of 1 unit of international soybean oil price compared to the previous period leads to a rise of 0.5392 unit of domestic soybean price, which increases to 0.5643 unit after the trade friction; and it shows that the rise of international soybean oil price exerts about 5% positive influence on domestic soybean price under Sino-US trade friction. It indicates that the short-term price of domestic soybean market has no obvious transmission effect on the price of squeezed products in the international market, and the domestic soybean price can still keep running in a stable range after the occurrence of Sino-US trade friction.

According to the long-term regression estimation (Figure 2), before and after Sino-US trade friction, the impact of international soybean oil price on domestic soybean price has been basically consistent in the first 7 periods. Since the 8th period, Stage 1 sees a steady decline of positive effect; and Stage 2 experiences 3 periods of fall, rises sharply until the peak of 0.061 unit in the 13th period and drops rapidly afterwards. It indicates that under the impact of international soybean oil price, Sino-US trade friction increased the fluctuation range of domestic soybean price, changed the fluctuation direction of domestic soybean price, and made the future long-term price of domestic soybean market uncertain.
3.3. Study on the influence of international soybean oil price on domestic soybean oil and soybean meal price

According to the short-term regression estimation (Table 3), the international soybean oil price exerts insignificant impact on domestic soybean oil and soybean meal price, suggesting the insignificant difference in the transmission chain before and after Sino-US trade friction. Each rise of 1 unit of domestic soybean oil price compared to the previous period leads to a rise of 0.5655 unit of international soybean oil price, which becomes a rise of 0.3934 unit after the trade friction, showing a decline rate of approximately 20%. Domestic soybean meal price changes are also basically consistent with soybean oil. It indicates that domestic soybean oil and soybean meal prices have certain bargaining power over international soybean oil and soybean meal prices, and the negative impact of Sino-US trade frictions can be reduced through independent squeezing and other methods.

According to the long-term regression estimation (Figure 3), the international soybean oil price exerts basically consistent positive influence on domestic soybean oil price before and after Sino-US trade friction. However, in the first 11 periods, Stage 2 shows less volatility and a lower peak than Stage 1; and after the 11th period, both stages see declining fluctuation and gradually approach 0, with the amplitude in Stage 2 relatively higher than that in Stage 1. Meanwhile, the international soybean oil price also exerts basically consistent positive influence on domestic soybean meal price before and after Sino-US trade friction. Both stages reach the peak of impact in the 4th period, with the influence on domestic soybean meal price in Stage 1 slightly higher than that in Stage 2. In the first 12 periods, Stage 2 shows less volatility than Stage 1; and after the 12th period, both stages see declining fluctuation and gradually approach 0, with the fluctuation amplitude in Stage 2 relatively higher than that in Stage 1 and a slower speed to reach 0 in Stage 2. It indicates that under the impact of international soybean oil prices, Sino-US trade frictions have a relatively weak impact on the long-term prices of domestic soybean oil and soybean meal markets, but Barriers to international soybean oil trade prolong the time for the domestic soybean meal market prices to recover to normal, which is likely to increase the acquisition costs of the major consumer industries such as the domestic feed industry [18].

![Figure 1. Impulse response of international soybean to domestic soybean.](image-url)
3.4. Granger causality test on the transmission between international oil price and domestic oil price

Table 4 lists the Granger causality test on the transmission between international oil price and domestic oil price. The results show that: 1) international soybean price has been a long-term Granger cause for the changes of domestic soybean price whether Sino-US trade friction takes place or not; 2) However, it is not true conversely, as domestic soybean price is not a Granger cause for international soybean price; 3) Domestic soybean price has become a Granger cause for international soybean oil price since the 3rd period, and the null hypothesis is more significantly rejected along with the longer period of trade friction. It demonstrates that domestic soybean price cannot change international soybean price in the long run, and domestic soybean price cannot change international soybean oil.
price within a short term (within 2 periods) and is significantly affected by Sino-US trade friction; 4) Whether Sino-US trade friction occurs or not, the change of international soybean oil has always been a long-term Granger cause for the changes of domestic soybean oil and soybean meal prices; but it is not the case on the contrary; 5) Since the 5th period, domestic soybean meal price has also become the long-term Granger cause of international soybean oil, and it is more obvious after Sino-US trade friction( Figure 4).

### Table 4. Granger causality test for two stages.

|                      | Stage1       | Stage2       |
|----------------------|--------------|--------------|
|                      | 1 2 3 4 5 6 1 2 3 4 5 6 |             |
| DDUS_IS → DDCH_LS    | 0.0005 0.0001 0.0000 0.0000 0.0000 0.0000 0.0000 0.0004 0.0002 0.0000 0.0000 0.0000 | 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 |
| DDCH_LS → DDUS_JS    | 0.8265 0.4663 0.2112 0.1330 0.0991 0.1966 0.9737 0.4922 0.3326 0.2770 0.1414 0.0899 |             |
| DDUS_IO → DDCH_JS    | 0.0025 0.0002 0.0000 0.0000 0.0000 0.0000 0.0000 0.0011 0.0000 0.0000 0.0000 0.0000 | 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 |
| DDCH_JS → DDUS_IO    | 0.1623 0.1002 0.0303 0.0899 0.0437 0.0190 0.0291 0.0563 0.0092 0.0244 0.0091 0.0032 |             |
| DDUS_IO → DDCH_LO    | 0.0044 0.0001 0.0000 0.0000 0.0000 0.0000 0.0000 0.0031 0.0002 0.0000 0.0000 0.0000 |             |
| DDCH_LO → DDUS_IO    | 0.5786 0.9333 0.9117 0.9802 0.8918 0.6743 0.4066 0.7931 0.8557 0.9311 0.6436 0.4969 |             |
| DDUS_IO → DDCH_LP    | 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 |             |
| DDCH_LP → DDUS_IO    | 0.1627 0.5352 0.1088 0.1011 0.0363 0.0026 0.3325 0.4624 0.2512 0.2065 0.0199 0.0014 |             |

### 4. Conclusions and policy suggestions

#### 4.1. Research conclusions.

This paper applied the spatial-temporal APT-ETM model and conducted empirical and comparative study on the asymmetric transmission between international oil price and domestic oil price before and after Sino-US trade friction. Major research conclusions include the follows:

a) Before Sino-US trade friction, international soybean price exerts significant influence on domestic soybean price, while the domestic price exerts insignificant influence on international price. In the short run, the self-adjustment ability of the domestic soybean market price is not balanced. After the Sino-US trade friction, the market "bottom" price is relatively stable, but the ability to calm down the high price is weak. In the long run, the domestic soybean market prices to recover a long time, to some extent will enhance the domestic soybean market to the price of the panic mood [19].

b) Before Sino-US trade friction, the influence of international soybean oil price on domestic soybean price is stable in the early stage and fluctuates significantly in the latter stage. Distinguished from soybean prices, Sino-US trade friction shows more evident influence on price transmission in this respect and changes the fluctuation direction of domestic soybean price and made the future long-term price of domestic soybean market uncertain.

c) Before Sino-US trade friction, international soybean oil price has insignificant influence on domestic soybean oil price. In the short run, Sino-US trade friction has improved the transmission capacity of domestic soybean oil and soybean meal prices to international soybean oil price; and in the long run, it takes a longer time for domestic soybean oil and soybean meal prices to return to normal due to international soybean oil trade barrier, which lengthens the operation cycle of domestic oil industry chain and increase procurement costs for downstream industries [20].

#### 4.2. Policy suggestions.

1. According to the Sino-US trade friction characteristics, improve the oil crops and processing industry chain, and carry out the vertical and horizontal expansion of the industry chain. Sino-US trade friction makes the price transmission of domestic and international oil crops significant, that is, in the
short term, the positive impact and negative impact not only have different effects on the adjustment range and change speed of product prices in the downstream of the industrial chain, but also have a fluctuating impact on the price of other transnational products [21], continue to promote bilateral trade negotiations with major trading countries including the US, strengthen the cooperation with big agricultural producing countries on “the Belt and Road” and diversify import channels [22]. Actually, such trade collision also requires expanding the exchange depth of oil crop trade on the horizontal dimension, incorporating the international soybean oil market price in the soybean trade price system [23], improving the price formation mechanism of the oil industry market and strengthen the risk resistance of soybean products against the international market [24].

2. According to the characteristics of Sino-US trade friction, increase the self-sufficiency of domestic oil crops and realize the integration of oil crop pressing industry cluster. The impact of Sino-US trade friction on China lies more in the blocked import of agricultural products. International grain merchants’ control over oil crops such as soybeans has gone beyond the supply of oil crops and extended to the oil crop pressing industry. Compared with the small-scale, extremely dispersed and low-yielding domestic crushing enterprises, it is urgent to improve their industrial scale and operational capacity. Therefore, it’s necessary to integrate the clusters of soybean crushing industry, which can offer major support to domestic large and medium-sized crushing enterprises. Meanwhile, if necessary, we should centralize resources to convert crushing capacity into market value and enhance the bargaining power with import enterprises. Except that, increasing investment in production and research of high-quality soybean and providing subsidies for the floating price difference based on the soybean varieties [25]. By means of offering credit funds or tax reduction and exemption to purchasers, we can lower the procurement cost of soybean. Ultimately government should consider the oil and feed reserve mechanism comprehensively, which impose overall control and stabilize domestic soybean market price.

3. According to the characteristics of Sino-US trade frictions, a market information early warning and monitoring system for oil crops was established, and market regulation was used to enhance the linkage of domestic and foreign oil prices. We can make use of the market to strengthen the linkage between domestic and foreign oil prices. Trade frictions between China and the United States are frequent [26]. We need a scientific, efficient and accurate monitoring and warning system, which could effectively deal with uncertainties such as international market, natural disasters and emergencies. For this purpose, the government could gather domestic and foreign oil crop planting bases, pressing enterprises, feed processing enterprises together. Research institutes could utilize their own research advantages to integrate, collect, publish and analyze all kinds of information resources of oil crop market and design the risk prevention and control system of the soybean processing industry chain, which could effectively avoid violent fluctuation of market prices caused by adverse factors and resist price risks. Meanwhile, we also should pay attention to the relative rise of domestic and foreign oil prices due to the low exchange rate and resist financial risks [27].

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