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An attribution analysis of soybean price volatility in China: global market connectedness or energy market transmission?

RESEARCH ARTICLE

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Abstract

This study examines the impact of international soybean price and energy price on Chinese soybean price. Applied to monthly data over the period of 2007-2017, results show that both international soybean price and energy price have significant impacts on Chinese soybean price, while the impact from global soybean market tends to be more profound. First, we find that in the long run the cumulative pass-through elasticity of Chinese soybean price to international soybean price is greater than the elasticity to international energy price. Second, in the short run, international soybean price shocks transmit more quickly to Chinese soybean price. Our results shed new light on the determinants of soybean price volatility in China, and provide meaningful implications on the price risk management for market participants and policy makers.

Keywords: soybean price, price transmission, soybean trade, energy market, transportation costs
JEL code: Q11, Q13, Q41

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1. Introduction

China is the world's leading soybean consumer and importer (Song *et al.*, 2009). In the last decade, the annual consumption of soybean in China averaged 80.38 million tons, of which approximately 68.45 million tons were imported[1]. The fluctuation of Chinese soybean prices has profound impacts on both domestic and global markets. Since the beginning of 21st century, the co-movements among Chinese soybean price, international soybean price and international energy price have been frequently witnessed. Indeed, the Chinese soybean pricing is affected by international soybean price through import trade (Muhammad, 2015). The Chinese soybean price follows the booms and busts of the international price. Meanwhile, the impact of energy price on Chinese soybean price is also non-negligible. The role of fuel-powered machinery and fertilizer makes Chinese soybean price vulnerable to energy price shocks. The market-oriented pricing of soybeans in China is affected by international energy price through transportation costs and other channels (Wang *et al.*, 2015).

Figure 1 shows the trajectories of Chinese soybean price, international soybean price and international energy price from 2007 to 2017. As discussed above, the price co-movements appeared frequently, e.g. it illustrates an inverted V-shape pattern of price dynamics that appeared synchronously among Chinese soybean price, international soybean price and international energy price during the world food crisis from 2007 to 2008. Throughout the period, Chinese soybean price followed closely with the movement of international soybean price and international energy price. This raised an intriguing question: how and how much do international soybean price and international energy price affect Chinese soybean price under the co-movements among Chinese soybean price, international soybean price, and international energy price? The answer to this question remains unclear at this point. Analysis of this question will help better understand the price co-movement phenomenon, and clarify the main driving force of the fluctuation of Chinese soybean price.

In the ongoing debate over the causes of Chinese soybean price volatility, the main body of literature emphasizes the role of international soybean price and international energy price separately. First, some literature focuses on the impacts of international soybean price on Chinese soybean price, and provides empirical evidence supporting that international soybean price transmit strongly to Chinese soybean price. They find the huge import demand of China provides a foundation for soybean price transmission from the

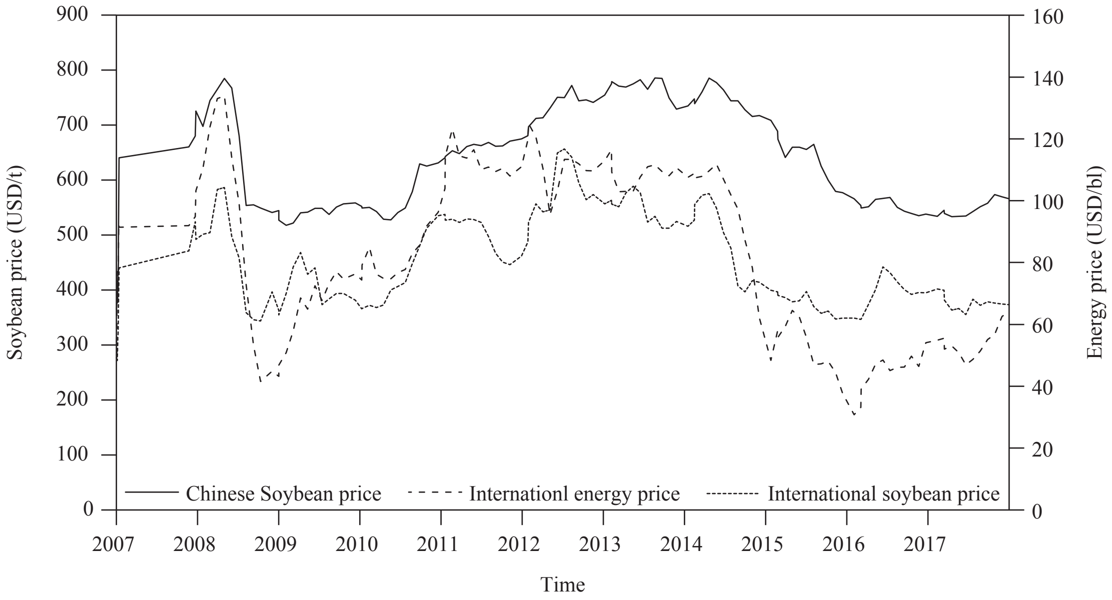

Figure 1. International soybean price, international energy price, and Chinese soybean price: 2007 to 2017 (data from: https://www.wind.com.cn).

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[1] Wind economic database. Available at: https://www.wind.com.cn

international market (Li *et al.*, 2017a,b; Yang *et al.*, 2010). And there is significant price transmission from international soybean market to Chinese soybean market (Arnade *et al.*, 2007; Jiang and Wang, 2013; Yan *et al.*, 2016), including volatility spillover effects and risk transmission (Chavas and Li, 2020; Ke *et al.*, 2019; Lin, 2018). Second, there are another strand of papers discussing the impacts of international energy price on Chinese soybean price. They explore the channels through which energy price affect soybean price (Fang *et al.*, 2014; Zhang and Qu, 2015), such as cost-pushing factors (e.g. production costs and transportation costs) and demand-pulling factors (e.g. biofuel expansion). The impacts of international energy price on Chinese soybean price include the long run equilibrium and short-run dynamic relationships (Zhang and Reed, 2008), as well as the price spillover effects and volatility spillover effects (Ma *et al.*, 2015).

To date, most existing studies have typically focused on a single source of the impacts on Chinese soybean price (i.e. either international soybean price or international energy price). However, there is a notable absence of an integrated framework that considers Chinese soybean price, international soybean price, and international energy price. As mentioned above, to a certain extent, international soybean price, international energy price, and Chinese soybean price have experienced synchronized boom and bust cycles. Both international soybean price and international energy price have potential significant impacts on Chinese soybean price, ignoring either of them may affect the accuracy of research results. Therefore, in this paper, we attempt to explain how and how much do international soybean price and international energy price affect Chinese soybean price under an integrated framework.

The rests of the paper are organized as follows: Section 2 introduces the analytical framework, data and the model employed in the study. In Section 3, the empirical findings are presented, discussed, and interpreted. Finally, Section 4 provides a conclusion and presents some suggestions for further work.

2. Analytical framework, data and model

2.1 Analytical framework

China is the largest soybean importer in the world, fluctuations in international price unavoidably have widespread effects on Chinese soybean price mainly through international trade (Peng *et al.*, 2016), which means international soybean price affects Chinese port-of-entry (POE) soybean price, and further affects Chinese inland soybean price. This relationship is illustrated in Figure 2.

In terms of influence from international energy price, there are three possible channels: transportation costs, production costs, and bioenergy. Because China relies heavily on imported soybeans and bioenergy is still in its infancy in China, the contributions of production costs and bioenergy are limited. There are widespread problems in transporting soybeans in this vast country, both in international imports and in domestic distribution. Therefore, in this paper, we focus on the impact of international energy price on Chinese inland soybean price through the transportation costs channel. The fuel cost transmission consists of two pathways. Firstly, international energy price affects Chinese POE soybean price, which finally affects

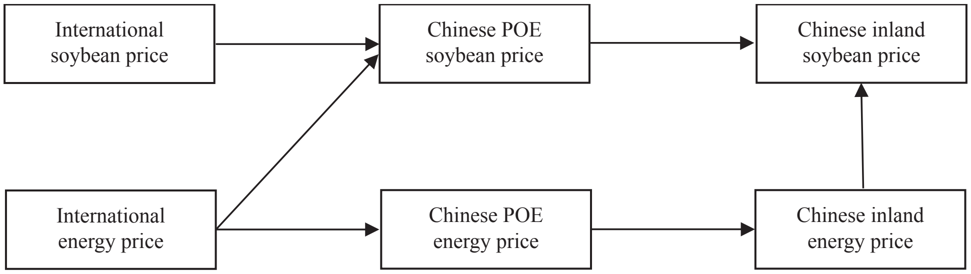

Figure 2. How international soybean price and international energy price affect Chinese soybean price.

Chinese inland soybean price. Secondly, international energy price affects Chinese POE energy price, which affects Chinese inland energy price, and then affects Chinese inland soybean price. These relationships are also illustrated in Figure 2.

Our empirical strategy involves stepwise estimation of models. According to the channels in Figure 2, we divide the analytical framework into four steps. To begin with, we estimate the impact of international soybean price and international energy price on Chinese POE soybean price (step 1). Step 2, we estimate the impact of international energy price on Chinese POE energy price. Then we estimate the impact of Chinese POE energy price on Chinese inland energy price (step 3). Finally, we estimate the impact of Chinese POE soybean price and Chinese inland energy price on Chinese inland soybean price (step 4).

In this article, the relationship between international soybean price and international energy price is not considered. It makes the following identifying assumptions at the same time: China is a price taker in international markets for both soybeans and energy. There is no feedback from soybean price to energy price in China, rendering energy price weakly exogenous to soybean price. Also, as international prices are transmitted to inland markets via POEs in China, POE prices are weakly exogenous to inland markets prices.

2.2 Data

Monthly prices from 2007 to 2017 are adopted as follows. International soybean price is No. 1 soybeans in the US Gulf in USD per ton. International energy price is free on board (FOB) Brent crude oil at the UK main port in USD per barrel. The selected POE markets are Qingdao, Tianjin[2] and the POE soybean price is the average of cost, insurance and freight (CIF) Qingdao and Tianjin (in RMB per ton). The POE energy price is the average price of Diesel No. 0 in Qingdao and Tianjin (in RMB per ton). The selected inland markets are Zhengzhou and Beijing. The inland soybean price is the average price in Zhengzhou and Beijing markets[3] in RMB per ton. The inland energy price is the average price of Diesel No. 0 in Zhengzhou and Beijing in RMB per ton. For the empirical analysis, Chinese soybean price and energy price are converted into USD per ton using the appropriate exchange rates from the State Foreign Exchange Administration of China. Other data are procured from the wind financial database (https://www.wind.com.cn).

The characteristics of data is the important basis for us to choose which method to test the price transmission of international soybean market and international energy market to Chinese soybean market. Thus, we need to check the characteristics of the time series data above. In order to avoid the spurious regressions in the econometric analysis, the stationarity of each price series first needs to be determined. When it is stable, we investigate the relationship between variables by constructing a vector autoregression (VAR) model. Otherwise, we form stable series by difference, and make cointegration test on the original series. If there is a cointegration relationship between series, we use the original series to construct the vector error correction (VEC) model. If not, the difference series will be used to construct the VAR model.

The unit root test is used to examine the stationarity with Augmented Dickey-Fuller test (ADF), Kwiatkowski-Phillips-Schmidt-Shin test (KPSS), and Dickey-Fuller Test with Generalized Least Squares Detrending test (DFGLS). Table 1 shows that all the original series are non-stationary, while the first-order difference series are stationary at the 1% level. The series consisting of the international soybean price, international energy price, Chinese POE soybean price, Chinese POE energy price, Chinese inland soybean price, and Chinese inland energy price are *I(1)* series, which satisfy the requirement of the cointegration test.

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[2] Qingdao and Tianjin are the main soybean import ports in China. For example, Qingdao Customs and Tianjin Customs imported 11.47 million tons and 4.77 million tons of soybeans in 2016, respectively. Soybean imports ranked first and second in Chinese coastal ports.

[3] Zhengzhou is an important grain-trading center in China. Zhengzhou Grain Wholesale Market is Chinese first national and standardized grain wholesale market. It was established in 1990 with the approval of the State Council. Beijing is an important consumer market in China: the 'Jinxiudadi Yuquan Road' wholesale market is known as the 'rice bag' in Beijing, and it bears not only the normal supply of grain, but also the bridge of communication between production and marketing areas in Beijing. Therefore, Zhengzhou and Beijing appropriately represent the inland market of soybeans.

Table 1. Unit root test.[1]

Methods[2]	Variables	Original	First-difference	Variables	Original	First-difference
ADF	S_t^G	-2.921	-8.409***	O_t^G	-2.792	-6.644***
	S_t^P	-2.966	-8.238***	O_t^P	-1.756	-6.617***
	S_t^I	-2.662	-7.756***	O_t^I	-1.961	-7.891***
KPSS	S_t^G	0.282	0.036***	O_t^G	0.255	0.043***
	S_t^P	0.231	0.061***	O_t^P	0.523	0.058***
	S_t^I	0.253	0.064***	O_t^I	0.527	0.053***
DFGLS	S_t^G	-2.223	-8.379***	O_t^G	-2.283	-6.612***
	S_t^P	-1.889	-8.118***	O_t^P	-1.577	-6.635***
	S_t^I	-1.571	-7.754***	O_t^I	-1.527	-7.681***

[1] Asterisks indicate the significance level: * at the 10% level, ** at the 5% level, and *** at the 1% level.

[2] ADF = Augmented Dickey-Fuller test; KPSS = Kwiatkowski-Phillips-Schmidt-Shin test; DFGLS = Dickey-Fuller Test with Generalized Least Squares Detrending test.

As for the analysis of long-term equilibrium, Table 2 shows that the series in step 1 are cointegrated at the 10% level. This means that there is a long-run equilibrium among the international soybean price, the international energy price, and Chinese POE soybean price. Similarly, Johansen cointegration tests for the series in steps 2, step 3, and step 4 all provide evidence of long-term equilibrium at the 10% level (Johansen, 1991, 1995).

Therefore, the long-term cointegration relationship in each group exists, i.e. international soybean price, international energy price, and Chinese POE soybean price; international energy price and Chinese POE energy price; Chinese POE energy price and Chinese inland energy price; Chinese POE soybean price, Chinese inland energy price, and Chinese inland soybean price.

2.3 The models

Based on the results of unit root test and Johansen cointegration test, we construct the VEC model. Following Dillon and Barrett (2016), our empirical approach involves stepwise estimation of error correction models (step 1, step 2, step 3, and step 4), and possible asymmetric adjustment to negative/positive deviations from long-run equilibrium in all steps is allowed.

First, we estimate the impact of international soybean price and international energy price on Chinese POE soybean price. The two-stage asymmetric error-correction models are set as follows:

$$S_t^P = \alpha_{11} + \beta_{11} S_t^G + \beta_{12} O_t^G + \varepsilon_{1t} \tag{1}$$

$$\Delta S_t^P = \lambda_1 ECM_{t-1}^+ + \lambda_2 ECM_{t-1}^- + \sum_{i=1}^{p} \{\lambda_{3i} \Delta S_{t-i}^P + \lambda_{4i} \Delta S_{t-i}^G + \lambda_{5i} \Delta O_{t-i}^G\} + \nu_{1t} \tag{2}$$

Table 2. Johansen cointegration test.

Variables	Trace statistic	10% critical value	Cointegration relationship
S_t^P, S_t^G, O_t^G	34.425	27.066	Yes
O_t^P, O_t^G	14.889	13.428	Yes
O_t^I, O_t^P	21.129	13.428	Yes
S_t^I, S_t^P, O_t^I	29.431	27.066	Yes

where S_t^P is Chinese POE soybean price in month *t*, S_t^G is the international soybean price in month *t*, O_t^G is the international energy price in month *t*, Δ is the first order difference, *i* is the lag order of the difference term on the right side of Equation 2, ε_{1t} and ν_{1t} are statistical error terms. The error correction term, ECM_{t-1}, is |the residual from Equation 1 that measures period *t-1* deviations from the long-run stationary relationship. The + and – superscripts indicate the sign of the residuals (i.e. $ECM_{t-1}^{+} = max(ECM_{t-1}, 0)$, $ECM_{t-1}^{-} = min(ECM_{t-1}, 0)$. Estimates $\hat{\lambda}_1$ and $\hat{\lambda}_2$ are speed-of-adjustment parameters for negative and positive deviations from the long-run equilibrium, respectively. The absolute values $|\hat{\lambda}_1|$ and $|\hat{\lambda}_2|$ give the share of the deviation from the long-run equilibrium that decays each month.

Equation 1 represents the cointegrating vector, i.e. the long-run equilibrium relationship between international soybean price, international energy price, and Chinese POE soybean price. Equation 2 captures the short-run dynamics of the three variables in Equation 1.

Second, we estimate the impact of international energy price on Chinese POE energy price. The two-stage asymmetric error-correction models are set as follows:

$$O_t^P = \alpha_{21} + \beta_{21} O_t^G + \varepsilon_{2t} \tag{3}$$

$$\Delta O_t^P = \delta_1 ECM_{t-1}^{+} + \delta_2 ECM_{t-1}^{-} + \sum_{i=1}^{m} \{\delta_{3i} \Delta O_{t-i}^P + \delta_{4i} \Delta O_{t-i}^G\} + \nu_{2t} \tag{4}$$

Where O_t^P is Chinese POE energy price in month *t, i* is the lag order of the difference term on the right side of Equation 4, and the other variables or coefficients have the same meaning as in the previous equations. Equation 3 represents the cointegrating vector, i.e. the long-run equilibrium relationship between international energy price and Chinese POE energy price. Equation 4 captures the short-run dynamics of the two variables in Equation 3.

Third, we estimate the impact of Chinese POE energy price on Chinese inland energy price. The two-stage asymmetric error-correction models are set as follows:

$$O_t^I = \alpha_{31} + \beta_{31} O_t^P + \varepsilon_{3t} \tag{5}$$

$$\Delta O_t^I = \chi_1 ECM_{t-1}^{+} + \chi_2 ECM_{t-1}^{-} + \sum_{i=1}^{n} \{\chi_{3i} \Delta O_{t-i}^I + \chi_{4i} \Delta O_{t-i}^P\} + \nu_{3t} \tag{6}$$

where O_t^I is Chinese inland energy price in month *t, i* is the lag order of the difference term on the right side of Equation 6, and the other variables or coefficients have the same meaning as in the previous equations. Equation 5 represents the cointegrating vector, i.e. the long-run equilibrium relationship between Chinese POE energy price and Chinese inland energy price. Equation 6 captures the short-run dynamics of the two variables in Equation 5.

Finally, we estimate the impact of Chinese POE soybean price and Chinese inland energy price on Chinese inland soybean price. The two-stage asymmetric error-correction models are set as follows:

$$S_t^I = \alpha_{41} + \beta_{41} S_t^P + \beta_{42} O_t^I + \varepsilon_{4t} \tag{7}$$

$$\Delta S_t^I = \theta_1 ECM_{t-1}^{+} + \theta_2 ECM_{t-1}^{-} + \sum_{i=1}^{q} \{\theta_{3i} \Delta S_{t-i}^I + \theta_{4i} \Delta S_{t-i}^P + \theta_{5i} \Delta O_{t-i}^I\} + \nu_{4t} \tag{8}$$

where S_t^I is Chinese inland soybean price in month *t*, *i* is the lag order of the difference term on the right side of Equation 8, and the other variables or coefficients have the same meaning as in the previous equations. Equation 7 represents the cointegrating vector, i.e. the long-run equilibrium relationship between Chinese POE soybean price, Chinese inland energy price, and Chinese inland soybean price. Equation 8 captures the short-run dynamics of the three variables in Equation 7.

If we denote $\eta_{S_t^P S_t^G}$ as the long-run elasticity of S_t^P with respect to S_t^G, we could calculate the elasticity through the formula $\eta_{S_t^P S_t^G} = \beta_{11}\bar{S}_t^G/\bar{S}_t^P$, where $\bar{S}_t^G$ and $\bar{S}_t^P$ are the average of S_t^G and S_t^P. If we denote $\eta_{S_t^P O_t^G}$ as the long-run elasticity of S_t^P with respect to O_t^G, we could calculate the elasticity through the formula $\eta_{S_t^P O_t^G} = \beta_{12}\bar{O}_t^G/\bar{S}_t^P$, where $\bar{O}_t^G$ is the average of O_t^G. If we denote $\eta_{O_t^P O_t^G}$ as the long-run elasticity of O_t^P with respect to O_t^G, we could calculate the elasticity through the formula $\eta_{O_t^P O_t^G} = \beta_{21}\bar{O}_t^G/\bar{O}_t^P$, where $\bar{O}_t^P$ is the average of O_t^P. If we denote $\eta_{O_t^i O_t^p}$ as the long-run elasticity of O_t^I with respect to O_t^P, we could calculate the elasticity through the formula $\eta_{O_t^I O_t^P} = \beta_{31}\bar{O}_t^P/\bar{O}_t^I$, where $\bar{O}_t^I$ is the average of O_t^I. If we denote $\eta_{S_t^I S_t^P}$ as the long-run elasticity of S_t^I with respect to S_t^P, we could calculate the elasticity through the formula $\eta_{S_t^I S_t^P} = \beta_{41}\bar{S}_t^P/\bar{S}_t^I$, where $\bar{S}_t^I$ is the average of S_t^I. If we denote $\eta_{S_t^I O_t^I}$ as the long-run elasticity of S_t^I with respect to O_t^I, we could calculate the elasticity through the formula $\eta_{S_t^I O_t^I} = \beta_{42}\bar{O}_t^I/\bar{S}_t^I$.

3. Results

3.1 Estimation results

Table 3 shows the estimates of Equation 1 to Equation 8. The coefficients of international soybean price and international energy price in Equation 1 are positive at the 1% level. This means that Chinese POE soybean price is accompanied positively by both international soybean price and international energy price. The coefficients of error correction term in Equation 2 is significant at the 10% level during periods of positive deviation from the long-run equilibrium (ECM_{t-1}^{+}). When Chinese POE soybean price increases and deviates from the long-term equilibrium, the adjustment back to the long-run equilibrium is not instantaneous at a monthly adjustment rate of 18%.

In Equation 3, international energy price has a significant impact on Chinese POE energy price at the 1% level. The coefficient is positive indicates that a change in international energy price leads Chinese POE energy price to change in the same direction. The coefficient of ECM_{t-1}^{+} in Equation 4 is significant and negative at the 10% level, which indicates that the price is able to revert back to long-run equilibrium at a monthly adjustment rate of 10% when Chinese POE energy price increasing and deviating from the long-run equilibrium.

The coefficient of Chinese POE energy price in Equation 5 is very close to unity, Chinese inland energy market is very well integrated with Chinese POE energy market. It clearly shows that coefficients of ECM_{t-1}^{+} and ECM_{t-1}^{-} in Equation 6 are negative and statistically significant at the 1% and 5% levels. The coefficients of ECM_{t-1}^{+} and ECM_{t-1}^{-} are -0.434 and 0.225 denoting that Chinese inland energy price reacts to its long-run equilibrium path by 43% and 23% speed of adjustment every month. Price increases generally transmit faster than price decrease.

Changes in Chinese POE soybean price and Chinese inland energy price shows a significant effect on Chinese inland soybean price at the 1% level in Equation 7. The coefficients of 0.593 and 0.115 indicate that a change of 10% in Chinese POE soybean price and Chinese inland energy price will lead to Chinese inland soybean price to change in the same direction by 5.93% and 1.15%. In Table 3 we also report the second-stage results of the asymmetric ECM based on Equation 8. The coefficients of ECM_{t-1}^{+} and ECM_{t-1}^{-} are -0.117 and -0.119, respectively, at the 5% level. When Chinese inland soybean price deviate from the long-term equilibrium, the rates adjustment back to long-run equilibrium are 12% per month.

3.2 Effect of international soybean and international energy price on Chinese inland soybean price

To compare the effect of international soybean price and international energy price on Chinese soybean price, we combine the estimated vectors and short-run adjustment results across price series pairs. First, according to the calculation method of the elasticity mentioned above, we obtain the elasticity values between the relevant price series and the results are shown in Table 4.

Table 3. Two-stage asymmetric ECM results.[1]

Equations	Variables	Coefficients	Equations	Variables	Coefficients
1	S_t^G	0.775^{***} (0.064)	5	O_t^P	0.935^{***} (0.022)
	O_t^G	0.123^{***} (0.026)		C	531.635^{***} (154.094)
	C	$1,095.418^{***}$ (126.328)		R^2	0.934
	R^2	0.849			
2	$ECM_{t\text{-}1}^{+}$	-0.183^{*} (0.096)	6	$ECM_{t\text{-}1}^{+}$	-0.434^{***} (0.120)
	$ECM_{t\text{-}1}^{-}$	-0.148 (0.103)		$ECM_{t\text{-}1}^{-}$	-0.225^{**} (0.087)
	$\Delta S_{t\text{-}1}^{P}$	0.046 (0.123)		$\Delta O_{t\text{-}1}^{I}$	0.168 (0.110)
	$\Delta_{t\text{-}1}^{G}$	0.254^{**} (0.118)		$\Delta O_{t\text{-}1}^{P}$	0.279^{**} (0.139)
	$\Delta O_{t\text{-}1}^{G}$	0.061 (0.057)		R^2	0.315
	R^2	0.201			
3	O_t^G	0.897^{***} (0.046)	7	S_t^P	0.593^{***} (0.074)
	C	$3,130.734^{***}$ (193.956)		O_t^I	0.115^{***} (0.034)
	R^2	0.755		C	$1,308.891^{***}$ (220.761)
				R^2	0.623
4	$ECM_{t\text{-}1}^{+}$	-0.099^{*} (0.048)	8	$ECM_{t\text{-}1}^{+}$	-0.119^{**} (0.049)
	$ECM_{t\text{-}1}^{-}$	-0.024 (0.032)		$ECM_{t\text{-}1}^{-}$	-0.117^{**} (0.051)
	$\Delta O_{t\text{-}1}^{P}$	0.371^{***} (0.081)		$\Delta S_{t\text{-}1}^{I}$	0.144 (0.098)
	$\Delta O_{t\text{-}1}^{G}$	0.213^{***} (0.062)		$\Delta S_{t\text{-}1}^{P}$	0.233^{***} (0.082)
	R^2	0.406		$\Delta O_{t\text{-}1}^{I}$	-0.003 (0.047)
				R^2	0.275

[1] Asterisks indicate the significance level: * at the 10% level, ** at the 5% level, and *** at the 1% level; the values in parentheses are standard errors; the optimal lag order of Equation 2, 4, 6 and 8 are one order smaller than the VAR model, and the optimal lag order of the VAR model is determined by the five criteria of Likelihood Ratio, Final Prediction Error, Akaike Information Criterion, Schwarz Criterion and Hannan-Quinn.

In Table 4, the estimated elasticities of Chinese POE soybean price with respect to international soybean price and international energy price are 0.58 and 0.12, respectively. On average, an increase of 1% in the soybean price and energy price on the international market make Chinese POE soybean price increase by 0.58% and 0.12%, respectively. Chinese soybean consumption relies heavily on imports. Hence, the soybean import market is well integrated with the international soybean market. In general, international energy price has little effect on Chinese imported soybean price through international transportation costs channel. The estimated elasticities of Chinese inland soybean price with respect to Chinese POE soybean price and Chinese inland energy price are 0.52 and 0.17, respectively. On average, a 1% increase in Chinese POE soybean price and Chinese inland energy price leads to an increase in Chinese inland soybean price of 0.52% and 0.17%, respectively. In recent years, especially after the market-oriented reform of the soybean pricing mechanism in China, Chinese inland soybean market has increasingly integrated with its imported soybean market. However, Chinese local oil price is more intervened by the government, thus its effect on the inland soybean price through domestic transportation costs channel is not significant.

The estimated elasticity of Chinese POE energy price with respect to the international energy price is 0.53. On average, a 1% increase in the price of international energy leads to an increase in Chinese POE energy price of 0.53%. The international energy price, which is an important reference for domestic refined oil pricing in China, is closely correlated with Chinese POE oil price. The estimated elasticity of Chinese inland energy price with respect to Chinese POE energy price is 0.92. On average, a 1% increase in the price of Chinese POE energy price leads to an increase in Chinese inland energy price of 0.92%. At present, Chinese refined oil pricing mechanism still is government-oriented, with a constraint on international crude oil price. For that reason, oil prices in different parts of China often experience similar historical patterns.

Table 4. Relevant price elasticity among international, port-of-entry, and inland markets.[1]

Means of independent variables	**Estimated coefficients**	**Means of dependent variables**	**Elasticity of dependent variables to independent variables**
2,946.498 ($\bar{S}_t^G$)	0.775	3,874.481 ($\bar{S}_t^P$)	0.589 (elasticity of S_t^P to S_t^G)
4,001.497 ($\bar{O}_t^G$)	0.123	3,874.481 ($\bar{S}_t^P$)	0.127 (elasticity of S_t^P to O_t^G)
3,874.481 ($\bar{S}_t^P$)	0.593	4,397.544 ($\bar{S}_t^I$)	0.524 (elasticity of S_t^I to S_t^P)
6,819.941 ($\bar{O}_t^I$)	0.115	4,397.544 ($\bar{S}_t^I$)	0.179 (elasticity of S_t^I to O_t^I)
4,001.497 ($\bar{O}_t^G$)	0.897	6,720.636 ($\bar{O}_t^P$)	0.534 (elasticity of O_t^P to O_t^G)
6,720.636 ($\bar{O}_t^P$)	0.935	6,819.941 ($\bar{O}_t^I$)	0.921 (elasticity of O_t^I to O_t^P)
Elasticity of $\bar{S}_t^I$ to $\bar{S}_t^G$ = (elasticity of $\bar{S}_t^I$ to $\bar{S}_t^P$) × (elasticity of $\bar{S}_t^P$ to $\bar{S}_t^G$) = 0.309			
Elasticity of $\bar{S}_t^I$ to $\bar{O}_t^G$ = {(elasticity of $\bar{S}_t^I$ to $\bar{S}_t^P$) × (elasticity of $\bar{S}_t^P$ to $\bar{O}_t^G$) + {(elasticity of $\bar{S}_t^I$ to $\bar{O}_t^I$) × (elasticity of $\bar{O}_t^I$ to $\bar{O}_t^P$) × (elasticity of $\bar{O}_t^P$ to $\bar{O}_t^G$) = 0.193			

[1] The fourth column is equal to the product of the first column and the second column divided by the third column.

According to the channels that international soybean price and international energy price affect Chinese soybean price, we obtain the elasticities of Chinese inland soybean price to international soybean price and international energy price. The last three rows in Table 4 show the estimated cumulative pass-through elasticities of Chinese inland soybean price with respect to international soybean price and international energy price. We find that in the long run, Chinese inland soybean price is more affected by international soybean price. The cumulative pass-through elasticity of Chinese inland soybean price with respect to the international soybean price is 0.31. In the process of soybean price transmission, transmission from Chinese POE market to its inland market confronts relatively greater resistance than that from the international soybean market to Chinese POE market.

The cumulative pass-through elasticity of Chinese inland soybean price with respect to international energy price is 0.19, which is less than the cumulative pass-through elasticity of Chinese inland soybean price to international soybean price. In conclusion, there appear small elasticities either that Chinese POE soybean price responds to international energy price or that Chinese inland soybean price responds to its inland energy price. Therefore, international transportation costs and domestic transportation costs have no significant effect on Chinese inland soybean price.

Second, Table 5 summarizes the speed-of-adjustment findings by showing the number of months needed to absorb 80% of international soybean price and international energy price based on the elasticities and error correction coefficients in previous tables.

Table 5. Speed of adjustment for inland soybean price (months).[1,2]

Energy price		**Soybean price**		**Soybean price**	**Energy price–Soybean price**
International–POE (1)	POE–Inland (2)	International–POE (3)	POE–Inland (4)	International–Inland (3) + (4)	International–Inland (1) + (2) + (4)
4.289	0.907	2.572	2.071	4.643	7.267

[1] Authors' calculations based on results in Table 3 and Table 4; the last line represents when there is an 80% increase in international market price, the months required for the relevant domestic market price to adjust to equilibrium; the last two columns are obtained by directly adding the previous related columns. Here we implicitly believe that the adjustments occur sequentially rather than simultaneously.

[2] POE = port-of-entry.

The results show that in the short run, the international soybean price also has a larger effect on Chinese inland soybean price than international energy price does. Specifically, in Table 5 we see that if the international soybean price and international energy price increase by 80%, it would take Chinese inland soybean price 4.64 months and 7.26 months, respectively to correct to equilibrium. Chinese inland soybean price converges to a new equilibrium substantially faster in response to an international soybean price shock than to an international energy price shock. Therefore, when international soybean price and international energy price both increases, in the short run, Chinese inland soybean price will be greatly affected, primarily by the international soybean price.

4. Conclusions

The recent co-movements among Chinese soybean price, international soybean price, and international energy price lead to increasing concern of policy makers, academia, and global market participants. In this paper, we examine the effect of international soybean price changes and international energy price changes on Chinese soybean price volatility.

We find that both international soybean and energy price have impact on Chinese soybean price. In the long run, the cumulative pass-through elasticity of Chinese soybean price to international soybean price is 0.31, which is greater than the cumulative pass-through elasticity of Chinese soybean price to international energy price of 0.19. In the short run, Chinese soybean price is sensitive to price shocks from the international soybean market, and typically reaches a new equilibrium in a few months. The price of international energy also transmits to Chinese soybean market, but at a slower speed. Hence, both in the long run and the short run, we provide evidence that global soybean market connectedness, other than energy market transmission, is found to be the main driving force of Chinese soybean price volatility.

These results above help clarify the determinant of the co-movements among Chinese soybean price, international soybean price, and international energy price. Based on those findings, a special focus should be placed on the international soybean price to timely manage the risk of soybean imports for Chinese soybean traders. The shock of transportation costs caused by international energy price is relatively less significant but should not be ignored, since its impact can be further strengthened if domestic energy pricing becomes more market-oriented in China.

The findings provide useful information about how and how much international soybean price and international energy price affect Chinese inland soybean price. Different with existing research, our analysis is based on a model that incorporates transportation costs (i.e. energy price) as a non-fixed cost. As for limitations, the analysis presented in this paper is restricted by data availability: only two representative markets are considered for Chinese POEs and inland markets. It would be useful to be applied to more commodities and other countries.

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