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Full Length Research paper

Impact on the Chinese soybean markets from international prices volatility: Empirical study based on VEC model

Yu Zhao[1, 2]*, Miaomiao Yang[1], Yu Zhang[1, 2], and Chunjie Qi[1]

[1]College of Economics and Management, Huazhong Agricultural University, Wuhan, 430070, P. R. C.
[2]College of Economics and Management, East China Institute of Technology, Nanchang, 330013, P. R. C.

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The paper uses VEC model to analyze the impact of international prices volatility on Chinese soybean spot and future markets before and since the outbreak of the global financial crisis. The results show that: there is a one-way or both-way leading relation between domestic and international soybean markets; there is an equilibrating mechanism of prices in the world soybean market, which shows that the ability of market correction and the degree of adjustment of the mechanism became higher since the outbreak of the crisis; the future market can reduce the risk of prices volatility; prices volatility in domestic soybean markets is aroused by leading exporters, and there has been a volatility spillover effect between domestic soybean spot market and future market since the outbreak of the crisis.

Key words: Soybean market, soybean import, prices volatility, financial crisis, VEC model.

INTRODUCTION

Soybean is the earliest variety been marketed among all the cereal and oil crops in China. Since the implement of lower tariff policy in 1996, Chinese soybean import has been increasing. In 2000, China's soybean import has surpassed 10000 thousand tons, more than a quarter of that year's world soybean import, becoming the world's biggest soybean importer. At the same time, proportion of Chinese soybean production in the world decreased. Proportion of Chinese soybean production in the world in 1998 was about 9.4%, and the proportion in 2007 decreased to about 6.4%. But the proportion of USA, Brazil and Argentina in the world production in 2007 is 36.7, 24.9 and 20.6% respectively. During the period from 1998 to 2007, soybean production of USA has been decreasing, while that in Brazil and Argentina have been growing quickly. Because of the development of industry and the rising of consumption level, soybean consumption is increasing. Chinese soybean consumption in 1998 accounted for only 11.8% of the world total consumption of soybean, and the proportion exceeded 20.2% in 2007. But the proportion of the USA has decreased from 32.2 to 23.7%.

The largest consumption countries or regions, but the USA and China, are Argentina, Brazil and EU; the proportions of soybean consumption of the three in 2007 are 15.6, 15.2 and 7.2% respectively. The top three soybean exporters are USA, Brazil and Argentina. Soybean exports of the USA in 1998 accounted for 58.6% of the world total soybean exports, and that in Brazil and Argentina accounted for 21.7 and 8% respectively, while the proportion in 2007 became 42.5, 32.9 and 13.4% respectively (Figure 1). China, Japan and EU are the major soybean importers. With the decrease of soybean production and increase of domestic industry demand, China has become the largest soybean importer in the world. Soybean import of China in 1998 was about 2.94 million tons, accounting for 7.5% of the world total soybean import, while that in 2007 was about 30.82 million tons (worth about 11.47 billion dollars), accounting for over 41.6% of the world total soybean import. Soybean import of China in 2008 reached 37.44 million tons, which increased by 21.5% than 2007, setting a record of soybean import in China for the fourth consecutive year. World agricultural supply and demand

*Corresponding author. E-mail: math052360@gmail.com.

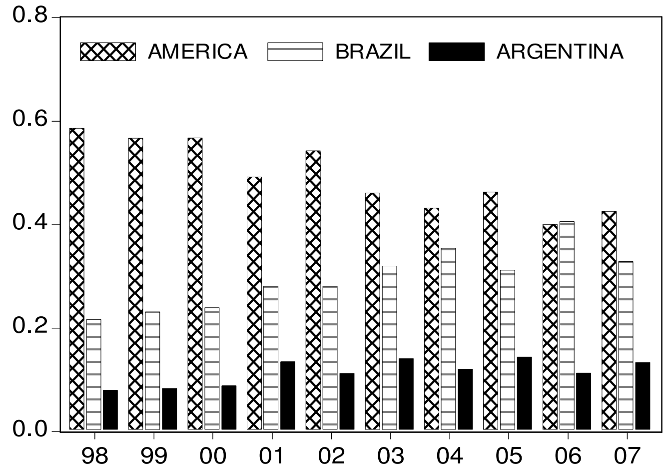

Figure 1. Proportion of export in world total export.

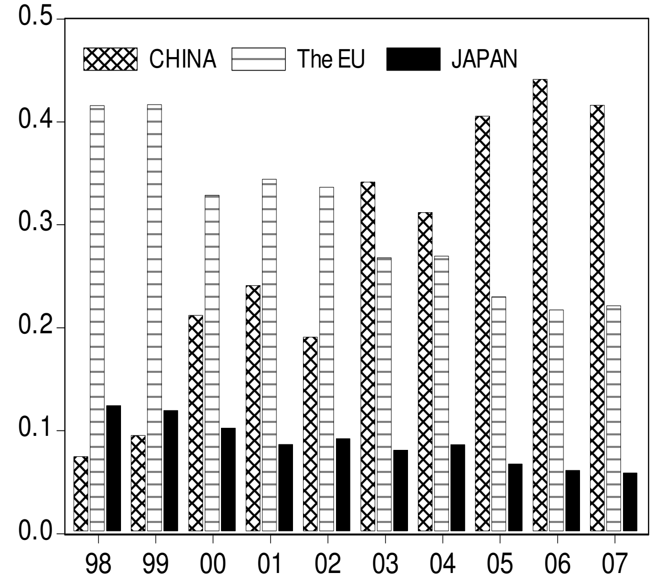

Figure 2. Proportion of import in world total import.

of USDA (United States Department of Agriculture) estimates soybean import of China will reach 38.1 million tons during 2009 to 2010. Latest data of China's General Administration of Customs shows China has imported 22.1 million tons soybean in the first half of the year, which has increased 28% year-on-year. Because of the restriction on GM food, soybean import in UN falls off slightly. Its proportion in world total soybean import decreased from 41.6% in 1998 to 22.2% in 2007 (Figure 2). Japan is a net importer of soybean; its soybean import maintains between 4 million and 5 million tons because of its soybean reserve mechanism. Through comparative analysis of production, consumption, import and export of soybean, we find that Chinese soybean supply mainly depends on international market and the degree of dependency is intensifying. Excessive dependency on international market increases risks on domestic soybean market and soybean industrial chain of China. After the accession to the WTO, several risks resulted from big changes of soybean prices in Chinese soybean market.

Soybean import price fluctuated fiercely during 2002 to 2003, resulting in bankrupt or acquisition of all domestic oil manufacture enterprises except COFCO (China Grain Group) and Sanjiu Enterprise Group. Moreover, domestic soybean importers suffered different amounts of loss until Chinese government temporarily established transgenic office to restrict the import of transgenic soybean in order to make domestic soybean market survive the shock of price volatility. Sharp fluctuation in soybean import prices also occurred in 2007 and 2008. Fierce price volatility this time not only affected domestic soybean market but also affected downstream breeding industry. Comparing with domestic soybean market, wheat, corn and paddy markets whose degree of internationalization are much lower, don't meet similar crisis. Does high degree of internationalization result in fierce price volatility of domestic soybean? To answer this question, we need analyze transmission mechanism of international soybean price volatility. So, quantifying the impact of international soybean price volatility on domestic soybean market has some theoretical value and realistic meaning. It's not only helpful to objectively realize international soybean price volatility but also helpful to take relevant measures aiming at preventing risk. There are many researches about soybean prices at home and abroad, but few are about the impacts of trade price volatility of foreign main soybean planted countries on the price of Chinese soybean. Domestic researches mainly focus on soybean futures market and pay less attention to volatility characteristics of spot prices. Machado et al (2001) took Brazil and Argentina for example to study international transmission of soybean seasonal prices, and found that time series of soybean prices of Brazil, Argentina and CBOT (Chicago Board of Trade) all have season term. Liu et al (2006) used ECM model to study volatility relationship between Chinese soybean futures prices and spot prices. Results shows there are co-integration relationship and bidirectional causality between spot prices and futures prices of Chinese soybean. Margarido et al. (2007) took CIF (Cost Insurance and Freight) Rotterdam, FOB (Free on Board) Paranagua BRZ (Brazil), FOB Up River ARG (Argentina) and FOB US Gulf as research objectives, and used VEC model to calculate conductive elasticity between prices. Results shows responses of the three countries to the shock of international market are different. Brazil and Argentina respond faster to the shock, thus they are price takers. USA responds slower to the shock, thus it is price maker. Then the paper explains the results from the different time of harvest and marketing for different commodities. Li and Wu (2007) used EC-TARCH-M to study the influence of spot market information and futures transaction behavior of soybean, soybean meal, corn et al on futures market volatility.

Results showed both soybean spot market and futures market have leverage effect. Hua and Liu (2007) used two-parameter AR-EGARCH model to study the volatility spillover effect of soybean prices in CBOT and DCE (Dalian Commodity Exchange). They found influence of international soybean futures market on domestic soybean futures market is greater than the influence of domestic soybean futures market on the international market. Zhou and Zou (2007) studied relationship between soybean futures prices in the USA, Japan and China by using VAR (3). Results showed American soybean futures market hold a leading position in global soybean futures pricing, but influences of China and Japan on price formation of global soybean futures were limited. The paper takes intra-day data from November 10, 2006 to July 31, 2009 as samples, and quantifies the impact of international soybean price volatility on domestic soybean markets and gets corresponding policy implications. The paper is divided into five parts. Besides the introduction part, the second part is about basic hypothesis and models setting, mainly focusing on deriving basic econometric models on the basis of hypothesis. The third part describes samples and tests and tests relevant data. The fourth part gives results of econometric analysis. The last part draws conclusions and proposes corresponding policy implication.

THEORETICAL DERIVATION AND MODELS

Trade status of Chinese soybean is not coordinated to its international pricing power. Price of international soybean trade usually uses transaction price in CBOT as benchmark price, which is the basis for suppliers and demanders signing an agreement about contract price (Wang, 2007). CBOT is the biggest pricing center of soybean trade in the world. But China, as the world's biggest soybean importer, may have feedback effect on international market while its domestic market is shocked by international price. So we assume that domestic soybean market has feedback effect on the international market. Mundlack and Larson (1992) assumed price equalization existed between domestic prices and international prices of agricultural commodities in the long run and allowed for deviations in the short run. They developed theoretical model of price conduction as follows. $P_{it}=P^{*}_{it} \times E_t \times (1+\tau)$, which means one country's soybean price P_{it} is equal to the product of world soybean price P^{*}_{it}; nominal exchange rate E_t and tariff $(1+\tau)$. Here τ is tariff rate and be regarded as a constant. On the basis of the theoretical model, we deduce statistical form of the price conduction model:

$$\ln P_{it} = \alpha + \beta \ln P^{*}_{it} + \gamma \ln E_t + \varepsilon_{it} \quad (1)$$

Here α is equal to $ln(1+\tau)$ and β is the elasticity of price conduction. Consider representative soybean price in world market and domestic prices of spot and futures as a price system to study the shock of foreign soybean prices to domestic soybean market. Comprehensively consider long term trend and short term volatility of prices, we need use error term to correct price conduction model, so we choose VEC model proposed by Engle and Granger in 1987.

On the one hand, difference term in VEC model eliminates trend factor that may contain in variables, thus avoiding spurious regression. On the other hand, error correction term in VEC model ensures that information of original variables is not ignored. USA, Brazil and Argentina are the three most important soybean exporters. CIF US Gulf, FOB Paranagua BRZ and FOB Up River ARG are often used in international soybean trade. Thus, we choose the three representative prices to represent international prices of soybean. Note them as P_u, P_b and P_a respectively. Choose Dalian soybean spot prices and DCE futures closing prices of nearby delivery month to represent the domestic prices, and note the two as P_s and P_f respectively.

Consider ΔlnP_t as price volatility because of $\Delta lnP_t=lnP_t-lnP_{t-1}=ln(P_t \div P_{t-1})$. VEC model is as follows:

$$\Delta \ln P_t = \alpha ecm_{t-1} + \sum_{i=1}^{q} \Gamma_i \Delta \ln P_{t-i} + \varepsilon_t \quad (2)$$

q refers to lag order and its value is determined by SC and AIC. ε_t refers to residual vector of equation k at time t. Assume it has the characteristic of white noise. Error correction term ecm_{t-1} is the function of price lnP_{t-1} and its number is undetermined. Coefficient Γ_i indicates matrix of volatility elasticity. The concrete form of model will be determined after data diagnosis.

DATA AND DIAGNOSIS

Data

The paper uses intra-day data from November 10, 2006 to July 31, 2009 to do the research. All price data are got from Yi Sheng Information Database of CZCE (Zhengzhou Commodity Exchange). Units of the three international prices are all U.S. dollars/tons and that of the two domestic prices are Yuan/ton. Exchange rates of the Chinese Yuan against the US dollar (Medial Rata) are from State Administration of Foreign Exchange. International prices are converted at the spot exchange rate of the current day. Match all the price variables according to trading day and there are 649 sets of data after rejecting deleted observed value.

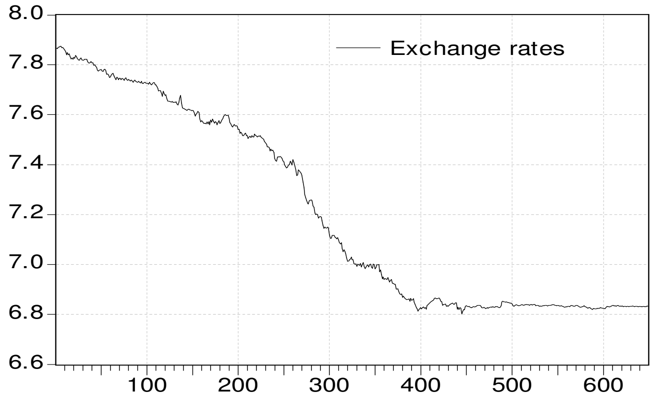

Figure 3. Exchange rates of the Chinese Yuan against the US dollar.

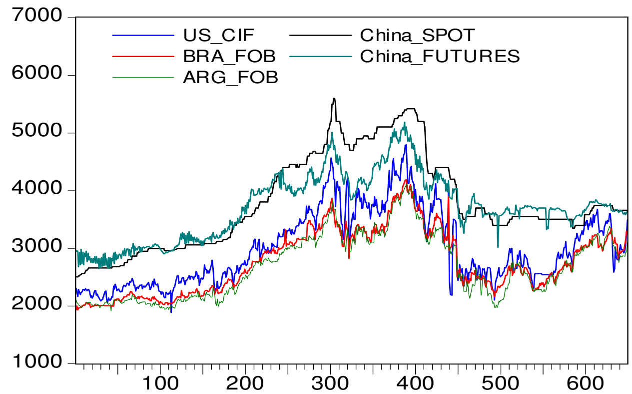

Figure 4. Soybean prices at home and abroad (unit: Yuan/ton).

In order to eliminate influence of volatility of exchange rate on the results of research, the paper firstly uses exchange rate (Medial Rata) to transmit international prices to Yuan/ton (Figure 3). In Figure 4, soybean prices at home and abroad volatile fiercely in the past three years. During the period, the lowest spot price of domestic soybean is 2500 Yuan/ton and the highest is 5600 Yuan/ton, whose amplitude of the difference has reached 3100 Yuan/ton. The lowest future price is 2647 Yuan/ton and the highest is 5185 Yuan/ton, whose amplitude of the difference has reached 2538 Yuan/ton. The lowest price of CIF US Gulf is 1888 Yuan/ton and the highest is 4797 Yuan/ton, whose amplitude of the difference has reached 2909 Yuan/ton. The lowest price of FOB Paranagua BRZ is 1929 Yuan/ton and the highest is 4187 Yuan/ton, whose amplitude of the difference has reached 2258 Yuan/ton. The lowest of FOB Up River ARG is 1912 Yuan/ton and the highest is 4105 Yuan/ton, whose amplitude of the difference has reached 2193 Yuan/ton.

Unit root test

Many economic variables are non-stationary. They may be integrations with one order or more. For non-stationary variables, classical regression models can't be used, or will result in spurious regression. Thus, we need test stationarity of price series before modeling. Seeing from checking results, price series are all integrations of order one. That is to say, first order difference of the price series are stationary series. The result shows that spurious regression will not appear no matter modeling with original variables or difference of the variables. In order to build models, we also need to test whether there are long term equilibrium mechanisms among models. If there were, we still need to confirm the number of equilibrium mechanism; if there weren't, coefficient before emc_{t-1} in model (1) is 0. Thus VEC model becomes VAR model.

Co-integration test

In a predictable economic system, there are some kinds of equalizing internal mechanism existing among economic variables. If one variable deviates from the long term equilibrium point because of disturbance, the equilibrium mechanism will adjust in the next period and bring it back to equilibrium state. If variables are all integrations, they may be co-integration only when the order of their integration is the same. For more than three variables, if the order is different, they may compose integration variables with lower order or stationary variables through linear combination. Use Johansen co-integration test to test equilibrium mechanism of the system to confirm whether there is some kind of stationary linear combination among the variables. In other words, whether there is long term stationary relationship (co-integration relationship) among variables. The form of co-integration test is determined by the result of unit root tests, which is "system just has intercept term c but doesn't have linear trend term t".

The detailed results of Johansen co-integration test are listed in Table 2. Test results show that the first null hypothesis of "no long-term equilibrium relationship between variables" is rejected at the significant level of 1%. That's to say there is at least one co-integration vector between the five variables. The second null hypothesis of "one co-integration vector between variables at most" is rejected at the significant level of 1%. That's to say there are at least two co-integration vectors between variables. The third null hypothesis of "two co-integration vectors between variables at most" is accepted, which means that there are two kinds of equilibrium mechanism existing in soybean price system. The result indicates it's more rational to choose VEC model rather than VAR model to study soybean price system. Existing of equilibrium mechanism can only reveal the uni-directional causation between variables, so further test is expected to validate the direction of causality between domestic soybean price and international soybean price.

United causality test

Granger united causality test is built on the basis of VAR model. The basic principle of Granger causality is that if the past and present information about variable X can help the prediction of variable Y, then variable Y is caused by variable X on Granger causes. The first and second lines in Table 3 are causality between futures prices and spot prices of domestic soybean. Lines from the third to the eighth are causality between domestic spot price and international prices. Lines from the ninth to the fourteenth are causality between domestic futures price and international prices. From the testing results, we get following conclusions. First, in domestic soybean market, there is bidirectional causality between spot prices and futures prices. That's to say spot prices and futures prices are guided by each other. Second, CIF US Gulf have guiding function on domestic spot prices, but it rejects guiding function of

Table 1. Results of ADF test of soybean price series.

	t	Prob.	Optimum checking type		t	Prob.	Optimum checking type
InP_s	-1.9099	0.3278	1. 0. 2	ΔInP_s	-13.3557	0	0. 0. 1
InP_f	-1.9388	0.3144	1. 0. 3	ΔInP_f	-17.2166	0	0. 0. 2
InP_u	-1.8954	0.3346	1. 0. 5	ΔInP_u	-17.2480	0	0. 0. 4
InP_b	-1.7065	0.4275	1. 0. 1	ΔInP_b	-29.7988	0	0. 0. 0
InP_a	-1.6547	0.4539	1. 0. 0	ΔInP_a	-25.8321	0	0. 0. 0

Note: Checking type is (c, t, k). Value of c is 0 or 1, in which 0 means there isn't intercept term in checking model and the meaning of 1 is just opposite. Value of t is 0 or 1, in which 0 means there isn't time trend term in checking model and the meaning of 1 is just opposite. k is nature number and it represents order of lag term in checking model.

Table 2. Diagnosis of equilibrium mechanism of soybean price system.

Null hypothesis	Unit root	Trace statistic value	Significance of 1%	Significance of 5%	Prob.
No co-integration vector	0.1083	142.1306	85.3365	76.9728	0.0000
One co-integration vectors at most	0.0628	68.3171	61.2669	54.0790	0.0016
Two co-integration vectors at most	0.0255	26.5780	41.1950	35.1928	0.3106
Three co-integration vectors at most	0.0089	9.9690	25.0781	20.2618	0.6429
Four co-integration vectors at most	0.0065	4.2258	12.7608	9.1645	0.3795

Table 3. United causality test.

Null hypothesis	Prob.								
	Lag 2	Lag 3	Lag 4	Lag 5	Lag 6	Lag 7	Lag 8	Lag 9	Lag 10
$InP_f ο InP_s$	3.5×10^{-7}	2.0×10^{-6}	8.0×10^{-7}	8.6×10^{-7}	2.9×10^{-6}	6.6×10^{-6}	3.0×10^{-6}	5.7×10^{-6}	3.8×10^{-6}
$InP_s ο InP_f$	0.0022	0.0018	0.0105	0.0224	0.0307	0.0293	0.0436	0.0577	0.0780
$InP_u ο InP_s$	6.5×10^{-10}	9.4×10^{-9}	3.6×10^{-8}	8.0×10^{-8}	7.1×10^{-9}	4.9×10^{-8}	2.8×10^{-8}	5.8×10^{-8}	3.6×10^{-9}
$InP_s ο InP_u$	7.9×10^{-7}	1.3×10^{-5}	3.7×10^{-5}	0.0260	0.1340	0.1979	0.1943	0.1969	0.1668
$InP_b ο InP_s$	1.1×10^{-6}	4.6×10^{-7}	2.0×10^{-7}	2.9×10^{-7}	8.2×10^{-7}	3.2×10^{-6}	1.2×10^{-7}	3.7×10^{-7}	3.7×10^{-8}
$InP_s ο InP_b$	0.2927	0.5732	0.6048	0.6124	0.4450	0.5346	0.5911	0.6716	0.7581
$InP_a ο InP_s$	0.0301	0.1416	0.1189	0.1959	0.1679	0.0212	0.0260	0.0307	0.0406
$InP_s ο InP_a$	9.8×10^{-6}	2.2×10^{-5}	8.5×10^{-5}	0.0002	0.0003	0.0006	0.0012	0.0002	0.0003
$InP_u ο InP_f$	3.3×10^{-9}	8.1×10^{-8}	1.5×10^{-7}	1.5×10^{-6}	3.5×10^{-6}	1.5×10^{-6}	4.3×10^{-6}	7.8×10^{-6}	1.4×10^{-5}
$InP_f ο InP_u$	1.2×10^{-5}	8.5×10^{-5}	0.0006	0.0060	0.0097	0.0058	0.0091	0.0095	0.0191
$InP_b ο InP_f$	4.5×10^{-11}	4.6×10^{-12}	2.4×10^{-12}	4.6×10^{-12}	1.6×10^{-12}	7.0×10^{-12}	2.9×10^{-11}	1.1×10^{-10}	3.0×10^{-10}
$InP_f ο InP_b$	0.1653	0.2764	0.4184	0.3989	0.3422	0.5419	0.5474	0.5293	0.5467
$InP_a ο \lambda nP_f$	0.0088	0.0232	0.0104	0.0278	0.0302	0.0394	0.0305	0.0321	0.0551
$InP_f ο InP_a$	6.7×10^{-5}	2.1×10^{-6}	8.4×10^{-6}	8.8×10^{-6}	1.4×10^{-5}	2.0×10^{-5}	3.1×10^{-5}	0.0001	0.0002

Note: $A ο B$ indicates A is not the Granger cause of B. Null hypothesis is rejected when P is less than 0.1.

domestic spot prices on CIF US Gulf in most of the lag phases. Third, FOB Paranagua BRZ has guiding function on domestic spot prices, but domestic spot prices don't have guiding function on it. Fourth, FOB Up River ARG has certain guiding function on domestic spot prices in most lag phases, and domestic spot prices have guiding function on it too. Fifth, there are mutual guiding function between CIF US Gulf and domestic futures prices. Sixth, FOB Paranagua BRZ has guiding function on domestic futures prices, but domestic futures prices don't have guiding function on it. Seventh, there are mutual guiding function between FOB Up River ARG and domestic futures prices. We know, from the above results, that relationship between domestic soybean futures price and international prices is stronger than that between spot prices and international prices, which is just in accord with price discovery function of futures markets.

We can understand the above conclusions from import structure of Chinese soybean. In 2007, soybean importing from USA and Argentina to China increased, but that from Brazil decreased.

Table 4. Estimation value of co-integration equations.

Variables	Before the outbreak of financial crisis		After the outbreak of financial crisis	
	$ecm_{1,t-1}$	$ecm_{2,t-1}$	$ecm_{1,t-1}$	$ecm_{2,t-1}$
$lnP_{s,t-1}$	1	0	1	0
$lnP_{f,t-1}$	0	1	0	1
$lnP_{u,t-1}$	-2.0981***	-0.4120	-4.7858***	-6.0775***
	[-6.1479]	[-1.0667]	[-5.0830]	[-5.4824]
$lnP_{b,t-1}$	-3.6623***	-5.1696***	-6.3730***	-7.0735***
	[-7.1190]	[-8.8797]	[-3.5348]	[-3.3322]
$lnP_{a,t-1}$	4.7136***	4.7871***	8.7628***	10.4179***
	[9.1903]	[8.2476]	[5.9347]	[5.9926]
	0.3582	-1.7448***	11.2515**	14.0049***
	[0.8168]	[-3.5160]	[2.5127]	[2.6563]

Note: Numbers in [ ] are t statistics. ** denotes significant at confidence level of 5%. *** denotes significant at confidence level of 10%.

Soybean importing from USA and Argentina to China in 2007 was 11.57 million tons and 8.277 million tons respectively, increased by 17.1 and 33.1%, respectively. Soybean importing from Brazil was10.58 million tons, decreased by 8.9%. Total quantity of soybean importing from the three markets accounted for 98.7% of China's soybean import in 2007. Soybean importing from USA to China in 2008 reached 15.431 million tons, accounting for 41.2% of whole Chinese soybean import of that year. Comparing with 11.571 million tons importing from USA in 2007, there was an increase of 3860 thousand tons with the increasing percent of 33.4. Soybean importing from Brazil to China in 2008 reached 11.653 million tons, accounting for 31.1% of whole Chinese soybean import of that year. Comparing with 10.583 million tons importing from Brazil in 2007, there was an increase of 1070 thousand tons with the increasing percent of 10.1. Soybean importing from Argentina to China in 2008 reached 9.849 million tons, accounting for 26.3% of whole Chinese soybean import of that year. Comparing with 8.278 million tons importing from Argentina in 2007, there was an increase of 1571 thousand tons with the increasing 19%. Chinese soybean markets are close to American soybean markets, which may be related to that, USA is the world pricing center of global transgenic soybean and China is the world pricing center of global non-transgenic soybean. In addition, China is the biggest importer of American soybean. During the sample period of the paper, futures prices of Chinese soybean can't guide FOB Paranagua BRZ. China has increased soybean import from Argentina over the past two years. Argentina exported 9.56 million tons soybean in 2007, of which about 86.6% were exported to China. The proportion remained 83.1% in 2008. Though the whole soybean exports of Argentina has decreased obviously in 2009, its soybean is mainly exported to China, which kindly explains why there are mutual causality between soybean prices of China and Argentina. Results of united causality test prove the hypothesis of "domestic soybean market has feedback effect on the international market", so it's rational to regard domestic and international soybean prices as a system and adopt VEC mode to do the study.

ESTIMATION RESULTS OF MODELS

We can confirm there are two co-integration equations contained in the system from co-integration test. Use Eviews5.0 to estimate models. In order to compare the influence of financial crisis in 2008 on international market and domestic market, the paper takes the outbreak of financial crisis as borderline to divide the series into two phases: the first phase is from November 10, 2006 to September 14, 2008 and the second phase is from September 15, 2008 to July 31, 2009. Results of parametric estimation of VEC model of the two phases are listed in Table 4. Table 5 only lists results of parametric estimation of domestic spot prices and domestic futures prices.

Equilibrium mechanism of global soybean markets before the outbreak of financial crisis is as follows:

$$ecm_{1,\ t-1} = lnP_{s,\ t-1} -2.0981\ lnP_{u,\ t-1} -3.6623\ lnP_{b,\ t-1} +4.7136\ lnP_{a,\ t-1} \quad (3)$$

$$ecm_{2,\ t-1} = lnP_{f,\ t-1} -5.1696\ lnP_{b,\ t-1} +4.7871\ lnP_{a,\ t-1} -1.7448 \quad (4)$$

Equilibrium mechanism of global soybean markets after the outbreak of financial crisis is as follows:

$$ecm_{1,\ t-1} = lnP_{s,\ t-1} -4.7858\ lnP_{u,\ t-1} -6.3730\ lnP_{b,\ t-1} +8.7628\ lnP_{a,\ t-1} +11.2515 \quad (5)$$

$$ecm_{2,\ t-1} = lnP_{f,\ t-1} -6.0775\ lnP_{u,\ t-1} -7.0735\ lnP_{b,\ t-1} +10.4179\ lnP_{a,\ t-1} +14.0049 \quad (6)$$

Wave equations of spot market and futures market of domestic soybean before the outbreak of financial crisis:

$$\Delta lnP_{s,\ t} = -0.0315 ecm_{1,\ t-1} + 0.0222 ecm_{2,\ t-1} + 0.1772 \Delta lnP_{s,\ t-1} + 0.0272 \Delta lnP_{u,\ t-1} \quad (7)$$

$$\Delta lnP_{f,\ t} = -0.7468 \Delta lnP_{f,\ t-1} + 0.0532 \Delta lnP_{u,\ t-1} + 0.2003 \Delta lnP_{b,\ t-1} + 0.1070 \Delta lnP_{a,\ t-1} \quad (8)$$

Table 5. Estimation value of error correction equations.

Variables	Before the outbreak of financial crisis				After the outbreak of financial crisis			
	$\Delta lnP_{s,t}$		$\Delta lnP_{f,t}$		$\Delta lnP_{s,t}$		$\Delta lnP_{f,t}$	
	Parameter	Value of t	Parameter	Value of t	Parameter	Value of t	Parameter	Value of t
$ecm_{1,t-1}$	-0.0315***	-6.0406	-0.0142	-1.1410	-0.1232***	-5.9937	0.1143**	2.1077
$ecm_{2,t-1}$	0.0222***	4.0700	-0.0124	-0.9557	0.1035***	6.0094	-0.0940**	-2.0694
$\Delta lnP_{s,t-1}$	0.1772***	3.8738	-0.0212	-0.1940	0.0464	0.6780	0.4508**	2.4970
$\Delta lnP_{f,t-1}$	0.0031	0.2229	-0.7468***	-22.5011	-0.0858***	-3.1832	-0.2893***	-4.0708
$\Delta lnP_{u,t-1}$	0.0272**	2.0251	0.0532*	1.6582	0.0296**	2.0146	-0.0094	-0.2418
$\Delta lnP_{b,t-1}$	0.0164	0.7028	0.2003***	3.5931	0.0125	0.5155	0.1110*	1.7351
$\Delta lnP_{a,t-1}$	-0.0064	-0.3180	0.1070**	2.2258	0.0307	1.4347	0.0289	0.5125
R^2	0.214		0.5703		0.1991		0.1693	
$Adj\text{-}R^2$	0.203		0.5643		0.1756		0.1448	
SSR	0.0293		0.1671		0.0162		0.1126	
AIC	-6.7405		-4.9989		-6.5714		-4.6317	
SC	-6.6751		-4.9336		-6.4602		-4.5205	

Note: *denotes significant at confidence level of 10%. ** denotes significant at confidence level of 5%. *** denotes significant at confidence level of 1%.

Wave equations of spot market and futures market of domestic soybean after the outbreak of financial crisis:

$$\Delta lnP_{s,t}=-0.1232ecm_{1,t-1}+0.1035ecm_{2,t-1}-0.0858\Delta lnP_{f,t-1}+0.0296\Delta lnP_{u,t-1} \quad (9)$$

$$\Delta lnP_{f,t}=0.1143ecm_{1,t-1}-0.0940ecm_{2,t-1}+0.4508\Delta lnP_{s,t-1}-0.2893\Delta lnP_{f,t-1}+0.1110\Delta lnP_{b,t-1} \quad (10)$$

Equations (3) to (10) indicate, after the outbreak of financial crisis, both the equilibrium mechanism of world soybean market and its adjustment efforts, as well as volatility structure of the domestic market, have changed.

CONCLUSION AND DISCUSSION

First, there are close connection between domestic and international soybean market. It is concretely manifested in the aspect of price guiding. CIF US Gulf has guiding function on both domestic spot and futures prices, and Chinese soybean futures prices also have guiding function on CIF US Gulf. FOB Paranagua BRZ has guiding function on both domestic spot and futures prices, but domestic soybean prices don't have guiding function on it. Margarido's research shows Brazil soybeans are mainly exported to EU through Rotterdam, which makes FOB Paranagua BRZ mainly guided by FOB Rotterdam (Margarido, 2007). There are mutual guiding function between FOB Up River ARG and domestic soybean prices.

Second, there are price equilibrium mechanism between domestic soybean market and international soybean market. The mechanism can adjust market to equilibrium state, which is in accord with price equilibrium theory of international agricultural products proposed by Mundlack in 1992. Knowing from coefficients before error correction term, adjustment efforts of equilibrium mechanism in spot market before the outbreak of financial crisis is (-0.0315, 0.0222) and that in futures market is (0, 0), while that after the outbreak of financial crisis is (-0.1232, 0.1035) and (0.1143, -0.0940), respectively. It's obvious that adjustment efforts of equilibrium mechanism have changed after the outbreak of financial crisis. The adjustment efforts became smaller after the outbreak of financial crisis, which means soybean market can make self-adjustment according to market quotation.

Third, after the outbreak of financial crisis, coefficients before futures market fluctuation term $\Delta lnP_{f,\ t-1}$ in wave equations (9) and (10) is negative, which indicates Chinese soybean futures market can reduce the risk of prices volatility in spot market. Soybean futures market fulfills its function of decreasing risk of prices volatility during financial crisis. Fourth, before the outbreak of financial crisis, coefficients before fluctuation terms $\Delta lnP_{u,\ t-1}$, $\Delta lnP_{b,\ t-1}$ and $\Delta lnP_{a,\ t-1}$ are all positive, indicating volatility of CIF US Gulf, FOB Paranagua BRZ and FOB Up River ARG before the outbreak of financial crisis can aggravate volatility in Chinese soybean market. Coefficients before fluctuation term $\Delta lnP_{s,\ t-1}$ in wave equation (7) is bigger than 0, which indicates that spot price volatility of soybean before the outbreak of financial crisis is not only affected by international market but also affected by supply and demand in domestic market. In addition, we can see from equations (7) and (8), there doesn't have a volatility spillover effect in domestic soybean spot market and futures market before the outbreak of the crisis. After the outbreak of financial crisis, coefficients before fluctuation terms $\Delta lnP_{u,\ t-1}$ and $\Delta lnP_{b,\ t-1}$

are 0.0296 and 0.1110 respectively, which indicates that CIF US Gulf and FOB Paranagua BRZ after the outbreak of financial crisis will aggravate volatility in Chinese soybean market. Meanwhile, it indicates volatility of Chinese soybean market is mainly influenced by international market. Wave equations (9) and (10) have $\Delta lnP_{f,\ t-1}$ and $\Delta lnP_{s,\ t-1}$ respectively, indicating domestic soybean market has a volatility spillover effect after the outbreak of financial crisis.

Soybean is the variety with the highest level of marketization and internationalization among Chinese cereal and oil crops. Soybean markets have the ability to self-modification and self-regulation, so management departments are not suitable for excessive intervention for price volatility. For futures markets, it needs to further improve the construction of futures markets, so that it can better fulfill the function of price discover and reduce the risk of prices volatility in spot markets. It's not suitable to excessively restrict price volatility of soybean futures to prevent decreasing of market liquidity or compromising market volatile efficiency. We should accelerate innovation of risk management system and guard against the risk of market volatility on the premise of none losing of volatile efficiency. We should pay more attention to production and self-supply of domestic soybean to avoid over-reliance on foreign soybeans. After the outbreak of financial crisis, we can appropriately increase soybean import from Argentina to decrease the impact of soybean market fluctuation in the USA and Brazil to domestic markets.

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