Effects of exchange rates on China's agricultural products: The case of soybean trade between China and the U.S.

by

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Abstract

Exchange rate is a potentially important factor affecting international trade. In the past 30 years, the exchange rate of RMB against USD has changed a lot. In the recent 10 years, for example, the real RMB appreciated against the USD by 30%. This study develops an Equilibrium Displacement Model (EDM) to analyze the effects of a change in the Yuan/USD exchange rate on China's imports of soybeans from the United States and soybean prices. The EDM predicts that when the RMB strengthens against the USD, the price China pays for soybeans imports from the United States decreases, its imports from the United States increases, and price received by U.S. producers of soybeans increases. In the second part of this paper, the predictions from the EDM are tested by replicating the empirical analysis of Devadoss *et al*. (2014). The empirical model provides estimates of the short- and long-run effects of a change in Yuan/USD exchange rate on China's soybean imports from the US, the real price of soybeans in China, and the real US farm price. The results suggest the exchange rate has no effect on China's imports of in the short-run, which conflicts with the findings by Devadoss *et al*. (2014). The estimated long-run effect of the exchange rate on imports is also insignificant. Thus result is consistent with Devadoss *et al*. (2014)'s findings. Overall, results suggest the most important factor affecting China's imports is China's real GNP (elasticity = 1.08), followed by the production cost of soybeans in China (elasticity = 0.38). The income elasticity suggests China's imports of soybeans from the United States will grow at about the same pace as income growth. The estimated price equations showed little explanatory power. The exchange rate in particular was found to have no effect on price of soybeans in either China or the United States.

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List of Abbreviations

AIC	Akaike Information Criterion
ARDL	Autoregressive Distributed Lag
CPI	Consumer Price Indexes
CH	China
EC	Error Correction
EDM	Equilibrium Displacement Model
ER	Exchange rate
GDP	Gross Domestic Product
LOP	Law of One Price
RMB	Chinese Yuan Renminbi
ROW	Rest of World
US	the United States
USD	US Dollar

Effects of exchange rates on China's agricultural products:

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1. Background

Soybeans have been an important agricultural product that people consumed in China for a long time. In the period before the 1990s, the supply of soybeans was mainly dependent on domestic product. After the 1990s, with the increase of soybean demand, China began to import soybean from the world market.

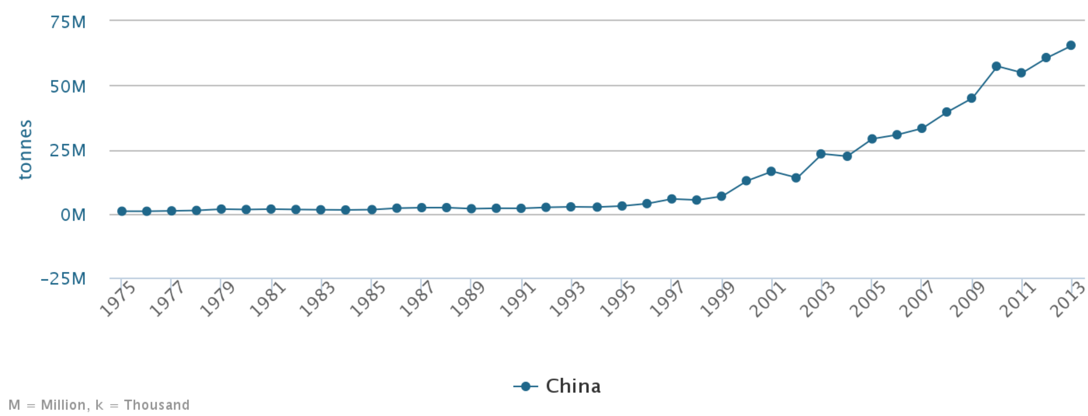

Figure 1. 1975-2013 China's soybean import quantity (Source: FAOSTAT)

In recent years, China has become the world's largest soybean importer, and a large proportion of the soybean is from the American market.

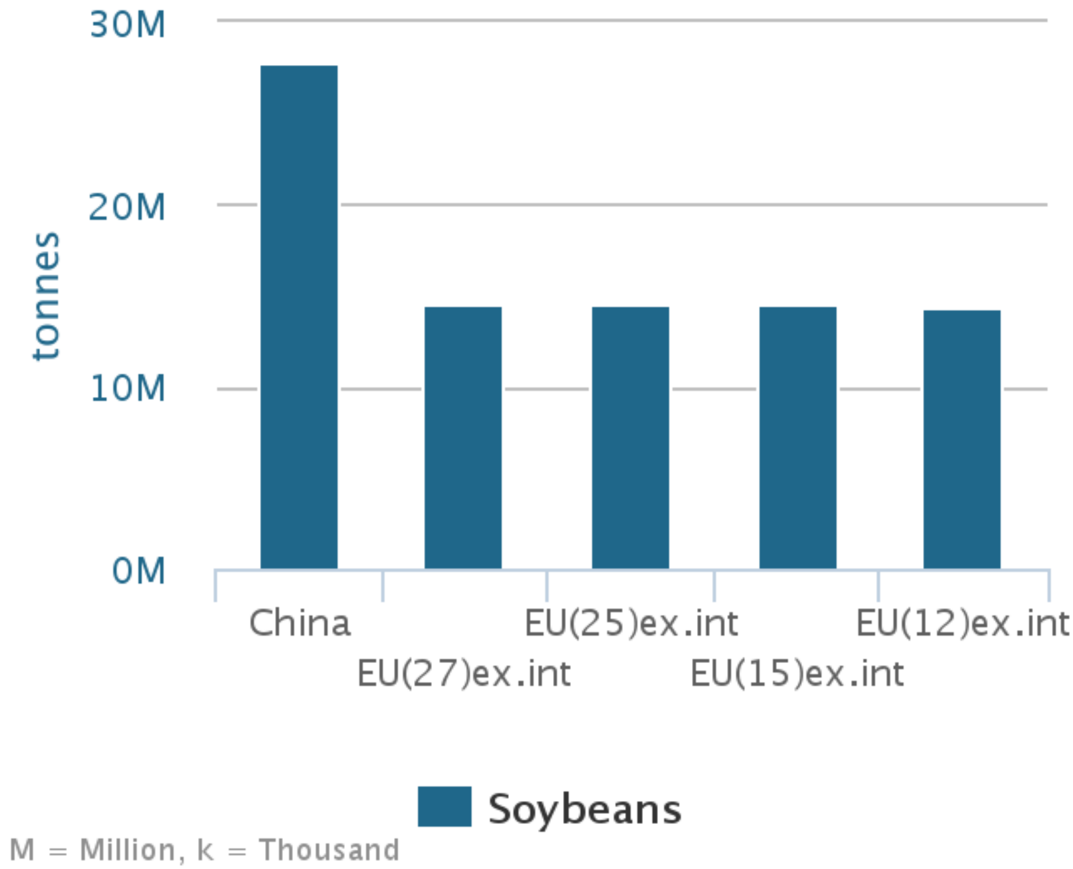

Figure 2. Top 5 soybean importers of the world (Source: FAOSTAT)

In 2014, China imported 73,000,000 tons of soybeans from other countries, taking the proportion of 86% of total consumption, and 42.05% of the imports is from the U.S..

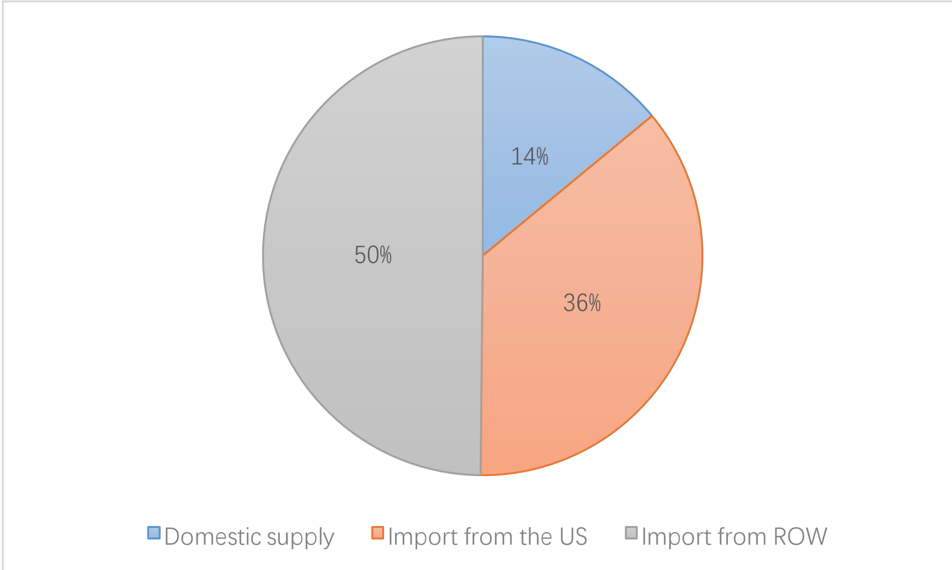

Figure 3. The proportion of China's soybean imports in 2014

The exchange rate of RMB has fluctuated largely in the past decade, leading the international soybean trade to an unstable state. Based on this situation, the exchange rate between RMB and USD has played an important role on the soybean trade.

The exchange rate is defined as the value ratio between two different currencies. In this paper, I consider the exchange rate as Y/$. Generally speaking, the nominal exchange rate could not indicate the accurate rate of currency value because of the inflation. To make the data more convincible, it is better to use the real exchange value, which accounts for the difference in CPI. The real exchange rate is e*CPI us/CPI ch where e = Y/$. The tendency of nominal exchange rate and real exchange rate from 1986 to 2014 is shown in the following chart.

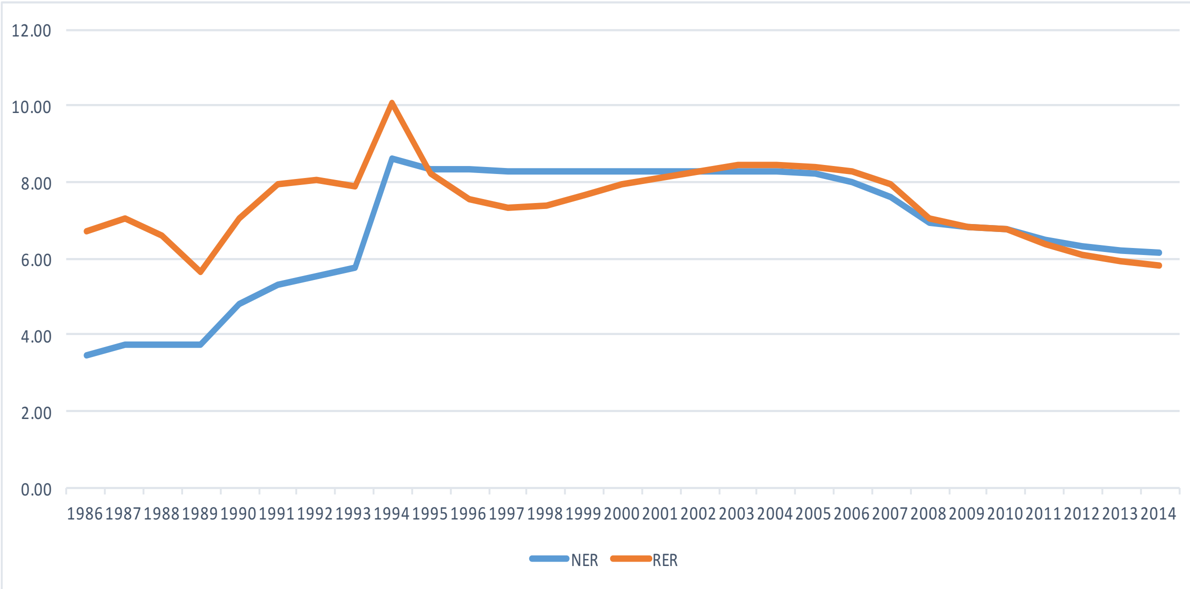

Figure 4. Nominal exchange rate (Y/$) and real exchange rate ((Y/CPI_ch)($/CPI_us)) over 1986-2014

In this figure 1 we can see that from 1986 to 2005, the real exchange rate between China and the US is unstable. From 1986 to 1994 the Y/$ exchange rate increased, meaning the U.S. dollar strengthened relative to the Yuan or the Yuan weakened. From 1994 to 2005 the exchange rate was stable, after which it decreased, meaning the Yuan strengthened. In 2005, the People's Bank of China, the central bank, unpegged the Yuan from the dollar. This new exchange rate policy means the price will be more flexible, and the world agricultural market will be influenced by the price competition between the producer and consumer.

2. Literature review

Empirical analysis about the effects of exchange rates on agricultural products (Kong and Li 2008) shows that a stronger yuan has negative effects on trade surplus in agricultural products. Trade surplus is also called favorable balance of trade, which means the value of exports exceeds the value of imports. The correlation coefficient between exchange rate and trade surplus is 0.166 when the lag phase equals -3. This result indicates that a stronger yuan in this month will decrease the trade surplus of three mouths later.

Richards (2011) did research on the soybean market of South America, and found that the depreciation of the Brazilian real contributed to the creation of and additional 63,000km^2in Brazil's soybean production or 29% of total area harvest in 2009. The weakening of Brazilian currency has positive effect on soybean export, and then promotes Brazilian soybean production. Wang (2010) analyzed the relationship between exchange rates, the prices of substitute and the import of soybean, and found that each 1% appreciation in the RMB against the US dollar is estimated to increase China's imports of soybeans from the United States by 2.8% in quantity.

Devadoss et al. (2014) developed a theoretical framework to serve as the basis for their empirical analysis of the effects of Yuan undervaluation on prices, supply, demand, and trade in the United States, China, and their competitors. They illustrated theoretical predictions with diagrams to show how the supply and demand curves shift in response to changes in the value of China's currency. After discussing the theoretical effects of changes in the exchange rate on soybean prices and trade, the authors test the theoretical predictions using cointegration analysis. They found that as China's currency weakens against the U.S. dollar, China's imports of soybeans from the United States decreases. This result is consistent with theory.

Research that linked the relationship between monetary policy and exchange rates to the world soybean market by Thraen and Hwang (1992) was based on soybean export and import equations. This paper investigates the linkage of soybean trade between the exporting countries of the United States, Brazil and Argentina in the EC-12 and Japan import market and monetary trade competition model was adopted. By analyzing the data from 1965 to 1985, the authors found that the elasticities of world price and U.S. soybean export with respect to the value of USD is -2.16 and -0.19, respectively. In this paper, the U.S. monetary growth affects exchange rate, and then the world price and U.S. export change follow the exchange rate.

Thorbecke (2006) did research on the relationship between the value of RMB and the U.S. trade balance with China. He found that the exchange rate coefficient shows that a 10 percent RMB appreciation will increase China's total imports from the U.S. by 36 percent. He also claimed that an appreciation of the RMB would help to reduce the trade deficit between the U. S. and China by investigating the relationship between the value of the RMB and the flow of trade between the two countries.

Williams and Luo (2015) focused on the effects of undervaluation of Chinese RMB on world's soybean markets in the scenario of with supply chain and without supply chain. To analyze the consequence of the RMB devaluation on soybean market, the author used a price equilibrium simulation model, which allows for the determination of supplies, demands, prices and trade of other soybean products in different regions. After analyzing data from 1993/94 to 2012/13, the author found that as the equilibrium RMB/USD decreased by 5.9 percent over 1994 to 2013, in the scenario of with supply chain, the percentage change in the U.S. soybean exports is -3.5, the percentage change in China soybean imports is -13.9, and the percentage change in China farm price and import price is 23.7 and 22.2. In the scenario of with supply chain, the percentage change in U.S. exports, China imports, China farm price, China import price is -4.0、

-15.3、22.7、23.1. Despite to the percentage change that found in the research, it did not state how does the exchange rate affect on these changes directly.

The research of Song and Marchant (2009) analyzed the market power of China's soybean import market. The author provided that in 2005, the U.S. exported 24 million metric tons of soybeans, accounting for 37% of the world soybean export market. At the same time, China imported 27 million metric tons of soybeans, accounting for 41% of the world total. The data indicated that Chinese soybean importers have stronger market power relative to U.S. soybean exporters, and the soybean market will continue to be the most important market for the U.S. China's rapid increase in soybean demand and relative slow increase in domestic soybean production create a large demand for imports.

The main theories that applied in the past research were the theory of Marshall-Lerner condition and J-curve effect. The J-curve describes a situation where the value of imports initially declines in response to domestic currency strengthening before they increase. The models researchers used were AR or VAR or VECM to get the Co-integration equation. Granger Causal Relation Test is also a popular method to see the cause-and-effect relationship. Some of the research, for example, Que and Wang's paper concluded that the RMB strengthening would decrease the import price and increase China's soybean import.

The purpose of this research is to determine how the exchange rate works in international trade by estimating the effect changes in the real RMB/USD exchange rate on China's imports of soybeans from the United States. The analysis is similar to the study by Devadoss et al. (2014) in that cointegration analysis is used to test whether Yuan devaluation/revaluation causes China imports of soybeans from the U.S. to decrease/increase, as predicted by theory. It differs from Devadoss et al. (2014) in that the price effects of Yuan devaluation/revaluation are also tested. Specifically, theory indicates Yuan devaluation will cause the price of soybeans in China to increase, and the price of soybeans in the U.S. to decrease. Devadoss et al. (2014) did not test these two predictions from theory. This study fills this gap. A second objective is to test the robustness of Devadoss et al.'s finding with respect to China's imports of soybeans from the United States. Specifically, using annual data for the period 1986 to 2010, Devadoss et al. (2014, p. 31, table 4) obtained the following estimates of the long-run parameters of the soybean relation

(1) $\ln X_t = -31.85 + 1.69^* \ln GDP_t - 2.42 \ln PI_{us,t} + 0.54^* \ln PI_{ch,t} + 0.27 \ln ER_t$

where X_t is the quantity of soybeans China imported from the United States in year t; GDP_t is China's real GDP in Yuan in year t. $PI_{us,t}$ is the U.S. real production cost of soybeans in $/bushel in year t; $PI_{ch,t}$ is China's real production cost for soybeans in Yuan/bu in year t; and ER is the real exchange rate between China and the U.S. in year t defined as Y/$. The asterisk (*) indicates the estimated coefficient (elasticity) is significant at the 5% level or better. Equation (1) suggests China's imports of soybeans from the United States is most sensitive to China's GDP, followed by China's production costs. The cost of producing soybeans in the United States, which affects export supply, has no effect on China's imports, nor does the exchange rate. Since the latter is inconsistent with theory, at issue in the present analysis is whether the inference is robust. The robustness issue is examined by re-estimating equation (1) with the sample period updated through 2014.

The contribution of this paper is to estimate both price and quantity elasticities that indicate the effects of Chinese currency revaluation/devaluation on U.S.-Sino trade and trade value in soybeans. In addition, the partial equilibrium model developed by Davadoss et al. (2014) is recast as an Equilibrium Displacement Model. The model is then used to deduce hypotheses about the effects of exchange rate movements on U.S. and China's soybean prices, production, and trade.

3. Method

The method of this study is to replicate the study by Devadoss et al. (2014). Replication is a research method that relay on the theory or empirical model that applied in the earlier research. Researchers often use new data to refit the model, and attempt to confirm prior work or provide a depth understanding of the results (Tomek, 1993). The replication of this paper will contain two parts. The first part will be to recast Devadoss's partial equilibrium model in EDM form. The second part will be to re-estimate his empirical models using updated data.

4. Theoretical frameworks

The method that applied in Devadoss's paper was based on the supply and demand function, and then did first order derivation by Cramer's rule. The exogenous variable in the model was the exchange rate between China and the U.S. (e_{UC}); the endogenous variables were price of China (P_C), price of the U.S. (P_U), price of rest of the world (P_R), China's imports for the U.S.

(X_{UC}), China's imports from rest of the world (X_{RC}). The results of derivation showed the positive or negative effects of exchange rate on those endogenous variables respectively. According to Devadoss's model that considered China as an importer, an increase in the Y/$ exchange rate that makes exports from the United States more expensive causes China imports less from the U.S., and then increases Chinese price P_C. Since U.S. export decrease, less U.S. soybeans will be exported, and thus the U.S. price P_U will decline. In other words, devaluation of Yuan against to the U.S. dollar benefits Chinese soybean producers at the expense of the U.S. producer. As for market of ROW, Devadoss considered ROW currency did not depreciate with respect to Yuan, therefore the export from ROW will be less expensive than Yuan. Consequently, as the Y/$ exchange rate increase, China will import more from ROW, leading the price of ROW P_C to be higher.

To recast Devadoss et al.'s model in EDM form, consider China as a net importer of soybean. And the soybean exporter in the world is split to the U.S. and the rest of the world. As China is a net importer, the total soybean consumption is supplied by domestic production, imports of the U.S. and imports from the rest of the world. Another assumption is the law of one price （LOP）. The LOP which is based on the theory of purchasing power parity, posits that in free market, "*a good must sell for the same price in all locations*" once transportation costs are accounted for. As LOP holds, in this paper, the soybean is considered at one price but in different currencies, Yuan and U.S. dollar. As this study mainly focuses on the soybean trade between China and United States, assume that the exchange rate between ROW currency and USD stays constant. Thus, not as the prices that applied in Devadoss's paper, in this paper I will pick the prices of domestic market and world market, but omit the exchange rate for ROW. Then the structural model could be defined as follows:

(2) $Q_d = D(P_c)$ (Domestic demand)

(3) $Q_u = M(P_u)$ (Import supply from the U.S.)

(4) $Q_r = M(P_u)$ (Import supply from rest of the world)

(5) $Q_s = S(P_c)$ (Domestic supply)

(6) $P_u = \frac{P_c}{e}$ (Import price)

(7) $Q_d = Q_s + Q_u + Q_r$ (Market equilibrium)

where P_c is domestic price of soybean, in yuan terms; P_u is the import price of soybean, in dollar terms. These two prices are linked with the exchange rate, $e =$ Y/$. In this model, transportation costs are assumed to be zero. The quantity supplied of soybeans is assumed to be an increasing function of price, and the quantity demanded is assumed to be a decreasing function of price i.e., $D' < 0$, $S' > 0$, and $M' > 0$. Market equilibrium occurs when domestic demand exactly matches supply from the three sources: domestic production Q_d, imports from the United States, Q_u, and imports from Rest-of-World, Q_r.

The model contains six endogenous variables (Q_d, Q_s, Q_u, Q_r, P_c, P_u) and one exogenous variable (e). At issue is the effect of changes in the exchange rate on imports and prices. To determine that, we first write the model in proportionate change or EDM form as follows:

(8) $Q_d^* = \eta_d P_c^*$

(9) $Q_u^* = \varepsilon_u P_u^*$

(10) $Q_r^* = \varepsilon_r P_u^*$

(11) $Q_s^* = \varepsilon_d P_c^*$

(12) $P_u^* = P_c^* - e^*$

(13) $Q_d^* = \kappa_d Q_s^* + \kappa_u Q_u^* + \kappa_r Q_r^*$

where the asterisked variables indicate the relative change, e.g. $Q_d^* = dQ_d/Q_d$; $\eta_d(< 0)$ is the partial elasticity of domestic demand; $\varepsilon_u(> 0)$, $\varepsilon_r(> 0)$ and $\varepsilon_d(> 0)$ are the partial elasticities of import supply from U.S. soybean market, rest of the world and China's domestic supply, respectively. κ_d, κ_u and κ_r are quantity shares of domestic supply, U.S. supply and supply of rest of the world, $\kappa_d = Q_s/Q_d$, $\kappa_u = Q_u/Q_d$ and $\kappa_r = Q_r/Q_d$.

Solving equations (8) – (13) simultaneously for for P_u^* in terms of e^* yields the reduced-form elasticity of U.S. price with respect to the exchange rate:

(14) $$P_u^* = \frac{\eta_d - \kappa_d \varepsilon_d}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

The reduced-form elasticities for the remaining endogenous variables in the model may be obtained by substituting equation (14) into equations (8) – (13) to yield:

(15) $$P_c^* = \frac{\kappa_u \varepsilon_u + \kappa_r \varepsilon_r}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

(16) $$Q_d^* = \frac{\eta_d(\kappa_u \varepsilon_u + \kappa_r \varepsilon_r)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

(17) $$Q_u^* = \frac{\varepsilon_u(\eta_d - \kappa_d \varepsilon_d)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

(18) $$Q_r^* = \frac{\varepsilon_r(\eta_d - \kappa_d \varepsilon_d)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

(19) $$Q_s^* = \frac{\varepsilon_d(\kappa_u \varepsilon_u + \kappa_r \varepsilon_r)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} e^*$$

Based on the assumed signs of the structural elasticities, the sign of each coefficient in these equations is determined. Then the effects of exchange rate on the endogenous variables is shown in table 1:

Table 1. Reduced form elasticities of endogenous variables with respect to exchange rate

Endogenous variables	Reduced form elasticities with respect to exchange rate
P_u^* (U.S. currency price)	$\frac{\eta_d - \kappa_d \varepsilon_d}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} < 0$
P_c^* (Domestic currency price)	$\frac{\kappa_u \varepsilon_u + \kappa_r \varepsilon_r}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} > 0$
Q_d^* (Domestic consumption)	$\frac{\eta_d (\kappa_u \varepsilon_u + \kappa_r \varepsilon_r)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} < 0$
Q_u^* (Imported quantity from the U.S.)	$\frac{\varepsilon_u (\eta_d - \kappa_d \varepsilon_d)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} < 0$
Q_r^* (Imported quantity from rest of the world)	$\frac{\varepsilon_r (\eta_d - \kappa_d \varepsilon_d)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} < 0$
Q_s^* (Domestic production)	$\frac{\varepsilon_d (\kappa_u \varepsilon_u + \kappa_r \varepsilon_r)}{\kappa_d \varepsilon_d + \kappa_u \varepsilon_u + \kappa_r \varepsilon_r - \eta_d} > 0$

Theory predicts that Yuan depreciation, i.e., an increase in Y/$, will: 1) reduce the equilibrium price of soybeans in the United States, 2) increase the equilibrium price of soybeans in China, 3) reduce the equilibrium consumption of soybeans in China, 4) reduce the equilibrium quantity of soybeans that China imports from the United States and the Rest of the World, and 5) increase the equilibrium quantity of soybeans produced in China. Yuan devaluation makes imports of soybeans from the United States are more expensive, which causes China's demand for U.S. soybeans to decrease. Compare with the result of Devadoss's paper, there is a difference here. Assume that while Yuan depreciate against with the U.S. dollar, currency value of the ROW stays constant with respect to USD. Then the Y/$ exchange rate has the same effect on the imports from ROW with that from the U.S., which means an increase in the Y/$ exchange rate decreases the imports of soybean from ROW. With less demand, the U.S. price of soybeans P_u falls, as does China's imports. Reduced imports cause China's soybean market rely on domestic production in a greater degree than before, which result in a higher price in China's domestic market P_c. The increase in domestic price causes China's soybean producers supply more but consumers demand less.

5. Empirical analysis

5.1 The empirical model

The cointegration model is from Eq. (25) of Devadoss's paper using the autoregressive distributed lag (ARDL) approach. The model estimated by Devadoss et al. is as follows:

(19) $\Delta\ln X_t = \beta_0 + \sum_{l=1}^{N} \beta_{1,t-l}\, \Delta\ln X_{t-l} + \sum_{l=0}^{N} \beta_{2,t-l}\, \Delta\ln GDP_{t-l} + \sum_{l=0}^{N} \beta_{3,t-l}\, \Delta\ln PI_{us,t-l} +$

$$\sum_{l=0}^{N} \beta_{4,t-l}\, \Delta\ln PI_{ch,t-l} + \sum_{l=0}^{N} \beta_{5,t-l}\, \Delta\ln ER_{t-l} + \alpha EC_{t-1} + \varepsilon_t$$

where X_t is the soybean import quantity from the US to China at period t. To be consistent to the theoretical framework in this paper, I will replace X_t with $Q_{u,t}$ as China's soybean imports from the US. GDP is China's real GDP in Yuan. PI_{us} is the US real production cost for soybean in $/bu. PI_{ch} is China's real production cost for soybean in Yuan/bu. ER is the real exchange rate between China and the US, defined as Y/$. EC is the error correction term which indicates the speed of adjustment through the coefficient. This model provides not only the short run elasticities of imports with respect to the right-hand-side variables, but also the long-run relationships, which are determined using the estimated coefficient of the error-correction term. The data is updated to 2014, and the prices are all adjusted with CPI index to real prices based on the data that applied in Devadoss's paper.

Devadoss et al. (2014) tested the hypothesis that $\frac{Q_u^*}{e^*} < 0$, but did not test the hypotheses that $\frac{P_u^*}{e^*} < 0$ and $\frac{P_c^*}{e^*} > 0$. Thus, in addition to confirming whether $\frac{Q_u^*}{e^*} < 0$ holds, I will extend Devadoss et al.'s work by testing whether the price effects predicted by the model hold. In doing so, this paper will provide the estimation of error correction model for China's real import price of soybean and the U.S. real farm price of soybean, letting the exogenous variables in the model remain the same. In other words, the objective of my research is to determine whether the data are compatible with the hypotheses that Yuan depreciation against the U.S. dollar causes the U.S. price of soybeans to fall and the price in China to rise.

The regression equations are estimated by Eviews 9.0. To compare the results with Devadoss's research, I also use the Akaike Information Criterion (AIC) to determine the optimal lags for each variable, setting the max lag as 2. To determine the long-run relationship, Devadoss introduced two methods. One is using F-statistic: when the F-statistic value is less than both 5% and 10% level, no long-run relationship exists; when the F-statistic value exceeds the critical bounds, the long-run relationship does exist. According to Devadoss et al. (2014), the critical bounds are provided by Nrayan (2005). The lower value assumes integration of order 0, I(0), and high value assumes integration of order 1, I(0). Another method is determined by the coefficient of error-correction term. According to Kremers et al. (1992) and Banerjee et al. (1998), if the coefficient is negative and significant, the long-run relationship exists. In this paper we consider F-statistic as the first principle to determine the long-run effects, and ER term as the alternate way when the long-run relationship could not be determined by F-statistic.

Table 2. Estimation of the error correction model for Chinese soybean imports from the United States

Estimated long-run coefficients (present study)

$$\ln Q_{u,t-1} = -19.32 + 1.08 lnGDP_{t-1} + 0.10 lnPI_{us,t-1} + 0.38 lnPI_{ch,t-1} + 0.81 lnER_{t-1}$$

(0.09) *** (0.77) (0.14) *** (1.00)

F-statistic = 6.27 critical bounds (95%):3.06 - 4.22 and (90%): 2.53 - 3.56

Estimated long-run coefficients (Devadoss et al. (2014))

$$\ln Q_{u,t-1} = -31.85 + 1.69 lnGDP_{t-1} - 2.42 lnPI_{us,t-1} + 0.54 lnPI_{ch,t-1} + 0.27 lnER_{t-1}$$

(0.58) ** (1.56) (0.21) ** (0.52)

F-statistic=6.27 critical bounds (95%):3.06-4.22 and (90%):2.53-3.56

Error-Correction Model

Dependent Variable: $\Delta\ln Q_{u,t}$

Regressors	Coefficient (present study)	Coefficient (Devadoss et al. (2014)
$\Delta\ln Q_{u,t-1}$	0.34	0.29
	(0.21)	(0.18)
$\Delta\ln GDP_t$	0.16	3.07
	(2.38)	(2.14)
$\Delta\ln GDP_{t-1}$	-5.71	-5.54
	(2.61)**	(1.83)***
$\Delta\ln PI_{us,t}$	0.16	1.11
	(0.45)	(1.24)
$\Delta\ln PI_{us,t-1}$	-0.56	
	(0.47)	
$\Delta\ln PI_{ch,t}$	-0.42	-0.74
	(0.33)	(0.30)**
$\Delta\ln ER_t$	-0.97	-1.24
	(0.65)	(0.44)**
$\Delta\ln ER_{t-1}$	-0.75	

	(0.58)	
EC_{t-1}	-1.05	-0.95
	(0.26)***	(0.22)***

Optimal Lag (AIC) = (2,2,2,1,2) R-squared = 0.78 (present study)

Optimal Lag (AIC) = (2,2,1,1,1) R-squared = 0.84 (Devadoss et al. (2014)

Note: *P-value≤0.1, **P-value≤0.05, and ***P-value≤0.01.

Standard errors are in parentheses.

Table 3. Estimation of the error correction model for China' s real import price of soybean

Estimated long-run coefficients

$$\ln P_{ch,t-1} = 7.84 + 0.01 lnGDP_{t-1} + 0.13 lnPI_{us,t-1} - 0.02 lnPI_{ch,t-1} - 0.44 lnER_{t-1}$$

(0.08) (0.85) (0.17) (1.07)

F-statistic=2.51 critical bounds (95%):3.06-4.22 and (90%):2.53-3.56

Error-Correction Model

Dependent Variable: $\Delta\ln P_{\mathrm{ch},t}$

Regressors	Coefficient
$\Delta\ln P_{ch,t-1}$	0.69
	(0.30)**
$\Delta\ln GDP_t$	3.60
	(2.13)
$\Delta\ln PI_{us,t}$	0.40

	(0.35)
$\Delta \ln PI_{us,t-1}$	0.80
	(0.44)*
$\Delta \ln PI_{ch,t}$	0.34
	(0.29)
$\Delta \ln PI_{ch,t-1}$	-0.55
	(0.22)**
$\Delta \ln ER_t$	0.58
	(0.64)
$\Delta \ln ER_{t-1}$	-0.59
	(0.40)
EC_{t-1}	-0.86
	(0.32)**
Optimal Lag (AIC) = (2,1,2,2,2)	
R-squared = 0.68	

Note: *P-value≤0.1, **P-value≤0.05, and ***P-value≤0.01.

Standard errors are in parentheses.

Table 4. Estimation of the error correction model for US real farm price of soybean

Estimated long-run coefficients

$$\ln P_{us,t-1} = 3.17 + 0.004 lnGDP_{t-1} + 0.08 lnPI_{us,t-1} - 0.01 nPI_{ch,t-1} - 0.81 lnER_{t-1}$$

	(0.10)	(0.94)	(0.21)	(1.39)

F-statistic=2.6 critical bounds (95%):3.06-4.22 and (90%):2.53-3.56

Error-Correction Model

Dependent Variable: $\Delta \ln P_{\mathrm{us},t}$

Regressors	Coefficient
$\Delta \ln X_{t-1}$	0.31
	(0.23)
$\Delta \ln GDP_t$	3.62
	(1.72)*
$\Delta \ln GDP_{t-1}$	-2.27
	(1.92)
$\Delta \ln PI_{us,t}$	0.97
	(0.35)**
$\Delta \ln PI_{ch,t}$	-0.25
	(0.27)
$\Delta \ln PI_{ch,t-1}$	-0.45
	(0.17)**
$\Delta \ln ER_t$	-0.58
	(0.59)
$\Delta \ln ER_{t-1}$	-0.65

	(0.43)
EC_{t-1}	-0.63
	(0.25)**

Optimal Lag (AIC) = (2,2,1,2,2)

R-squared = 0.80

Note: *P-value≤0.1, **P-value≤0.05, and ***P-value≤0.01.

Standard errors are in parentheses.

5.2 Results

5.2.1 Chinese soybean imports from the United States

The value of F-statistic is 6.27, which exceeds the critical bounds at the 0.05 and 0.1 level. The null hypothesis (H_0) could be rejected, indicating that the long-run relationship exists among Chinese soybean imports from the United States, China's real GDP, China's real production cost of soybean, US real production cost of soybean and exchange rate between China and the US. This result is the same as that in Devadoss's paper. The estimated coefficient of error-correction term is negative and significant, which also indicates a long-run relationship.

In the short-run, the coefficient of ER is negative at period t and $t-1$, but not significant. Thus, there is no relationship between ER and soybean imports. This result is not consistent with the hypothesis implied by theory, which indicates that as the real exchange rate, defined as Y/$, decreases, China will import more soybean from the United States. Compare the result with that of Devadoss's, the result of this paper has 2 lags in ER term, both of them are not significant; the previous result has 1 lag and significant, which shows that there exists short-run relationship between ER and soybean imports at period t. The coefficient of lagged GDP variable is -5.71, and significant at the 10% level, which is the only factor that has significant coefficient in the short-run. This result indicates that in the short-run, the growth in GDP has negative effect on soybean imports.

For the long-run equation, the estimated coefficient of GDP is positive and significant, which shows an increase in China's GDP will expand the imports of soybean from the United States. The elasticity between China's real GDP and soybean imports is 1.08, which indicates that as China's real GDP increases, the soybean imports will increase with the close speed. From 2000 to 2014, the real GDP of China has increased by 370%, and the soybean imports from the US has increased by 414%. The coefficient of China's soybean input price PI_ch is 0.38, which positive and significant at the 5% level. This result shows that as the production cost increases, the domestic soybean price will increase, leading the demand for import soybean to increase. China's GDP and China's soybean input price PI_ch are the mainly factors that influences China's soybean imports. The coefficient of ER in the long-run equation is positive but not significant. Thus Devadoss et al.'s (2014) finding that China's imports of soybeans from the United States is insensitive to changes in the Y/$ exchange rate in the long run is confirmed.

5.2.2 China's real import price of soybean

As the value of F-statistic is 2.51, less than the critical bounds at both 5% and 10% level, the null hypothesis cannot be rejected, which indicates that there is no long-run relationship between China's import soybean price and the exogenous variables.

For short-run effects, the coefficient of GDP is 3.60 but insignificant, which indicates there is no relationship between domestic GDP and China's import price. The coefficient of US soybean production cost at t-1 is positive and significant. Therefore, the current US soybean input price has a positive effect on China's import price of the next period. The negative and significant coefficient of lagged PI_{ch} shows that an increase in China's domestic soybean input price will decrease China's real import price of the next period. For the exchange rate effect, the coefficient of ER in both t and t-1 are positive and insignificant. This result is not consistent with the hypotheses showing that as the real exchange increases, the RMB depreciates, then the import price of soybean will rise over the same period. The coefficient of lagged ER and coefficient in long-run equation is negative but insignificant, showing that there's no long-run relationship between ER and soybean import price.

5.2.3 US real farm price of soybean

The value of F-statistic is 2.6, which is within the critical bounds associated with a 10% level test. Therefore, the long-run relationship could not be determined by this method. As the coefficient of error correction term is negative and significant, we can conclude that there exists a long-run relationship between the exogenous variables and US farm price.

For short-run effects, the US soybean production cost has positive effects on US farm price, which indicates that as US soybean production cost increase, the US farm price will increase. The coefficient of PI_{us} 0.97, which is positive and significant at 10% level. China's real GDP has a positive relationship with US farm price, since with the increase of GDP, China will expand the import soybean demand, causing the price of supply side, US farm price, to go up. For the relationship between China's input price and US farm price, the coefficient of lagged PI_{ch} is negative and significant, which indicates that as China's production cost of soybean increases, the US farm price of the next period will decrease. The theory indicates that as the real exchange rate defined as Y/$ increase, RMB depreciates, China will reduce the imports of soybean from the US, and US farm price goes down. However, the estimated coefficient of ER in the U.S. price equation is negative but not insignificant, indicating there's no relationship. This result is not consistent to the hypothesis. The long-run result also shows to be no relationship between real exchange rate and US farm price.

Table 5. Summary of the results

	Short-run			Long-run		
	China's soybean	China's import	US farm price	China's soybean	China's import	US farm

	imports	price		imports	price	price
China's real GDP	negative		positive	positive		
US input price		positive	positive			
China's input price		negative	negative	positive		
ER defined as Y/$						

6. Conclusion

Over the last three years of the sample (2012-14) the Yuan has apppreciated against the U.S. dollar in real terms by 4.2 percent. For the short-run relationship, especially for the effects in the current period, although the estimated coefficients are insignificant, the effect directions are consistent with the hypotheses implied by theory. Different from the past studies, this paper also shows the mechanism of exchange rate effects by providing the coefficients for China's import price and U.S. farm price of soybean. That is, Yuan devaluation against the U.S. dollar makes imports of soybeans from the United States more expensive. Theoretically, this should decrease the equilibrium quantity of soybeans that China imports from the U.S., increase the equilibrium price of soybeans in China, and reduce the equilibrium price of soybeans in the United States. The statistical results obtained in this study are not fully consistent with these theoretical predictions.

The effects of real exchange rate between China and the US is not significant in the soybean trade. This may be due to limitations in the data, model specification, or theory. Devadoss et al. did find a significant short-run effect with the correct sign. The results in this paper suggest, however, that this effect is not robust. The result of long-run effects is the same with the result in Devadoss et al., which shows that the ER has no long-run effects on China's soybean imports. Compare with the theoretical prediction, the results of empirical analysis are not consistent with the predictions, as the results shows that the exchange rate has no long-run effects on soybean trade. Besides the effects of ER, the estimated cointegration equations provide the effects of other exogenous variables. For the equation of China's soybean imports from the US, China's real GDP and soybean input price has positive and effects on soybean imports in the long-run, and the elasticity is 1.08. The real GDP of China also has negative effect on import in the short run. For the equation of China's soybean input price, the soybean input price of China and the US has negative and positive effects on China's import price, respectively. However, the effects are with time-lag, which means the change in the input price will influence China's soybean input price in the next period. The US soybean farm price is influenced by China's real GDP, US soybean input price and China's soybean input price in the short run.

In conclusion, the mainly factor that influences the import quantity of soybean is China's real GDP, which has positive effects in the long-run. The China's import price and US farm price are mainly influenced by the price factors in the short run, such as China's input price has negative effects on China's import price and US farm price, while the US input price has positive effects on China's import price and US farm price.

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Appendix A

Compare with Devadoss's result

Estimation of the error correction model for Chinese soybean imports from the United States

Estimated long-run coefficients

$$\ln X_{t-1} = -31.85 + 1.69 lnGDP_{t-1} - 2.42 lnPI_{us,t-1} + 0.54 lnPI_{ch,t-1} + 0.27 lnER_{t-1}$$

(0.58) ** (1.56) (0.21) ** (0.52)

F-statistic=6.27 critical bounds (95%):3.06-4.22 and (90%):2.53-3.56

Error-Correction Model

Dependent Variable: $\Delta\ln X_t$

Regressors	Coefficient
$\Delta\ln X_{t-1}$	0.29
	(0.18)
$\Delta\ln GDP_t$	3.07
	(2.14)
$\Delta\ln GDP_{t-1}$	-5.54
	(1.83)***
$\Delta\ln PI_{us,t}$	1.11
	(1.24)
$\Delta\ln PI_{ch,t}$	-0.74
	(0.30)**
$\Delta\ln ER_t$	-1.24
	(0.44)**
EC_{t-1}	-0.95
	(0.22)***

Optimal Lag (AIC) = (2,2,1,1,1)

R-squared = 0.84

Appendix B

Data

Year	X	P_ch	P_us	PI_ch	PI_us	GDP	ER	CPI_us	CPI_ch
1986	1,667	2371	7.51	29.50	7.69	2,746	6.74	64	32
1987	2,206	2397	8.91	32.27	7.58	3,067	7.04	66	35
1988	2,132	2387	10.80	30.02	10.10	3,414	6.58	69	41
1989	1,691	2362	7.90	26.73	8.41	3,558	5.68	72	48
1990	1,991	2477	7.56	23.33	7.58	3,698	7.05	76	50
1991	1,898	2622	7.05	22.01	7.43	4,040	7.94	79	52
1992	2,169	2484	6.82	22.00	6.77	4,617	8.06	81	55
1993	2,526	2345	7.63	18.62	7.99	5,261	7.87	84	63
1994	1,894	3003	6.37	12.28	6.15	5,949	10.09	86	78
1995	2,725	2367	7.68	12.99	7.11	6,603	8.22	89	91
1996	3,548	2602	8.07	14.07	6.92	7,258	7.56	91	99
1997	4,641	2475	6.94	15.45	6.13	7,928	7.32	93	102
1998	2,976	2115	5.21	24.42	6.08	8,551	7.38	95	101
1999	4,657	1782	4.79	27.39	6.43	9,202	7.65	97	100
2000	7,438	1803	4.54	29.62	6.20	9,978	7.95	100	100
2001	7,823	1699	4.26	33.40	5.97	10,806	8.11	103	101
2002	6,820	1808	5.29	38.51	5.55	11,788	8.26	104	100
2003	9,999	2147	6.87	40.31	6.27	12,969	8.44	107	101
2004	11,337	2720	5.23	41.52	5.02	14,276	8.43	110	105
2005	12,817	2240	4.99	46.71	5.00	15,896	8.38	113	107
2006	11,762	1948	5.49	55.18	5.16	17,913	8.30	117	109
2007	11,568	2492	8.39	64.08	5.48	20,456	7.92	120	114
2008	15,432	3354	7.97	77.82	6.23	22,425	7.06	125	120
2009	23,541	2521	7.70	53.57	6.12	24,495	6.81	125	120
2010	23,597	2512	8.92	54.25	6.12	27,100	6.77	127	124
2011	22,227	2810	9.57	54.72	6.66	29,670	6.36	131	130
2012	25,969	2834	10.80	56.37	7.81	31,969	6.10	133	134
2013	22,238	2711	9.61	58.07	8.04	34,426	5.93	135	137

2014	30,829	2477	7.54	57.96	7.23	36,928	5.84	137	140

Appendix C

Data definition and source

Variable Name	Definition	Source
Q_u	China's imports of soybeans from the US in 1000 tons	FAO USDA
P_ch	China's real import price of soybeans in Yuan/metric ton.	FAO
P_us	U.S. real farm price of soybeans in $/bu.	USDA
PI_us	China's real production cost for soybeans in Yuan/bu.	USDA
PI_ch	US real production costs for soybeans in $/bu.	China Statistical Database
GDP	China's real GDP in billion Yuan	World Databank
ER	real exchange (Yuan/$)	USDA
CPI_us	Consumer Price Index of the US	EDATASEA
CPI_ch	Consumer Price Index of China	CE

FAO, Food and Agricultural Organization. USDA, U.S. Department of Agriculture.

Available at:

X http://faostat3.fao.org/download/T/TM/E http://www.nass.usda.gov/

P_ch http://faostat3.fao.org/download/T/TP/E

P_us http://www.nass.usda.gov/

PI_us http://ers.usda.gov/data-products/commodity-costs-and-returns.aspx

PI_ch http://data.stats.gov.cn/search.htm?s=大豆

GDP

http://databank.worldbank.org/data/reports.aspx?Code=NY.GDP.MKTP.CD&id=af3ce82b&report_name=Popular_indicators&populartype=series&ispopular=y#

ER

http://www.ers.usda.gov/datafiles/Agricultural_Exchange_Rate_Data_Set/Country_Spreadsheets/realannualcountryexchangerates_1_.xls

CPI_us http://www.edatasea.com/Content/us/ID/2

CPI_ch http://intl.ce.cn/specials/zxxx/201308/09/t20130809_24648757.shtml