Impacts of China's Food Consumption on U.S. Soybean Exports

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Abstract
A simultaneous equation system is estimated to examine how China's domestic prices of soybean oil and meal, their substitutes and meat products impact China's soybean imports from the U.S. and South America. The soybean crushing ratios are applied to derive an equation linking China's domestic prices to its soybean imports. The study indicates that China's soybean imports from the U.S. and South America are affected not only by the import prices but also by their substitute prices and domestic soybean product and meat product prices.

1. Introduction

China is the world's largest soybean importer and is also the largest importer of U.S. soybean exports. The other two major suppliers are Brazil and Argentina. These three countries provide 99 percent of China's soybean imports. Imported soybeans are processed to produce soybean oil and meal in China. In addition to importing soybeans to produce soybean oil domestically, China also imports a large quantity of soybean oil from Argentina, Brazil, and the United States.

China's soybean oil is its most consumed edible oil and soybean meal is a major animal feed source in China. Thus, soybean exports to China should be linked with China's domestic consumption of soybean oil and meat products. A series of papers discuss China's soybean and soybean product imports from the U.S. and South American countries (Yang and Sluis 1999, and Song et al. 2006a, 2006b), and the China's domestic meat industry's feed consumption (Tian and Chudleigh, 1999, and Zhou et al. 2008). This research contributes to the literature by investigating how China's domestic prices of soybean products and meat products impact U.S. soybean exports to China. The difficulty of integrating soybean trade and China's domestic prices into a framework stems from the lack of data. Although both monthly and annual price data available for China's soybean oil and meal consumption, for quantity, only annual data are available. Before1996, China was a net export country for soybeans, and soybean imports were very low compared to today. In 1994, China's soybean imports were only 0.8 million metric tons. If annual data were used, the number of observations is not enough to estimate a model covering all aspects mentioned above. If monthly data were used, the quantity information of China's domestic production and consumption is unavailable.

This research generates an equation based on the crushing ratios of soybeans and a presumption that China's domestic soybean oil and meal markets clear. The objective of this paper is to examine how China's domestic prices of soybean products (like soybean oil and meal), their substitutes (like rapeseed oil, palm oil and corn), and meat products (like hog and live chicken) affect U.S. and South American soybean exports. The paper is organized as follows. Section 2 gives an introduction of China's soybean trade, production and consumption. Section 3 reviews the literature. Model identification is in Section 4. Section 5 provides estimation results and conclusions are in Section 6.

2. China's Soybean and Soybean Product Production, Trade, and Consumption

China formally became a member of World Trade Organization (WTO) on 11 December 2001. From 2001 to 2007, although China's annual domestic soybean production was never higher than 17.4 million metric tons, its domestic soybean consumption increased dramatically from 28.3 to 48.7 million metric tons (USDA, FAS 2004d, 2005d, 2006c, 2007a, 2008a, and 2008e). Today, China's domestic soybean production supplies its soybean food consumption, like tofu and soymilk. It is China's strong demand for soybean oil and meal that boost its soybean imports. China's soybean imports provided 91 percent of all soybeans crushed to produce soybean oil and meal in 2007. The USDA predicted that China's domestic consumption of soybeans would reach 51.1 million metric tons in 2008.

In 2007, China imported 35 million metric tons of soybeans, and the U.S., Brazil, and Argentina accounted for 99 percent of it. The U.S. remains the largest soybean exporter to

China, except for 2005/06 (October 2005 – September 2006). Because the U.S. and South American countries are located in different hemispheres, their harvesting and importing seasons are different. In the period from *December to April*, China's soybean imports from the U.S. are higher than that from South America, while in the period from *June to October*, China's soybean imports from South America are higher than that from the United States. According to the Chinese government's policy, all imported soybeans are categorized as biotech commodities and cannot be planted domestically in China. The Chinese government implemented a series of regulations to manage biotech product imports in the 1990's. Marchant and Song (2005), Song and Marchant (2005), and Song and Marchant (2006) give a detailed and comprehensive description of China's biotech policies and their impacts on the U.S. trade. Their research points out that, in the short-term, these regulations delayed China from importing soybeans from the U.S.; however, in the long-term, U.S. soybean exports to China were not impacted significantly.

Chinese cuisine requires a large quantity of edible oil every year. *Soybean oil* is the most consumed edible oil in China (USDA, FAS 2008a). In 2007, China's soybean oil consumption was around 9.7 million metric tons. Considering the increasing personal disposable income, China's consumption of soybean oil will continue to increase in the next decade. In 2007, China also imported 3 million metric tons of soybean oil. Argentina, Brazil, and the U.S. account for 99 percent with the first two countries supplying 94 percent. Different from China's soybean imports, there is not evident seasonal cycle in China's soybean oil imports. Lin et al. (2006 and 2007) examine Chinese consumers' attitude toward biotech soybean oil.

To satisfy domestic demand for animal feed is another factor stimulating China's soybean imports. Today, according to USDA, FAS (2008a), more than 90 percent of *soybean meal* produced in China is used as feed and the quantity reached 29.7 million metric tons in 2007. Soybean meal is also the most consumed oilseed meal in China. The strong demand for soybean meal is caused by the growth in China's production and consumption of meat products. With disposable personal income increasing, meat consumption and demand for soybean meal will continue to grow rapidly in China.

3. Literature Review

Sarwar and Anderson (1990) set up a simultaneous supply and demand equation model to investigate U.S. soybean exports to different regions. Sarwar and Anderson's approach is from the perspective of the U.S., the exporting country. The estimated short-term own-price elasticity of export demand is -0.63 for developed countries, -0.42 for Asian countries, and -3.62 for Latin American countries.

Pothidee et al. (1999) examine how changes in prices of corn and soybean meal impact U.S. broiler's prices and demand. Results show that for every one percent increase in corn price, broiler production will decrease 0.028 percent, while its price will increase 0.09 percent; and for every one percent increase in soybean meal price, broiler production will decrease 0.032 percent, while its price will increase 0.118 percent.

Soybeans are the raw products, from which soybean oil and meal originate, and soybean oil and meal are joint products. Piggott and Wohlgenant (2002) develop an equation system containing both domestic and foreign markets for soybeans and soybean products. This system is based on Houck's (1964) model for joint products. Piggott and Wohlgenant (2002) conclude that taking account of trade in soybean oil and meal has a more profound impact on the responsiveness of total soybean demand than only taking account soybean trade.

Song et al. (2006a) applies a simultaneous equation system to analyze competitiveness of China's three soybean suppliers. The research indicates that soybean exports to China from the U.S. and South American are seasonally complementary to each other. By investigating the relationship between China's soybean imports and soybean stocks in exporting areas, it is pointed out in the paper that South American countries' soybean exports can be a complete substitute for the U.S. exports, while U.S. soybean exports are just a partial substitute for South American countries' exports.

Andino et al. (2006) set up a simultaneous equation system to detect the impact of exchange rates on U.S. soybean exports. This research implies that a strong dollar, either relative to an importer's currency or other competitor currencies, will decrease U.S. soybean exports.

4. Model and Data

This research is conducted from the perspective of the Chinese domestic soybean processing industry, which imports soybeans and soybean oil from the U.S. and South American countries, and sells soybean oil and meal in China's domestic markets.

The import demand for soybeans is based on the desire to produce soybean oil, a final product for consumers, and soybean meal, a popular animal feed. Given a production function, China's soybean processing industry makes an input decision to maximize its profit $\pi(\boldsymbol{p},\boldsymbol{w}) = \max_{\boldsymbol{x}\geq\boldsymbol{0}}\{\boldsymbol{p}'\boldsymbol{f}(\boldsymbol{x}) - \boldsymbol{w}'\boldsymbol{x}\}$, where $\boldsymbol{p}$ is the price vector of outputs, $\boldsymbol{f}(\boldsymbol{x})$ is the output vector, $\boldsymbol{w}$ is the price vector of inputs, and $\boldsymbol{x}$ is the input vector. In this case, $\boldsymbol{x} = \left(M_{CH}^{US}, M_{CH}^{SA}\right)'$, where M_{CH}^{US} and M_{CH}^{SA} are China's soybean imports from the U.S. and South America, respectively; $\boldsymbol{p} = \left(PSO_{CH}^{US}, PSO_{CH}^{SA}\right)'$, where PSO_{CH}^{US} and PSO_{CH}^{SA} are the corresponding monthly prices of China's soybean imports from these two areas;

$\boldsymbol{f}(\boldsymbol{x}) = \left(f_{SOL}\left(M_{CH}^{US}, M_{CH}^{SA}\right), f_{SML}\left(M_{CH}^{US}, M_{CH}^{SA}\right)\right)'$, where $f_{SOL}\left(M_{CH}^{US}, M_{CH}^{SA}\right)$ and $f_{SML}\left(M_{CH}^{US}, M_{CH}^{SA}\right)$ are the production functions of soybean oil and soybean meal, respectively; $\boldsymbol{w} = \left(PSOL_{CH}^{DO}, PSML_{CH}^{DO}\right)'$, where $PSOL_{CH}^{DO}$ and $PSML_{CH}^{DO}$ are the corresponding prices of these two soybean products in China's domestic market.

The profit maximization problem for China's soybean processing industry is

$$(1) \quad \max_{M_{CH}^{US}, M_{CH}^{SA} > 0} \left\{ PSOL_{CH}^{DO} \times f_{SOL}(\bullet) + PSML_{CH}^{DO} \times f_{SML}(\bullet) - PSO_{CH}^{US} \times M_{CH}^{US} - PSO_{CH}^{SA} \times M_{CH}^{SA} \right\}$$

Soybean imports from the U.S. and South America are substitutes for each other. Solving the profit maximization problem above, China's soybean imports from the U.S., M_{CH}^{US}, is a function of its own price, substitute prices and output prices. In addition to soybean imports, China also imports a large quantity of soybean oil every year. China's soybean oil imports reached three million metric tons in 2007. Therefore, China's soybean oil imports, whose price is $PSOL_{CH}^{IM}$, are substitutes for China's soybean imports from the U.S. and South America. Thus, the functions for China's soybean imports from the U.S. and South America are

$$(2) \quad M_{CH}^{US} = M_{CH}^{US}\left(\underset{-}{PSO_{CH}^{US}}, \underset{+}{PSO_{CH}^{SA}}, \underset{+}{PSOL_{CH}^{IM}}, \underset{+}{PSOL_{CH}^{DO}}, \underset{+}{PSML_{CH}^{DO}}, \underset{+}{DUS}, \underset{-}{DIU}, \underset{+}{DCS}\right)$$

$$(3) \quad M_{CH}^{SA} = M_{CH}^{SA}\left(\underset{+}{PSO_{CH}^{US}}, \underset{-}{PSO_{CH}^{SA}}, \underset{+}{PSOL_{CH}^{IM}}, \underset{+}{PSOL_{CH}^{DO}}, \underset{+}{PSML_{CH}^{DO}}, \underset{+}{DSA}, \underset{-}{DIS}, \underset{+}{DCS}\right).$$

A group of dummy variables are introduced into the system[1]. The signs of estimates are

[1] *DUS* represents the U.S. soybean export season (November to May), *DIU* represents months when China's soybean imports from the U.S. less than 1,000 metric tons (July and August 2003 and August and October 2004), *DCS* represents months when the Chinese government subsidized swine production (from July 2006 to December 2007), *DSA* represents the South America soybean export season (from April to December), and *DIS* represents months when China's soybean imports from South America less than 1,000 metric tons (March 2003).

marked below the corresponding variables. China's soybean imports from the U.S., M_{CH}^{US}, should be decreasing in its own price, PSO_{CH}^{US}, but increasing in its substitute prices, PSO_{CH}^{SA} and $PSOL_{CH}^{IM}$, and output prices $PSOL_{CH}^{DO}$ and $PSML_{CH}^{DO}$. In its export season and the period when Chinese government subsidized swine production, the U.S. soybean exports should also increase. A similar identification is conducted for China's soybean imports from South America, M_{CH}^{SA}.

China's domestic demand for *soybean meal* is derived from the profit maximization problem of meat products, which is similar to equation (1). The monthly demand for the input of soybean meal, $QSML_{CH}^{DO}$, is a function of the price of soybean meal in China, $PSOL_{CH}^{DO}$; price of its major substitute, corn, in China, $PCON_{CH}^{DO}$; and China's domestic prices of meat products, like hog, $PHOG_{CH}^{DO}$, and live chicken, $PCKN_{CH}^{DO}$. The equation of $QSML_{CH}^{DO}$ is

(4) $QSML_{CH}^{DO} = QSML_{CH}^{DO}\left(PSML_{CH}^{DO}, PCON_{CH}^{DO}, PHOG_{CH}^{DO}, PCKN_{CH}^{DO}\right)$.

The monthly domestic consumption of *Soybean oil* in China, $QSOL_{CH}$, consists of soybean oil crushed domestically, $QSOL_{CH}^{DO}$, and imported from overseas, $QSOL_{CH}^{IM}$,

(5) $QSOL_{CH} = QSOL_{CH}^{DO} + QSOL_{CH}^{IM}$.

Based on consumer theory, $QSOL_{CH}$ is a function of the Chinese domestic soybean oil price, $PSOL_{CH}^{DO}$; substitute edible oil prices, like rapeseed oil price, $PRSL_{CH}^{DO}$ and imported palm oil price, $PPML_{CH}^{IM}$; and the income level, *INC*.

(6) $QSOL_{CH} = QSOL_{CH}\left(PSOL_{CH}^{DO}, PRSL_{CH}^{DO}, PPML_{CH}^{IM}, INC\right)$

As introduced previously, there are no monthly data for China's domestic consumption of soybean meal, $QSML_{CH}^{DO}$, and soybean oil, $QSOL_{CH}$. However, this problem can be overcome by using the fixed crushing ratios of soybeans and a presumption that the markets clear for soybean oil and meal in China. Soybeans are crushed to produce two products, soybean oil and meal. The crushing ratios for producing these two products are 18 and 79 percent, respectively. This means that crushing 100 metric tons of soybeans will produce 18 metric tons of soybean oil and 79 metric tons of soybean meal. Every year, China's domestic soybean oil and meal markets clear. For soybean oil, from 2003 to 2007, the percentage of annual stock was not higher than two percent. For soybean meal, there was no annual stock, and the percentage of annual net exports was not higher than four percent. The percentages of net stock in China's soybean oil supply and net export in China's soybean meal supply are contained in Table 2.

Furthermore, annual soybean consumption from 2002 to 2007 is calculated from China's production of soybean meal and oil. These results are compared to China's consumption of crushing use soybeans reported in USDA, FAS (2004d, 2005d, 2006c, 2007a, 2008a, and 2008e). The data are contained in Table 3. The differences among these three data series are very small. Therefore, Tables 2 and 3 imply that China's domestic soybean oil and meal markets clear every year, and China's domestic soybean oil and meal are produced in proportion to their crushing ratios. Therefore, it is derived that for soybean oil production,

(7) $QSOL_{CH}^{DO} = 0.18 \times QSO_{CH}$

, where QSO_{CH} is China's monthly total soybean consumption.

(5) and (7) $\Rightarrow$

(8) $QSOL_{CH} - QSOL_{CH}^{IM} = 0.18 \times QSO_{CH}$.

For soybean meal production,

(9) $QSML_{CH}^{DO} = 0.79 \times QSO_{CH}$,

and (8) and (9) $\Rightarrow$

$$(10)\ \frac{QSOL_{CH} - QSOL_{CH}^{IM}}{0.18} = \frac{QSML_{CH}^{DO}}{0.79} \Rightarrow$$

$$(11)\ \frac{QSOL_{CH}^{IM}}{0.18} = \frac{QSOL_{CH}}{0.18} - \frac{QSML_{CH}^{DO}}{0.79} \Rightarrow$$

$$(12)\ QSOL_{CH}^{IM} = QSOL_{CH} - \frac{0.18}{0.79} \times QSML_{CH}^{DO}$$

Then, put equations (4) and (6) into equation (12),

$$(13)\ \begin{aligned} QSOL_{CH}^{IM} &= QSOL_{CH}\left(PSOL_{CH}^{DO}, PRSL_{CH}^{DO}, PPML_{CH}^{IM}, INC\right) \\ &\quad - \frac{0.18}{0.79} \times QSML_{CH}^{DO}\left(PSML_{CH}^{DO}, PCON_{CH}^{DO}, PHOG_{CH}^{DO}, PCKN_{CH}^{DO}\right) \end{aligned} \Rightarrow$$

$$(14)\ \begin{aligned} QSOL_{CH}^{IM} = QSOL_{CH}^{IM}\big(&PSOL_{CH}^{DO}, PRSL_{CH}^{DO}, PPML_{CH}^{IM}, INC, PSML_{CH}^{DO}, PCON_{CH}^{DO}, \\ &PHOG_{CH}^{DO}, PCKN_{CH}^{DO}\big) \end{aligned}$$

China's soybean oil import price, $PSOL_{CH}^{IM}$, is a function of its quantity, $QSOL_{CH}^{IM}$, i.e. $PSOL_{CH}^{IM} = PSOL_{CH}^{IM}\left(QSOL_{CH}^{IM}\right)$. In order to calculate price elasticities of China's soybean imports, equation (15) is derived with a dummy variable included,

$$(15)\ \begin{aligned} PSOL_{CH}^{IM} = PSOL_{CH}^{IM}\big(&PSOL_{CH}^{DO}, PRSL_{CH}^{DO}, PPML_{CH}^{IM}, INC, PSML_{CH}^{DO}, PCON_{CH}^{DO}, PHOG_{CH}^{DO}, \\ &PCKN_{CH}^{DO}, DIO\big) \end{aligned}$$

where *DIO* represents January to December 2007 when China's soybean oil import price skyrocketed. An equation system is set up including equations (2), (3) and (15)

$$\begin{cases} M_{CH}^{US} = M_{CH}^{US}\left(PSO_{CH}^{US}, PSO_{CH}^{SA}, PSOL_{CH}^{IM}, PSOL_{CH}^{DO}, PSML_{CH}^{DO}, Lag1\left(M_{CH}^{US}\right), DUS, DIU, DCS\right) \\ M_{CH}^{SA} = M_{CH}^{SA}\left(PSO_{CH}^{US}, PSO_{CH}^{SA}, PSOL_{CH}^{IM}, PSOL_{CH}^{DO}, PSML_{CH}^{DO}, Lag1\left(M_{CH}^{SA}\right), DSA, DIS, DCS\right) \\ PSOL_{CH}^{IM} = PSOL_{CH}^{IM}\left(PSOL_{CH}^{DO}, PRSL_{CH}^{DO}, PPML_{CH}^{IM}, INC, PSML_{CH}^{DO}, PCON_{CH}^{DO}, PHOG_{CH}^{DO}, \right. \\ \qquad\qquad \left. PCKN_{CH}^{DO}, Lag1\left(PSOL_{CH}^{IM}\right), DIO\right) \end{cases}.$$

In order to calculate elasticities, logarithmize variables on both sides of each equation except for dummy variables. Lagged dependent variables are introduced into the system for each equation to remove autocorrelation in the variables.

The monthly values and quantities of China’s imports of soybeans, soybean oil and palm oil are collected from World Trade Atlas. The prices are calculated by dividing the values by the corresponding quantities. China’s domestic monthly prices for soybean oil, soybean meal and rapeseed oil are recorded in USDA, FAS (2004d, 2005d, 2006c, 2007a, 2008a, and 2008e). The monthly wholesale prices for hogs and live chickens are collected from USDA, FAS (2003a, 2004a, 2005a, 2006a, 2007b, and 2008d, and 2003c, 2004b, 2005b, 2006b, 2007d, and 2008c). Corn is the most consumed animal feed in China and its monthly prices are contained in USDA, FAS (2003b, 2004c, 2005c, 2006d, 2007c and 2008b). All of the prices are in terms of U.S. dollars, December 2007 by using Consumer Price Index (CPI) provided on the website of the Bureau of Labor Statistics, the U.S. Department of Labor. China’s monthly disposable income data are not observable and replaced by the monthly GDP level of China

This paper focuses on the period after China became a formal member of World Trade Organization (WTO) on December 11, 2001. However, because from February to May 2002, neither Argentina nor Brazil exported soybeans to China and the wholesale prices of hogs and live chickens in China are available from 2003, the model uses data from January 2003 to December 2007.

5. Estimation Results and Discussion

Model Specification Tests and In-Sample Predictions

The simultaneous equation system is estimated by using Generalized Method of Moment (GMM). GMM estimators are robust and not subject to strong distribution assumptions for data generation. Exogenous variables in the model are used as the instrument variables in estimation. The estimation results are contained in Table 4. In the equation of China's soybean imports from the U.S., M_{CH}^{US}, all the explanatory variables are significant at the 10% significance level except for the price of China's soybean imports from South America, PSO_{CH}^{SA}; and all the estimates have the correct signs except for China's domestic soybean oil prices, $PSOL_{CH}^{DO}$. In the equation of China's soybean imports from South America, M_{CH}^{SA}, all explanatory variables are significant at the 5% significance level; and all the estimates have the correct signs except for China's domestic soybean oil prices, $PSOL_{CH}^{DO}$, and China domestic soybean meal prices, $PSML_{CH}^{DO}$. In the equation of the prices of China's soybean oil imports, $PSOL_{CH}^{IM}$, all the explanatory variables are significant at the 5% significance level except for China's domestic hog price, $PHOG_{CH}^{DO}$, and the dummy variable for the months when the price of China's oil product imports skyrocketed, *DIO*.

The R^2 and adjusted R^2 indicate that the system explain most variation in the three dependent variables. Durbin-Watson (DW) statistics indicate that there is no serious autocorrelation in residuals. The hypothesis of homoskedasticity in the residuals is tested by White's test and p-values indicate that the hypothesis is not rejected for residuals at the 5% significance level for all three equations. Augmented Dickey-Fuller (ADF) test implies that residuals of all the three equations are stationary.

Figures 1 to 2 plot the historical and in-sample predictions of China's imports of soybeans from the U.S. and South America. The figures indicate that the models catch the seasonal cycle in China's soybean imports. Figure 3 plots the historical and in-sample predictions of the real monthly prices of China's soybean oil imports. The in-sample predictions indicate that the estimation of the equation $PSOL_{CH}^{IM}$, the real monthly prices of China's soybean oil imports, has the best accuracy.

Elasticities

The price and income elasticities of China's soybean imports from the U.S. and South America are contained in Table 5. Because the lagged dependent variables are introduced as exogenous variables into the model to avoid autocorrelation, there are two types of elasticities, the short-term and long-term.

For every one percent increase in the price of soybeans imported from the U.S., PSO_{CH}^{US}, China's soybean imports from the U.S., M_{CH}^{US}, decrease 5.46 and 6.48 percent in the short-term and long-term, respectively; while China's soybean imports from South America, M_{CH}^{SA}, increase 1.99 and 2.33 percent in the short-term and long-term, respectively. For every one percent increase in the price of soybeans imported from South America, PSO_{CH}^{SA}, China's soybean imports from the U.S. increase 1.15 and 1.36 percent in short-term and long-term, respectively; while China's soybean imports from South America decrease 4.95 and 5.81 percent. China's soybean imports from both the U.S. and South America are price elastic and the elasticities are significant. However the cross price elasticities of China's soybean imports from the U.S. with respect to the price of imports from South America are insignificant.

Soybean oil is the most consumed edible oil in China. When the soybean oil import price increases, China's soybean imports from the U.S. and South America increase. However, when

China's domestic soybean oil price increase, its soybean imports decreases. The consumption of rapeseed oil and palm oil in China's domestic market just follows that of soybean oil and are substitutes for soybean oil. Increases in their prices increase lead to China's soybean imports to increase.

Soybean meal is the most consumed meal feed in China and corn is its major substitute. When either China's domestic soybean meal price or corn price increases, China's soybean imports increase. Soybean meal is used as feed in the meat industry. Pork and chicken are the most consumed meat products in China. The increase in China's hog price leads to its soybean imports increase, however the increase in China's live chicken price lead to it soybean imports to decrease. These opposite effects can be explained by a higher feed conversion ratio of chicken and lower share of soybean meal in chicken feed. The ratio for chicken is 1:2 but 1:3-4 for hog. Moreover, in China, the share of soybean meal in chicken feed is much lower than that in hog feed. Therefore, to produce a same amount of meat, chicken will consume less soybean meal.

From 2003 to 2007, with disposable income increasing, China's soybean imports kept growing. However, the income elasticities of China's soybean imports from both the U.S. and South America are negative. In estimation, the GDP is used as a proxy variable for the monthly disposable income. From 2003 to 2007, China's monthly GDP data are not available and they are computed by interpolating using geometric series. In the model, the monthly disposable income keeps increasing without monthly fluctuation. Other proxy variables for disposable incomes should be used in estimation in the future.

Summary

The specification tests and in-sample predictions imply that (1) the equation system can explain most variation in the three dependent variables; (2) the equation of China's soybean oil import prices, $PSOL_{CH}^{IM}$, has the best in-sample predictions, highest R^2 , and performs the best for all diagnostic tests; and (3) because the identification of the equation of $PSOL_{CH}^{IM}$ is based on a presumption that China's domestic markets of soybean oil and meal clear every month, the satisfying performance of the estimation of $PSOL_{CH}^{IM}$ can be an evidence supporting this presumption.

The elasticities indicate that (1) most of them have the right signs as expected; (2) the wrong signs of elasticities of domestic price of chicken can be explained by a higher feed conversion ratio and lower share of soybean meal in chicken feed; (3) China's soybean imports from the U.S. and South America are price elastic with respect to their own prices; (4) the impacts of the import prices are greater than that of the prices in China's domestic market; and (5) in China's domestic market, the impacts of the soybean oil and meal prices are greater than that of meat product prices; (6) the impacts of China's domestic prices of soybean oil and income on China's soybean imports call for further investigation.

6. Conclusions

This paper proposes a model that examines how the international market prices and China's domestic market prices affect its soybean imports from the U.S. and South America. An equation of China's soybean oil import prices, $PSOL_{CH}^{IM}$, is designed based on the crushing ratios of soybeans and a presumption of market clearing for soybean oil and meal in China. The equation system is estimated by using GMM. The estimation results indicate that the model can explain most variation in the dependent variables. The satisfying estimation and in-sample prediction of $PSOL_{CH}^{IM}$ support this presumption.

The elasticities imply that China’s soybean imports from the U.S. and South America are greatest impacted by their own import prices, followed by substitute prices in both international and domestic markets. The effects of China’s domestic meat prices are significant, but the magnitudes are smaller relative to prices of soybeans, soybean products and their substitutes in both international and China’s domestic markets.

References:

Andino, Jose, Kranti Mulik, and Won Koo (2006). “The Impact of Brazil and Argentina's Currency Devaluation on U.S. Soybean Trade,” Selected paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Long Beach, California, July, 2006.

Bureau of Labor Statistics, U.S. Department of Labor. Consumer Price Index, U.S. All items, 1982-84=100. http://data.bls.gov/cgi-bin/surveymost?cu.

Hetemaki, Lauri and Jari Kuuluvainen (1992). “Incorporating Data and Theory in Roundwood Supply and Demand Estimation.” American Journal of Agricultural Economics, 74:4, 1010 – 1018.

Houck, James P. (1964). “Price Elasticities and Joint Products,” Journal of Farm Economics, 46:3, 652-656.

Lin, William, Yingchun Dai, Funing Zhong, Francis Tuan, and Xi Chen. (2007) “Does Biotech Labeling Affect Consumers’ Purchasing Decisions? A Case Study of Vegetable Oils in Nanjing, China,” selected paper presented at the IATRC Summer Meeting.

Lin, William, Agapi Somwaru, Francis Tuan, Jikun Huang, and Junfei Bai. 2006. “Consumers’ Willingness to Pay for Biotech Foods in China: A Contingent Valuation Approach,” AgBioForum, 9:3, 166-179.

Marchant, Mary A., and Baohui Song. (2005). “Assessment of Biotechnology Policies and International Trade in Key Markets for U.S. Agriculture” Journal of Agricultural and Applied Economics. 37:2, 379-391.

Piggott, Nicholas E and Michael K. Wohlgenant (2002). “Price Elasticities, Joint Products, and International Trade,” Australian Journal of Agricultural and Resource Economics, 46:4, 487-500.

Pothidee, Ajchara, Albert J. Allen, and Darren Hudson (1999). “Impacts of Corn and Soybean Meal Price Changes on the Demand and Supply of U.S. Broilers.” Selected Paper prepared for presentation at the American Agricultural Economics Association Meeting, Nashville, Tennessee, August 1999.

Sarwar, Ghulam and Dale G. Anderson (1990). “Estimating US Soybean Exports: A Simultaneous Supply/Demand Approach.” Journal of Economic Studies 17:1.

Song, Baohu, and Mary A. Marchant. (2005). “China’s Biotech Policies and Their Impacts on U.S. Agricultural Exports to China,” in China's Agri-Food Value Chain: Opportunities and Challenges, proceedings of the Assessing China as a Market and Competitor WCC-101 Research Project; Reno, NV. April, 2005. Conference

proceedings available on the World Wide Web: http://www.china.wsu.edu/.
Song, Baohui, Mary A. Marchant, and Shuang Xu. (2006a) "Competitive Analysis of Chinese Soybean Import Suppliers --U.S., Brazil, and Argentina," selected paper presented at theAmerican Agricultural Economics Association Annual Meetings Long Beach, CA, July 23-26, 2006.
Song, Baohui, Mary A. Marchant, and Shuan Xu (2006b). "Who Dominates Market Power for U.S.-China Soybean Trade?" Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings Orlando, Florida, February 2006.
Song, Baohui, Mary A. Marchant, Michael R. Reed, and Shuang Xu. (2007). "Market Power and Competitive Analysis of China's Soybean Import Market," the International Agricultural Trade Research Consortium (IATRC), Beijing, China, July 8-9th, 2007.
Tian, Wei-Ming and John Chudleigh (1999). "China's Feed Grain Market: Development and Prospects." Agribusiness, Vol. 15, No. 3, 393–409.
United States Department of Agriculture (USDA). (2007). "USDA Agricultural Projections to 2016".
United States Department of Agriculture, Foreign Agriculture Service (USDA, FAS). (2003a, 2004a, 2005a, 2006a, 2007b, and 2008d). "Global Agricultural Information Network (GAIN) Report: China, Peoples Republic of Livestock and Products Semi-Annual," Report Number CH3009 for 2003, CH4003 for 2004, CH5010 for 2005, CH6002 for 2006, CH7014 for 2007, and CH8014 for 2008. Available on the World Wide Web: http://www.fas.usda.gov/scriptsw/AttacheRep/default.asp
—— 2003b, 2004c, 2005c, 2006d, 2007c and 2008b. "GAIN Report: China, Peoples Republic of Grain and Feed Annual," Report Number CH3010 for 2003, CH4005 for 2004, CH5015 for 2005, CH6010 for 2006, CH7015 for 2007, and CH8012 for 2008. Available on the World Wide Web: http://www.fas.usda.gov/scriptsw/AttacheRep/default.asp
—— 2003c, 2004b, 2005b, 2006b, 2007d, and 2008c. "GAIN Report: China, Peoples Republic of Poultry and Products Semi-Annual," Report Number CH3011 for 2003, CH4004 for 2004, CH5011 for 2005, CH6004 for 2006, CH7016 for 2007, and CH8013 for 2008. Available on the World Wide Web: http://www.fas.usda.gov/scriptsw/AttacheRep/default.asp
—— 2004d, 2005d, 2006c, 2007a, 2008a, and 2008e. "GAIN Report Number CH4010: China, Peoples Republic of Oilseeds and Products Annual: Part 1 of 2 – Analysis," Report Number CH4010 for 2004, CH5017 for 2005, CH6006 for 2006, 2007a for 2007, and CH8010 and CH8088 for 2008. Available on the World Wide Web: http://www.fas.usda.gov/scriptsw/AttacheRep/default.asp
World Trade Atlas, http://www.gtis.com/product.cfm?level=1&type=W
Zhang, Li, and Lewell Gunter (2004). "A Marketing Analysis of U.S. Chicken Exports to China." Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meetings, Tulsa, Oklahoma, February, 2004.
Zhou, Zhang Y., Wei M. Tian, and Bill Malcolm (2008). "Supply and demand estimates for feed grains in China." Agricultural Economics 39: 111-122.

Table 1. Variables in the Model

Variable	Economic Meaning	Unit	Variable	Economic Meaning	Unit
M_{CH}^{US}	China's Monthly Soybean Imports from the U.S.	Million Metric Tons	PSO_{CH}^{US}	Real Monthly Prices of China's Soybean Imports from the U.S.	$/Metric Ton
M_{CH}^{SA}	China's Monthly Soybean Imports from South America	Million Metric Tons	PSO_{CH}^{SA}	Real Monthly Prices of China's Soybean Imports from South America	$/Metric Ton
$PSOL_{CH}^{IM}$	Real Monthly Prices of China's Soybean Oil Imports	$/Metric Ton	$PSOL_{CH}^{DO}$	Real Monthly Prices of China's Soybean Oil Wholesale	$/Metric Ton
$PSML_{CH}^{DO}$	Real Monthly Prices of China's Soybean Meal Wholesale	$/Metric Ton	$PRSL_{CH}^{DO}$	Real Monthly Prices of China's Rapeseed Oil Wholesale	$/Metric Ton
$PPML_{CH}^{IM}$	Real Monthly Prices of China's Palm Oil Imports	$/Metric Ton	$PCON_{CH}^{DO}$	Real Monthly Prices of China's Corn Wholesale	$/Metric Ton
$PHOG_{CH}^{DO}$	Real Monthly Prices of China's Pork Wholesale	$/Metric Ton	$PCKN_{CH}^{DO}$	Real Monthly Prices of China's Live Chicken Wholesale	$/Metric Ton
INC	China's Real Monthly GDP	Billion Dollars	$QSML_{CH}^{DO}$	China's Monthly Soybean Meal Consumption	Million Metric Tons
QSO_{CH}	China's Monthly Total Soybean Consumption	Million Metric Tons	$QSOL_{CH}$	China's Monthly Total Soybean Consumption	Million Metric Tons
$QSOL_{CH}^{DO}$	China's Monthly Soybean Oil Consumption Produced Domestically	Million Metric Tons	$QSOL_{CH}^{IM}$	China's Monthly Soybean Oil Consumption from Imports	Million Metric Tons
DUS	A Dummy Variable for the U.S. Exporting Season		DSA	A Dummy Variable for the South America Exporting Season	
DIU	A Dummy Variable for the Months When Soybean Imports from the U.S. Less than 1,000 Metric Tons		DIS	A Dummy Variable for the Months When Soybean Imports from South America Less than 1,000 Metric Tons	
DIO	A Dummy Variable for the Months When the Price of China's Oil Product Imports Skyrocketing		DCS	A Dummy Variable for the Months When Chinese Government Subsidized Swine Production	

Table 2. Percentages of Net Export in China’s Soybean Meal Supply and Net Stock in China’s Soybean Oil Supply

	2002	2003	2004	2005	2006	2007
Percentages of Net Export in China's Soybean Meal Supply	**4.1%**	**3.1%**	**2.3%**	**-1.8%**	**3.0%**	**0.3%**
Percentages of Net Stock in China's Soybean Oil Supply	**0.6%**	**2.0%**	**-1.3%**	**-0.6%**	**0.6%**	**-0.7%**

Source: USDA, FAS (2004d, 2005d, 2006c, 2007a, 2008a, and 2008e)

Table 3. Comparison of China’s Consumption of Soybeans (Unit: Million Metric Tons)

	2002	2003	2004	2005	2006	2007
China's Consumption of Soybeans Calculated from Soybean Meal Production	**26.6**	**25.3**	**31.4**	**35.1**	**35.6**	**38.6**
China's Consumption of Soybeans Calculated from Soybean Oil Production	**25.8**	**25.0**	**31.1**	**34.2**	**35.2**	**38.2**
China's Consumption of Soybeans in USDA Report	**26.5**	**25.3**	**31.3**	**34.5**	**35.5**	**38.5**

Source: USDA, FAS (2004d, 2005d, 2006c, 2007a, 2008a, and 2008e)

Table 5. Elasticities of China’s Soybean Imports from the U.S. and South America

	M_{CH}^{US}		M_{CH}^{SA}	
	Short-Term	Long-Term	Short-Term	Long-Term
PSO_{CH}^{US}	**-5.46(1.40)*** **	**-6.48(1.54)*** **	**1.99(0.63)*** **	**2.33(0.73)*** **
PSO_{CH}^{SA}	**1.15(1.68)**	**1.36(1.98)**	**-4.95(1.03)*** **	**-5.81(1.23)*** **
$PSOL_{CH}^{IM}$	**4.00(1.65)** **	**4.75(1.96)** **	**7.81(1.65)*** **	**9.17(1.97)*** **
$PSOL_{CH}^{DO}$	**-3.07(1.27)** **	**-5.18(2.35)** **	**-5.36(1.34)*** **	**-9.21(3.27)*** **
$PSML_{CH}^{DO}$	**2.51(0.82)*** **	**3.63(1.14)*** **	**0.41(0.56)**	**0.76(0.96)**
$PRSL_{CH}^{DO}$	**0.92(0.47)* **	**2.70(1.53)* **	**1.78(0.83)** **	**5.22(2.61)* **
$PPML_{CH}^{IM}$	**0.67(0.37)* **	**1.98(1.13)* **	**1.31(0.44)*** **	**3.83(1.37)*** **
$PCON_{CH}^{DO}$	**0.67(0.35)* **	**1.98(0.94)** **	**1.31(0.66)* **	**3.82(1.65)** **
$PHOG_{CH}^{DO}$	**0.23(0.14)* **	**0.69(0.36)* **	**0.46(0.27)**	**1.34(0.69)* **
$PCKN_{CH}^{DO}$	**-0.28(0.14)* **	**-0.84(0.47)* **	**-0.55(0.26)** **	**-1.62(0.81)* **
INC	**-1.66(0.90)* **	**-4.90(2.25)** **	**-3.25(1.66)*** **	**-9.48(3.86)*** **

Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

Table 4. Estimation Results of the Model by Using GMM Method

Variables	Full Model		
	M_{CH}^{US}	M_{CH}^{SA}	$PSOL_{CH}^{IM}$
Intercept	**0.57(3.74)**	**-1.70(3.00)**	**2.06(1.02)****
PSO_{CH}^{US}	**-5.46(.140)*****	**1.99(0.63)*****	—
PSO_{CH}^{SA}	**1.15(1.68)**	**-4.95(1.03)*****	—
$PSOL_{CH}^{IM}$	**4.00(1.65)****	**7.81(1.65)*****	—
$PSOL_{CH}^{DO}$	**-2.41(1.08)****	**-4.07(0.92)*****	**-0.17(0.10)****
$PSML_{CH}^{DO}$	**2.23(0.81)*****	**-0.96(0.57)***	**0.07(0.02)*****
$PRSL_{CH}^{DO}$	—	—	**0.23(0.09)****
$PPML_{CH}^{IM}$	—	—	**0.17(0.05)*****
$PCON_{CH}^{DO}$	—	—	**0.17(0.08)****
$PHOG_{CH}^{DO}$	—	—	**0.06(0.04)**
$PCKN_{CH}^{DO}$	—	—	**-0.07(0.03)****
$Lag1\left(M_{CH}^{US}\right)$	**0.16(0.04)*****	—	—
$Lag1\left(M_{CH}^{SA}\right)$	—	**0.15(0.02)*****	—
$Lag1\left(PSOL_{CH}^{IM}\right)$	—	—	**0.60(0.06)*****
INC	—	—	**-0.42(0.23)****
DUS	**1.83(0.27)*****	—	—
DIU	**-8.55(1.05)*****	—	—
DSA	—	**1.69(0.25)*****	—
DIS	—	**-14.08(1.99)*****	—
DIO	—	—	**0.03(0.02)**
DCS	**0.91(0.23)*****	**0.15(0.18)**	—
Goodness of Fit			
R^2	**0.81**	**0.89**	**0.96**
Adjusted R^2	**0.78**	**0.87**	**0.95**
Diagnostic Tests			
DW Statistic	**1.81**	**1.72**	**2.26**
White's Test ($\Pr > ChiSq$)	**0.11**	**0.08**	**0.48**
ADF Test ($\Pr < Tau$)	**<0.0001**	**<0.0001**	**<0.0001**

Note: *** 1% significance level, ** 5% significance level, * 10% significance level.

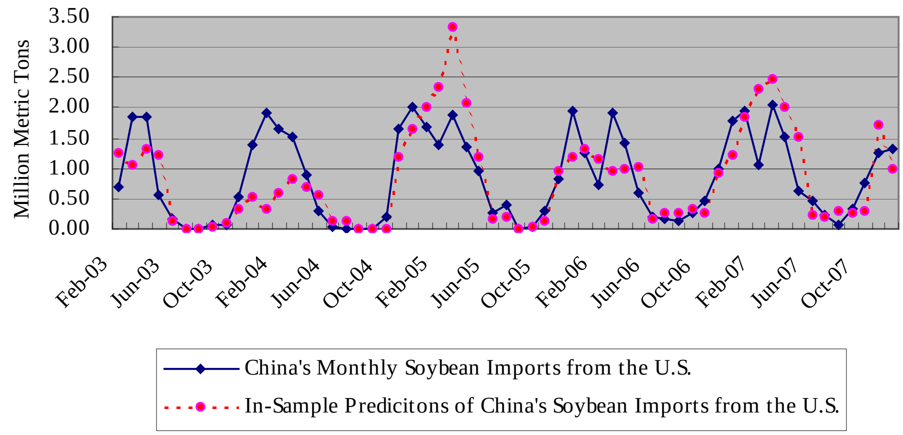

Figure 1. Historical and In-Sample Predictions of China's Monthly Soybean Imports from the U.S., February 2003 – December 2007.

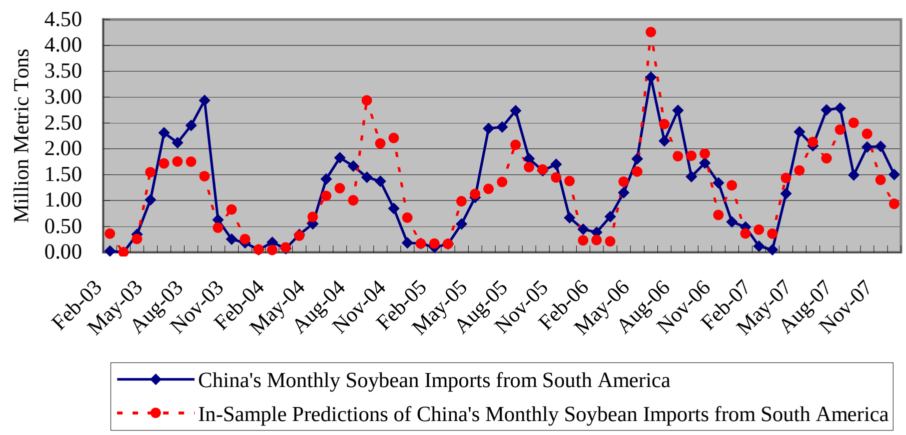

Figure 2. Historical and In-Sample Predictions of China's Monthly Soybean Imports from South America, February 2003 – December 2007.

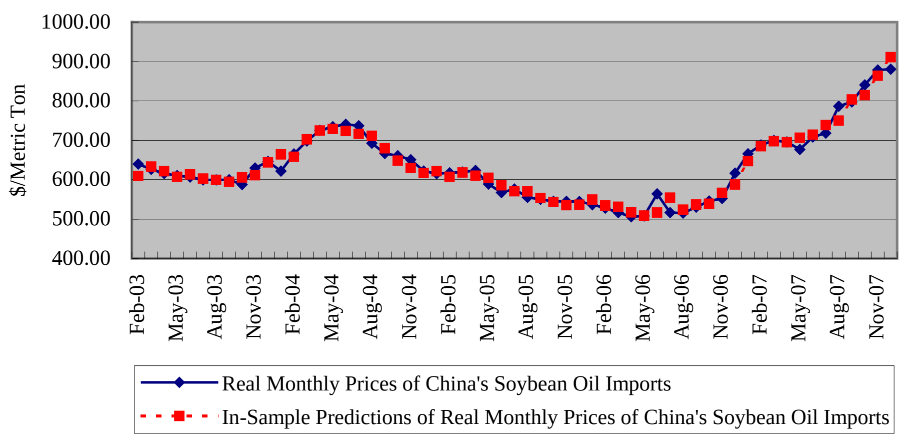

Figure 3. Historical and In-Sample Predictions of China's Real Monthly Soybean Oil Import Prices, February 2003 – December 2007.