China's soybean product imports: An analysis of price effects using a production system approach

Abstract

Purpose - The primary objective of this paper is to estimate China's demand for imported soybeans and soybean oil from both country-of-origin and product form perspectives.

Design/methodology/approach - A differential production approach is used to estimate China's demand for imported soybeans and soybean oil. The empirical demand estimates are then used to derive conditional and unconditional elasticities of demand for each exporting country with respect to changes in domestic and import prices, and the price of resources used in soybean meal and oil production.

Findings - Results indicate that both country-of-origin and product form competition exist in the Chinese market. Estimation results indicate that China's soybean meal prices significantly impacted its soybean and soybean oil imports. Seasonality is detected in China's soybean imports, but not in soybean oil imports.

Practical implications - Our findings suggest that, in addition to country-of-origin competition, product form competition should be considered when analyzing China's soybean demand.

Originality/value - This paper contributes to a better understanding of China's soybean import market by integrating both country-of-origin competition and product form competition into a single demand framework.

JEL classification – Q11, Q17

Keywords China, Soybean imports, Differential production approach, Conditional elasticities, Unconditional elasticities

Paper type Research paper

China's Soybean Product Imports: An Analysis of Price Effects using a Production System Approach

1. Introduction

China is the largest soybean and soybean oil importing country in the world. According to the United Nations, global soybean and soybean oil trade in 2009 were valued at $28.1 billion and $6.6 billion, respectively, where China accounted for about two-thirds and one-third of world imports, respectively (UN Comtrade, 2010). China's position in world soybean trade is due to an increase in imports that is fairly recent. For instance, during the period 2005−2008, China's soybean and soybean oil imports increased by 189 percent from $8.7 billion to $25.1 billion. While soybeans account for the greater share of total imports (soybeans and soybean oil), soybean oil has accounted for as much as 15 percent in recent years. The primary suppliers of soybeans to China include the United States, Brazil and Argentina. These countries account for nearly 100 percent of all soybean exports to China, and Argentina and Brazil account for nearly 100 percent of all soybean oil (Table 1).

[Table 1]

The soybean import market in China exhibits both country-of-origin (source) and product form (soybeans versus soybean oil) competition. Although soybeans are relatively homogeneous across exporting countries, the observed source competition in China is likely due to diversification efforts to minimize risk (Wolak and Kolstad 1991). Additionally, there are also perceived differences such as a country's reputation for quality, trade history, reliability and consistency, and political issues tied to trade resulting in imperfect substitutability across exporting sources (Muhammad and Kilmer, 2008). Product form competition is particularly interesting because in order to satisfy soybean oil demand, producers are faced with the decision to (1) import beans which are then processed to produce soybean oil and meal or (2) import oil directly. A trade dispute in early 2010 between China and Argentina brought to light the competitive relationship between soybean and soybean oil imports. Due to quality issues, the Chinese government banned soybean oil imports from Argentina (Niu and Misculin, 2011). As a result, soybean oil imports decreased by 50 percent, while soybean imports increased by 29 percent to a new historical high of 55 MMT (million metric tons) (USDA, FAS 2011). Given the importance of China to world soybean trade, a thorough understanding of the role that source and product form play in determining demand is of particular importance to exporters in the United States, Brazil, and Argentina as they engage in efforts to increase their share of the Chinese market.

The economic literature focusing on soybean import demand in China is quite extensive. Past studies include Taylor *et al.* (2009), where they applied a spatial optimization model to project future imports by 2020 conditional on technological progress in China's soybeans sector. Zhang and Xue (2007) applied a regime-switching model to study the efficiency of China's soybean production. They find that China will continue to rely on imports to satisfy its domestic demand. Tuan *et al.* (2010), and Marchant and Song (2005) both examined China's biotech policies and their effect on soybean imports; and policies such as the minimum price procurement and value added tax refund for China's soybean industry were discussed in Hansen *et al* (2011). Both Zhang *et al.* (2010) and Andino *et al.* (2006) examined the effects of exchange rates on China's soybean imports. Regarding the competition among sources, Song *et al*. (2009) used a partial equilibrium framework to assess the potential market power between China, the United States, and South America. To the authors' best knowledge, most of the existing research focused on the competition between exporting countries in China's soybean market (Zhang and Xue 2007; Tuan *et al.*

2010; Taylor *et al.* 2009; Song *et al.* 2009; and Zhang *et al.* 2010), but few studies have considered the competition between product forms.

To fill this gap, the primary objective of this research is to assess both country-of-origin and product form competition in China's imports. This is accomplished by estimating the derived demand for soybean and soybean oil imports differentiated by source, where we assess the impact of import, domestic, and resource prices on import demand. Given that soybean and soybean oil imports are for the most part intermediate goods, import demand is modeled as input demand. In treating imports as inputs, we relate domestic soybean oil and meal production not only to total import demand, but also to the demand for soybeans and soybean oil from specific exporting countries.

In this research, a production version of the Rotterdam model is used to estimate soybean import demand in China (Theil 1980; Laitinen 1980). The model is derived from a two-step profit maximization procedure and results in a structural system of import demand equations. Due to origin specific factors (real or perceived), each exporting country is treated as a unique supplier of soybeans and soybean oil. Chinese importers are faced with the two decisions. The first being, conditional on the level of total expenditures, importers decide how much soybeans and soybean oil to import from each supplying country. Second, importers then decide the actual level of total expenditures. This framework has been widely used to model import demand for agricultural commodities and include products such as apples (Seale, Sparks, and Buxton, 1992), whey (Washington and Kilmer, 2002), beef (Mutondo and Henneberry, 2007), butter (Muhammad and Kilmer, 2008), and flowers (Muhammad, 2009). Specific objectives of this study are as follows: first, we estimate China's demand for imported soybeans and soybean oil differentiated by country of origin; and second, the empirical demand estimates are used to derive conditional and unconditional elasticities of import demand for each exporting country with respect to changes in domestic and import prices, and the price of resources used in soybean meal and oil production.

2. Overview of China's soybean sector

Following the United States, Brazil and Argentina, China is the fourth largest soybean producing country with an annual production ranging from 14 to 17 MMT. In China, domestically produced soybeans are non-biotech and primarily used to produce food products like tofu and soymilk. In contrast, imported soybeans are categorized as biotech products and can only be used to produce soybean meal and oil. From 2002-2009, soybeans used for meal and oil production (crushed soybeans) have accounted for about three-quarters of total soybean consumption in China. In 2009 (2008/09 production season), the volume of crushed soybeans reached 41.0 MMT (USDA, FAS 2010). During this period, imports accounted for 99 percent of crushed soybeans, up from 81 percent in 2002 (Figure 1).

[Figure 1]

Without imports, China would need to plant an additional 34 million hectares of soybeans to obtain meal and oil output equivalent to its imports in 2009. At current yields, this would require about 30 percent of China's total arable land, which would have a significant negative effect on the production of other major grains such as rice, wheat, and corn. Furthermore, soybean-yield growth in China has been relatively slow when compared to the United States and South America. Given the difficulty in increasing the amount of land dedicated to soybean production as well as low yield growth, China will continue to depend on the global market to satisfy its soybean demand (Zhang and Xue, 2007). According to the U.S. Department of Agriculture long-term projections, China's soybean imports are projected to account for about 90 percent of the expected growth in world soybean trade by 2020 (USDA 2011).[1]

China's demand for soybean meal and oil is the main reason for the large volume of imports. Soybean meal and oil are joint products where 10 metric tons (MT) of raw soybeans typically produces 7.9 MT of soybean meal and 1.8 MT of soybean oil. In China, soybean meal is mostly used for its protein content in swine and poultry feed and is the most consumed feed meal ingredient. In 2009, based on authors' calculation using USDA, FAS data (USDA, FAS 2010), soybean meal accounted for 64 percent of China's total feed meal consumption, where 99 percent was produced from imported soybeans.

Soybean oil is the most consumed vegetable oil in China accounting for about 40 percent of total vegetable oil consumption in recent years. Soybean oil demand is primarily satisfied in two ways: soybeans are crushed to produce soybean oil and soybean oil is imported directly. In 2009, imported soybean oil and soybean oil produced from soybean imports totaled 9.8 MMT. This volume accounted for almost 100 percent of China's total soybean oil supply (USDA, FAS 2010). From this total, China imported around 2.5 MMT of soybean oil in 2009. To produce this quantity domestically would require 13.8 MMT of soybeans, which is equivalent to 34 percent increase in raw soybean imports and also equivalent to 89 percent of China's soybean production in 2009. China imports a large volume of soybean oil from South American countries every year. This means that China could substitute its soybean oil imports from South America for its soybean imports from this area, or vice versa. Moreover, since soybean crushing facilities operate year round,

[1] Section 2 is based on reports by the United States Department of Agriculture, Foreign Agriculture Service (2010, 2009, 2008, 2007, 2006, 2005, and 2004).

soybean oil imports may partly replace China's soybean imports from the United States, since the United States and its South American competitors have different harvesting seasons.

Overall, China's demand for soybean meal and oil is the main reason for the large volume of soybean imports. The research on product form competition between soybeans and soybean oil together with country-of-origin competition will improve our understanding about China's soybean imports.

3. Empirical import demand model

The production version of the Rotterdam model is used to estimate the demand for imported soybeans in China. The model is derived from the differential approach to the multiproduct firm (Theil, 1977; Laitinen and Theil, 1978; Laitinen, 1980; and Theil, 1980), and has been widely used in import demand analysis. Empirical applications include Clements and Theil (1978), Theil and Clements (1978), Washington and Kilmer (2002), and Muhammad (2007; 2009).

Assume a representative firm that imports raw soybeans for soybean meal and oil production from n exporting countries. The firm can also import soybean oil directly for further redistribution. Let x and w denote the import quantity and price, the subscripts g and h denote the product (soybeans and soybean oil), and the subscripts i and j denote the exporting country. Following Mutondo and Henneberry (2007), the derived demand for product g from country i can be expressed by the following log-difference equation: [2]

[2] There are two products (soybeans and soybean oil) and three countries (Argentina, Brazil, and the United States), resulting in six distinct imports in total. However, there are only five imports in this analysis due to soybean oil imports from the United States being zero throughout the data period.

$$\bar{f}_{g_it}\Delta x_{g_it} = \theta_{g_i}\Delta X_t + \sum_{h=1}^{2}\sum_{j=1}^{3}\pi_{g_ih_j}\Delta w_{h_jt} + \sum_{m=1}^{12}\rho_{g_im}D_m + \varepsilon_{g_it}. \qquad (1)$$

$\bar{f}_{g_it} = 0.5(f_{g_it} + f_{g_it-1})$, where f_{g_i} is the market share for product *g* from country *i* and is derived as follows:

$$f_{g_i} = \frac{w_{g_i}x_{g_i}}{\sum_{g=1}^{2}\sum_{i=1}^{3}w_{g_i}x_{g_i}}$$

Δ is the log-difference operator, where for any variable k_t, $\Delta k_t = \log k_t - \log k_{t-1}$. ΔX is the Divisia volume index, which is a measure of change in total expenditures (in real terms) on all soybean and soybean oil imports in China and is derived as follows:

$$\Delta X_t = \sum_{g=1}^{2}\sum_{i=1}^{3}\bar{f}_{g_it}\Delta x_{g_it}.$$

The parameter θ_{g_i} is the marginal import share which measures how an additional unit of expenditures is allocated to product *g* from country *i*, and $\pi_{g_ih_j}$ is the conditional price effect which measures how the price of product *h* in country *j* affects imports of product *g* from country *i*. The third term on the right accounts for the seasonality in China's imports. D_m is a monthly dummy variable where $D_m = 1$ in month *m* and $D_m = 0$ otherwise. The terms θ_{g_i}, $\pi_{g_ih_j}$, and ρ_{g_im} are assumed constant across time for estimation and ε is a random error term.

Economic theory suggests the following parameter restrictions:

$$\sum_{g=1}^{2}\sum_{i=1}^{3}\theta_{g_i} = 1,\ \sum_{g=1}^{2}\sum_{i=1}^{3}\pi_{g_ih_j} = 0, \text{ and } \sum_{g=1}^{2}\sum_{i=1}^{3}\rho_{g_i} = 0 \text{ (adding up);}$$

$$\sum_{h=1}^{2}\sum_{j=1}^{3}\pi_{g_ih_j} = 0 \text{ (homogeneity); and}$$

$$\pi_{g_ih_j} = \pi_{g_jh_i}; \pi_{g_ih_j} = \pi_{h_ig_j}; \pi_{g_ih_j} = \pi_{h_jg_i} \text{ (symmetry).}$$

Additionally, the matrix of conditional price effects $\mathbf{\Pi} = [\pi_{g_i h_j}]$ should be negative semidefinite (negativity), which implies that $\pi_{g_i g_i} \leq 0 \forall g_i$ (Laitinen, 1980). The import demand system defined by equation (1) satisfies adding-up by construction. The homogeneity and symmetry constraints must be imposed on the parameters and are empirically tested. Negativity is verified by inspection.

Theil (1977) shows that from the profit maximization problem we can derive the following Divisia index equation:

$$\Delta X_t = \sum_{r=1}^{2} \varphi_r \Delta p_{rt} + \sum_{h=1}^{2} \sum_{j=1}^{3} \psi_{h_j} \Delta w_{h_j t} + \psi_l p_{lt} + v_t . \quad (2)$$

Equation (2) indicates that expenditures on all imports are a function of domestic soybean meal and oil prices (p_r), soybean and soybean oil import prices (w_{h_j}), and the price of resources used in production such as labor (p_l). The output price coefficient (φ_r) should be positive since higher domestic soybean oil and meal prices should lead to greater imports. The import price coefficient (ψ_{h_j}) should be negative since higher import prices should lead to a decrease in total import expenditures. Similarly, the labor price coefficient (ψ_l) should also be negative. φ_r , ψ_{h_j} , and ψ_l are assumed constant and v is a random error term.

Note that equation (1) and (2) form a system, where equation (1) is the allocation of import expenditures across exporting sources and equation (2) is the determination of total imports expenditures. The estimation procedure assumes a two-step approach to profit maximization suggested by Theil (1980) and Laitinen (1980). First, firms minimize input expenditure subject to the technology constraint (conditional on output and input prices) and, second, they maximize profit by varying output. As noted by Theil (1980), this two-step procedure is preferred to a direct (one-step) profit maximization procedure because the resulting demand model is comparable to consumer demand models, and the disturbances of equations (1) and (2) are stochastically independent.

From equation (1), the conditional price and expenditure elasticities of demand are derived where the conditional price elasticity is $\pi_{g_i h_j} / \overline{f}_{g_i}$ and the conditional expenditure elasticity is $\theta_{g_i} / \overline{f}_{g_i}$. Substituting the right hand side of equation (2) for the Divisia index term in equation (1), the unconditional elasticities of demand for an individual product and country with respect to domestic prices, import prices, and wages can be derived. These are calculated, respectively, as

$$\eta_{g_i r} = \frac{d\left(\log x_{g_i}\right)}{d\left(\log p_r\right)} = \frac{\theta_{g_i}}{\overline{f}_{g_i}} \varphi_r \tag{3}$$

$$\eta_{g_i h_j} = \frac{d\left(\log x_{g_i}\right)}{d\left(\log w_{h_j}\right)} = \frac{\pi_{g_i h_j}}{\overline{f}_{g_i}} + \frac{\theta_{g_i}}{\overline{f}_{g_i}} \psi_{h_j} \tag{4}$$

$$\eta_{g_i l} = \frac{d\left(\log x_{g_i}\right)}{d\left(\log p_l\right)} = \frac{\theta_{g_i}}{\overline{f}_{g_i}} \psi_l . \tag{5}$$

Equation (3) measures the responsiveness of imports by product and country given a percentage change in domestic soybean meal or oil prices; equation (4) measures the responsiveness of imports given a percentage change in import prices; and equation (5) measures the responsiveness of imports given a percentage change in wages. Note that equation (4) is comprised of two effects. The first term is the direct or conditional effect of an import price change, which is the impact of relative prices (substitution effect), and the second term is the indirect effect of an import price change, which is the change in imports induced by the effect of import prices on total expenditures (expenditure effect). With total expenditures being constant, the conditional price elasticity only accounts for the substitution effect of a price change and reflects the competitiveness of an exporting country in that it measures how prices affect exporter market share. In contrast, the unconditional elasticity accounts for total effect of a price change and reflects the actual responsiveness of imports. Thus, while the conditional elasticity is more suited for assessing competition and substitutability, the unconditional elasticity is best suited for assessing the effects of price-distorting policies on imports.

4. Data and summary statistics

Monthly import data are provided by Global Trade Information Services, Inc. The time period considered for the analysis is January 2005−December 2009. Imports are disaggregated by country of origin (Argentina, Brazil, and the United States) and product form (soybeans and soybean oil) and are defined according to HS-4 categories 1201 *Soya Beans, Whether Or Not Broken* and 1507 *Soya-Bean Oil and Its Fractions*. Import values are measured in U.S. dollars ($) and quantities are in metric tons (MT). Unit values are used as proxies for import prices ($/MT). Domestic soybean oil and meal prices are obtained from the U.S. Department of Agriculture, Foreign Agricultural Service, and wages are provided by the China Economic Information Network.

During the data period, monthly imports of U.S. soybeans were valued at $464.9 million on average, followed by soybeans from Brazil and Argentina ($398.8. and $240.2, respectively). Soybean oil imports from Argentina and Brazil were valued at $111.7 and $32.3 million on average. The price of soybeans from the United States, Brazil and Argentina averaged $391.17/MT, $391.75/MT and $384.37/MT, respectively; while the price of soybean oil from Brazil and Argentina averaged $781.55/MT and $770.44/MT, respectively. The domestic price of soybean meal and oil in China averaged $409.47/MT and $998.82/MT during the data period.

5. Estimation procedure and empirical results

The import demand system as defined by equation (1) was estimated by using Iterative Seemingly Unrelated Regressions in SAS, and equation (2) (total expenditure equation) was estimated by Ordinary Least Squares in SAS. Theil (1980) showed that if the parameters in equations (1) and (2) are assumed constant and the errors normally distributed, then $\text{cov}(\varepsilon_{g_i t}, v_t) = 0$. This indicates that the total expenditure equation needs not be estimated jointly with the import allocation system. Due to the adding up property, the import allocation system was singular and required that an equation be deleted for estimation. The soybean oil equation for Argentina was deleted for this purpose and the parameters were recovered using the adding-up constraint. However, as shown by Barten (1969), estimates are invariant to the chosen deleted equation. Preliminary tests indicated that the errors in equations (1) and (2) were well behaved, i.e., serially uncorrelated, homoskedastic, and normally distributed. Wald tests are used to test the homogeneity and symmetry constraints. Both properties failed to be rejected at the 0.01 significance level and all reported estimates are homogeneity and symmetry constrained.

5.1. Import demand estimates

Conditional derived demand estimates for China's soybean and soybean oil imports are reported in Table 2. The marginal share estimates indicate a positive and significant relationship between total expenditures and imports from each country. Given a unit increase in total import expenditures, soybeans from Brazil are the most responsive (0.3296), followed by soybeans from Argentina (0.2810) and the United States (0.2713). These estimates are not statistically different from each other and indicate that for every one-dollar increase in total Chinese imports, about $.88 is allocated to soybeans, which are evenly split across the three exporting sources. This may be due to soybeans being relatively homogeneous across countries. The marginal share estimates for soybean oil are significantly smaller, 0.0947 for Argentina and 0.0234 for Brazil. This indicates that for every one-dollar increase in total imports, about $.12 is allocated to soybean oil. However, since soybean oil is a more differentiated product, we see a significant difference in the marginal shares for Brazil and Argentina.

The own and cross-price estimates are also reported in Table 2. These estimates are discussed in more detail when converted to elasticities. The own-price estimates (presented along the diagonal in Table 2) measure the responsiveness of Chinese import demand to changes in import prices for each soybean product and exporting country. Consistent with theory, they are all negative and significant. Note that the negativity property is confirmed when all own-price estimates are negative because Π is negative semidefinite when the trace of Π is less than or equal to zero. The own-price estimate for U.S. soybeans is -0.1897, which is larger than the estimate for soybeans from Brazil (-0.0290) and Argentina (-0.1044). For soybean oil, the estimates are -0.0511 and -0.1368 for Brazil and Argentina, respectively. This may imply that Chinese importers have a greater response to U.S. prices.

The cross-price parameter estimates indicate the Chinese market exhibits both source and product form competition. A number of countries/products are substitutes, where the cross-price effects are mostly significant for soybeans from Brazil. Results indicate that soybeans from Brazil compete with the following: soybeans from Argentina (0.0145), soybean oil from Brazil (0.0016), and soybean oil from Argentina (0.0116). Competitive relationships are also found for soybeans from the United States and Argentina (0.0755), and soybeans and oil from Argentina (0.0120).

[Table 2]

Table 3 presents the estimates of the total expenditure equation. Results show that total expenditures on imported soybeans and soybean oil in China are primarily determined by the domestic price of soybean meal, and the price of soybeans imported from Brazil and Argentina. The estimate for the domestic soybean meal price (0.9822) is positive as expected and significant at the 0.1 level, which indicates that China's soybean meal prices have a positive effect on total import expenditures and that a percentage increase in China's soybean meal price will cause total import expenditures to increase by 0.98 percent. Interestingly, domestic soybean oil prices were not significant. This may be due to soybean meal and oil being joint products and meal accounting for the greater share of crushed soybeans. Of all imports, the estimates for soybeans from Brazil (−0.0690) and Argentina (−0.1349) are the only significant import price estimates, but the magnitudes are relatively small when compared to the estimate for soybean meal prices. Consistent with theory, the prices of these imports have negative effects on total import expenditures, where a percentage increase in soybean prices in Brazil and Argentina causes total expenditures to decrease by 0.07 and 0.13 percent, respectively.

[Table 3]

5.2. Conditional and unconditional elasticities

The conditional and unconditional demand elasticities are reported in Table 4. The conditional expenditure elasticity, which measures the percentage responsiveness of an import to a percentage change in total import expenditures, is significant for all imported products. The expenditure elasticity is largest for soybeans and soybean oil from Argentina

(1.46 and 1.0584), and soybeans from Brazil (1.0312). The expenditure elasticity is close to unity for soybean oil from Brazil (0.9041), but somewhat smaller for soybeans from the United States (0.7282).

[Table 4]

The conditional own-price elasticities show that soybean import demand in China is highly inelastic, while soybean oil import demand is highly elastic. The responsiveness of soybeans from Brazil is particularly small (-0.0907) when compared to soybean imports from the United States (-0.5091) and Argentina (-0.5422). The demand for soybean oil from Brazil is the most elastic (-1.9738), larger than the own-price elasticity for soybean oil from Argentina (-1.5287).

The impact of domestic soybean meal prices on source-specific imports is mostly elastic, with U.S. soybeans and soybean oil from Brazil being the only exceptions. Given a percentage increase in the domestic soybean meal price, the responsiveness of soybean imports would range from 1.434 percent for soybeans from Argentina to 0.7152 percent for the United States. For soybean oil, imports from Argentina and Brazil would increase by 1.0396 and 0.8880 percent, respectively.

When the expenditure effect of prices is accounted for, the own-price elasticity for soybean imports from the United States and soybean oil imports from Brazil are no longer significant. However, the remaining imports are still decreasing in own-price and are larger in magnitude when compared to the corresponding conditional elasticities. Given that soybeans from Brazil and Argentina are the only imports to have a significant negative effect on total import expenditures, the unconditional own-price elasticity should be significantly different from the conditional elasticity for these two imports and larger in magnitude given the structure of equation (4). In considering the total effect of a price change, a percentage increase in own-price causes Chinese importers to decrease soybean imports from Brazil by 0.1357 percent and Argentina by 0.7587 percent.

The unconditional cross-price elasticities indicate that the total expenditure effect can outweigh the effect of relative price changes. Therefore, it is possible for two products to be conditional substitutes, but unconditional complements. Furthermore, since the expenditure effects are different for each product, unconditional complementarities need not be symmetric. For instance, the responsiveness of U.S. soybeans to a soybean-price increase in Brazil is -0.0284 percent. However, since U.S. prices do not affect total expenditures, the percentage responsiveness of Brazilian soybeans to a soybean-price increase in the U.S. is still positive. Given the total expenditure effect, conditional substitutes can also be unconditionally price-neutral (unrelated). For instance, soybean and soybean oil imports from Argentina are conditional substitutes; however, the unconditional elasticities indicate that these two products are unrelated when accounting for the expenditure effect.

5.3. Seasonality estimates

The seasonal effects for China's imports are reported in Table 5, which contains the estimates of the monthly dummy variables in equation (1). The United States and the South American countries are located in different hemispheres. The harvest seasons for soybeans planted in the United States is from late September to early November; while in Brazil and Argentina, harvest occurs from the beginning of March to the end of May and from the beginning of April to the end of June, respectively (U.S. Department of Agriculture, 1994). The estimates indicate that seasonality is an important determinant of China's soybean imports. Overall, the estimates show that when the change in soybean imports from the United States are positive (negative) due to seasonal factors, imports from Argentina and/or

Brazil are negative (positive). The estimates for soybean oil were mostly insignificant and are not reported in the table.

[Table 5]

6. Conclusions

Given China's limited arable land available for soybean production coupled with China's growing demand for soybean meal as major feed for meat production and soybean oil as the most consumed vegetable oil, China will continue to strengthen its position as the largest global import market for soybeans and soybean oil. China accounts for more than 50 percent of world soybean imports and around 20 percent of world soybean oil imports. The USDA (2011) projects that China will account for 90 percent of the projected growth in the world total soybean imports (30 MMT) over the next decade. Therefore, China's strong demand will be a driving force behind world demand and prices.

To investigate competition among exporters, a differential production model was used to examine China's demand for soybean and soybean oil imports by country and assess the competition between exporting countries. We further assessed how exporting countries are affected by domestic soybean product prices in China. Both conditional and unconditional cross price elasticities indicate that, in addition to country-of-origin competition (United States versus Brazil or Argentina) there exists competition between China's soybean and soybean oil imports. Competitive relationships were detected between soybeans and soybean oil from the same source, as well as from different sources. However, we found that when considering the total effect of a price change (substitution and expenditure effects), a number of conditional competitive relationships became unconditional complementary or price neutral relationships.

Overall, our results indicate that the following should be considered when analyzing the soybean import market in China. (1) The competition between soybean and soybean oil imports should not be ignored. That is, our results show that soybean and soybean oil imports are dependent. (2) The impact of prices on total import expenditures can have a significant effect on the competitive relationship between products and exporting countries. (3) Lastly, seasonality is an important determinant of soybean imports, but there is no significant seasonality in soybean oil imports.

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Table 1. Soybean and oil imports in China and exporter market shares: 2005-2009

Year	Soybean and oil imports (million $US)	Market shares (percent)						
		Soybeans	Soybean oil	U.S. soybeans	Brazil soybeans	Argentina soybeans	Brazil soybean oil	Argentina soybean oil
2005	8,685.18	89.55	10.45	36.39	27.41	25.08	1.98	8.43
2006	8,292.13	90.32	9.68	32.80	36.42	19.52	1.66	7.85
2007	13,610.54	84.24	15.76	31.24	28.59	23.22	2.31	12.52
2008	25,149.74	86.74	13.26	33.52	28.96	23.08	3.67	8.77
2009	20,634.07	91.07	8.94	45.22	35.63	8.00	1.90	6.83

Market shares may not add to 100 percent due to negligible quantities imported from the rest of the world.
Source: World Trade Atlas ®, Global Trade Information Services, Inc.

Table 2. Conditional derived demand estimates for China's soybean and oil imports

Product/ Country	Marginal factor share, θ_{g_i}	Price coefficients, $\pi_{g_i h_j}$: Soybeans, U.S.	Soybeans, Brazil	Soybeans, Argentina	Soybean oil, Brazil	Soybean oil, Argentina
Soybeans, U.S.	0.2713*** (0.0594)	-0.1897** (0.0712)	0.0013 (0.0061)	0.0755*** (0.0129)	0.02344 (0.0214)	0.0894 (0.0613)
Soybeans, Brazil	0.3296*** (0.0450)		-0.0290*** (0.0053)	0.0145*** (0.0047)	0.0016* (0.0001)	0.0116*** (0.0025)
Soybeans, Argentina	0.2810*** (0.0506)			-0.1044*** (0.0115)	0.0023 (0.0017)	0.0120** (0.0054)
Soybean oil, Brazil	0.0234*** (0.0087)				-0.0511* (0.0262)	0.0238 (0.0321)
Soybean oil, Argentina	0.0947*** (0.0255)					-0.1368** (0.0661)

Homogeneity and symmetry are imposed. *** Significance level = 0.01, ** Significance level = 0.05, * Significance level = 0.10.

Table 3. Total expenditure estimates for China's soybean and oil imports

Output price coefficients, φ_r		Import price coefficients, ψ_{h_j}					Resource price coefficient, ψ_l
Soybean meal, China	Soybean oil, China	Soybeans, U.S.	Soybeans, Brazil	Soybeans, Argentina	Soybean oil, Brazil	Soybean oil, Argentina	Labor
0.9822* (0.5527)	-0.8812 (0.8634)	0.3759 (0.4502)	-0.0690*** (0.0107)	-0.1349*** (0.0200)	0.7853 (0.5234)	-0.5740 (0.6902)	8.091e-6 (0.0002)

*** Significance level = 0.01, ** Significance level = 0.05, * Significance level = 0.10.

Table 4. Demand elasticities for China's soybean and oil imports

Product/ Country	Divisia index	Conditional own and cross-price				
		Soybeans, U.S.	Soybeans, Brazil	Soybeans, Argentina	Soybean oil, Brazil	Soybean oil, Argentina
Soybeans, U.S.	0.7282*** (0.1594)	-0.5091** (0.1911)	0.0034 (0.0162)	0.2027*** (0.0345)	0.0629 (0.0575)	0.2400 (0.1644)
Soybeans, Brazil	1.0312*** (0.1409)	0.0040 (0.0189)	-0.0907*** (0.0164)	0.0455*** (0.0147)	0.0049* (0.0028)	0.0363*** (0.0078)
Soybeans, Argentina	1.4600*** (0.2627)	0.3924*** (0.0668)	0.0755*** (0.0244)	-0.5422*** (0.0596)	0.0119 (0.0086)	0.0623** (0.0279)
Soybean oil, Brazil	0.9041*** (0.3347)	0.9055 (0.8275)	0.0599* (0.0343)	0.0887 (0.0640)	-1.9738* (1.0117)	0.9196 (1.2403)
Soybean oil, Argentina	1.0584*** (0.2850)	0.9990 (0.6844)	0.1296*** (0.0278)	0.1340** (0.0600)	0.2660 (0.3588)	-1.5287** (0.7390)
	Output price (soybean meal)	Unconditional own and cross-price				
Soybeans, U.S.	0.7152* (0.4403)	-0.2804 (0.4147)	-0.0284* (0.0180)	0.0947*** (0.0322)	0.6701* (0.4513)	0.3632 (0.5789)
Soybeans, Brazil	1.0129** (0.5883)	0.3279 (0.5126)	-0.1357*** (0.0217)	-0.1075*** (0.0311)	0.8647* (0.6031)	-0.8179 (0.7558)
Soybeans, Argentina	1.4340** (0.8700)	0.8529 (0.7271)	0.0118 (0.0310)	-0.7587*** (0.0559)	1.2293* (0.8827)	-1.1470 (1.0866)
Soybean oil, Brazil	0.8880* (0.6279)	0.1894 (0.9515)	0.0204 (0.0349)	-0.0454 (0.0502)	-1.2199 (1.1637)	0.1708 (1.4267)
Soybean oil, Argentina	1.0396* (0.6717)	1.3314* (0.8765)	0.0834*** (0.0287)	-0.0230 (0.0489)	1.1486* (0.7511)	-2.4053** (1.1339)

*** Significance level = 0.01, ** Significance level = 0.05, * Significance level = 0.10.

Table 5. Seasonality estimates for China's soybean imports

Month	Soybeans, U.S.	Soybeans, Brazil	Soybeans, Argentina
January	0.0422 (0.0730)	-0.0075 (0.0625)	0.0444 (0.0582)
February	-0.0486 (0.0761)	0.0376 (0.0663)	0.0242 (0.0627)
March	0.1648** (0.0756)	-0.1266* (0.0660)	-0.0604 (0.0624)
April	-0.2545*** (0.0666)	0.3464*** (0.0564)	-0.0982* (0.0540)
May	-0.2816*** (0.0651)	0.1929*** (0.0561)	0.1282** (0.0526)
June	-0.2051*** (0.0655)	-0.0016 (0.0564)	0.2306*** (0.0529)
July	0.0395 (0.0642)	0.0181 (0.0559)	-0.0765 (0.0522)
August	-0.0736 (0.0651)	0.0374 (0.0560)	0.0279 (0.0524)
September	0.0276 (0.0659)	-0.0874 (0.0567)	-0.0077 (0.0528)
October	0.0941 (0.0644)	-0.0635 (0.0560)	-0.0133 (0.0521)
November	0.2037*** (0.0718)	-0.1699*** (0.0578)	-0.0619 (0.0588)
December	0.2860*** (0.0649)	-0.1484** (0.0561)	-0.1196** (0.0522)

*** Significance level = 0.01
** Significance level = 0.05
* Significance level = 0.10.

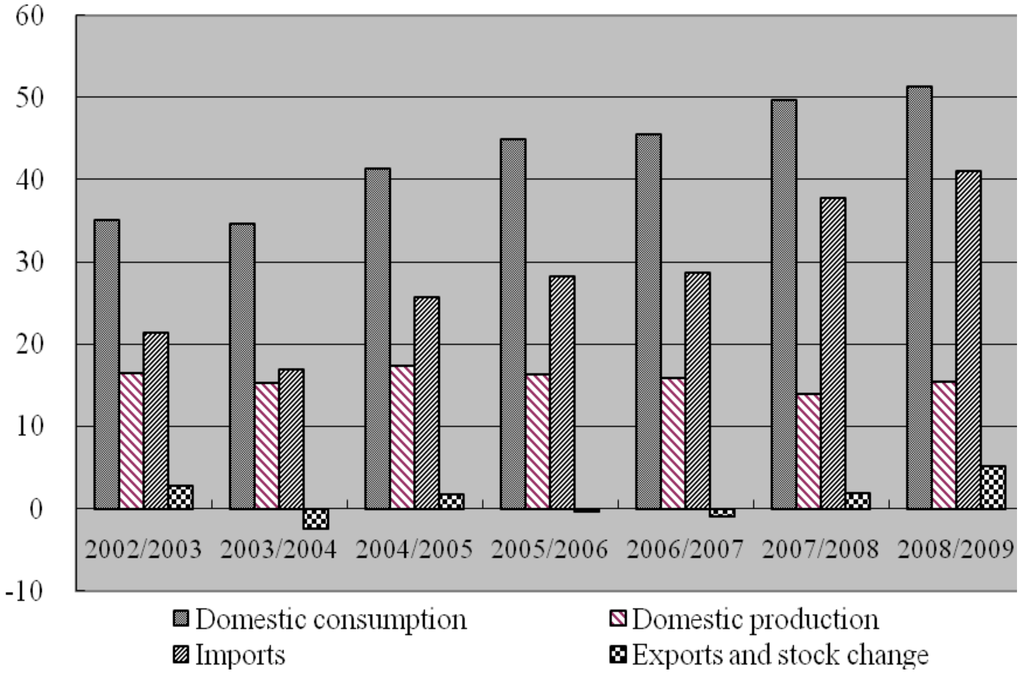

Figure 1. China's domestic soybean production, imports, and total consumption: 2002–2008 (units in million metric tons)
Source: Foreign Agricultural Service, U.S. Department of Agriculture (2010, 2009, 2008, 2007, 2006, 2005, and 2004).