Export Demand Estimation for U.S. Corn and Soybeans to Major Destinations

Yasser Saghaian, Michael Reed, and Sayed Saghaian

Department of Agricultural Economics

University of Kentucky

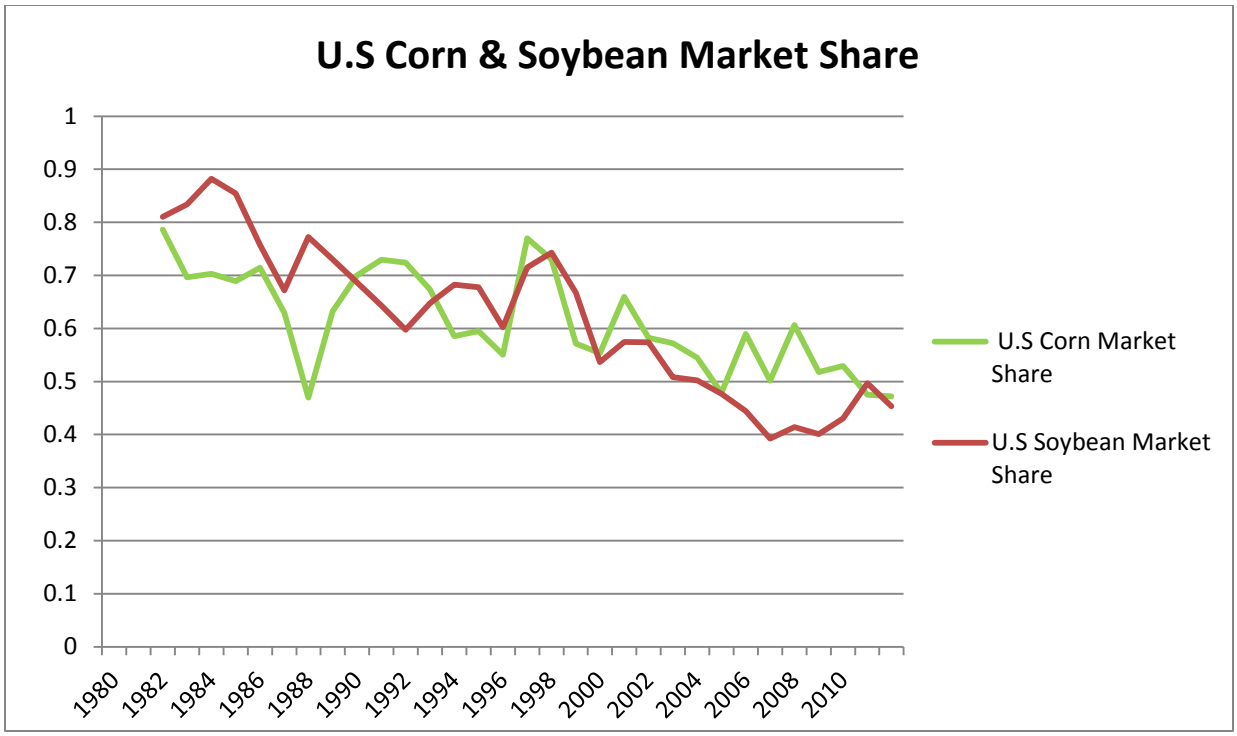
Selected paper prepared for presentation at the 2014 Southern Agricultural Economics Association (SAEA) Annual Meetings in Dallas, TX: Feb 1-4, 2014.

Abstract:

The United States is the leading producer and exporter of corn and soybeans in the world. The United States exports 20% of the world's corn and 30% of the world's soybeans every year. In this study, we empirically estimate the export demand of U.S. corn and soybeans to three main destinations, China, Japan, and EU, in the current context of energy and agriculture linkages and production of ethanol from corn. A log-linear equation is used to estimate the export demand estimation of U.S. corn and soybeans. Data for the U.S. and its three main importer markets were gathered for the 1980-2011 period. The results of the logarithmic model estimates showed that china had the most elastic demand. China has the highest income elasticity of 2.5, while the income elasticity for Japan and EU were close to 1. The parameter estimates for price of soybean as a cross price was significant for China and EU, and parameter estimates for price of corn as a cross price was significant only for Japan. The positive sign revealed soybeans and corn to be substitutes in those countries.

Introduction:

The U.S. has been and still is a major player in exporting agricultural crops such as corn and soybean worldwide. In recent years with high fuel prices, climate change, new export regulations due to use of corn and soybeans in bio-fuel production, corn and soybean prices have spiked. In return, we have seen reductions in the U.S. international market shares of corn and soybeans as shown in figure 1:



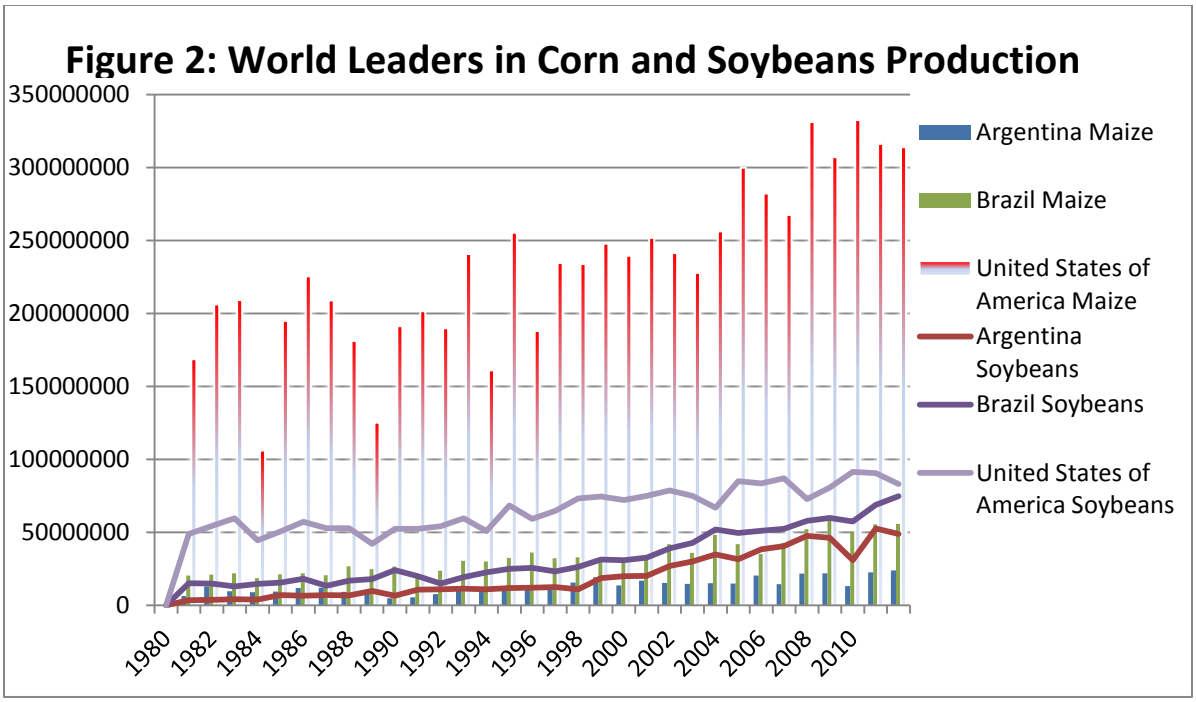
Other factors such as evolving stronger rivals in the international markets and a higher value of the U.S. dollar relative to some other currencies have also caused the loss of U.S. corn and soybean market shares worldwide.

The United States is the largest producer and exporter of corn and soybeans in the world. According to USDA U.S. farmers devote about 80 million acres of land every year planting corn and 77 million acres planting soybeans. Even though U.S. export value and quantity has been growing in the past 30 years, U.S. global trade share has been declining because major foreign corn and soybean producers have increased their output and expanded their exports of these crops. These other producers have been under-cutting U.S. export prices which affects U.S. agricultural importing countries such as South Korea that are price sensitive.

Main export destinations for U.S. corn and soybean include China, the European Union (EU), Japan, Mexico, and Taiwan. This study focuses on the three top importers of U.S. corn and soybeans, namely Japan, China and EU. According to the FAO world corn production is about

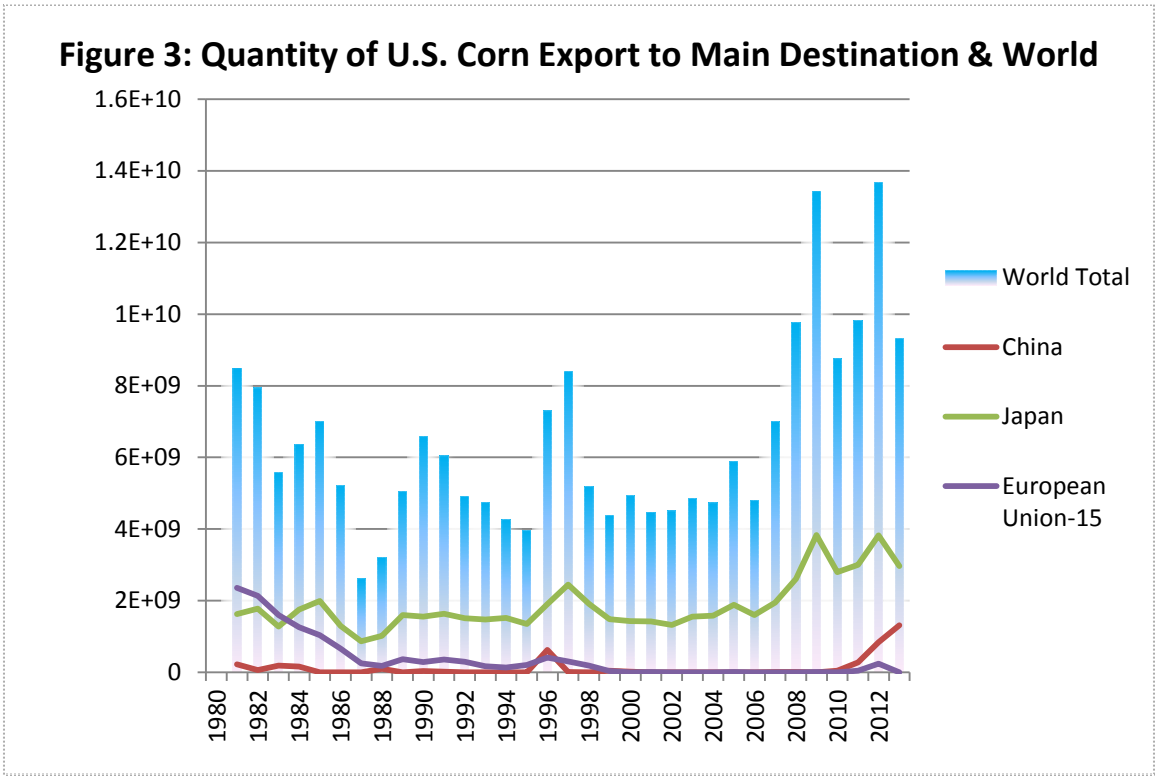
900 million tons and soybeans is about 260 million tons, which is produced largely in the U.S., Argentina, Brazil, South Africa, some Asian countries, and some parts of Europe. World production of corn and soybeans has almost tripled since 1980.

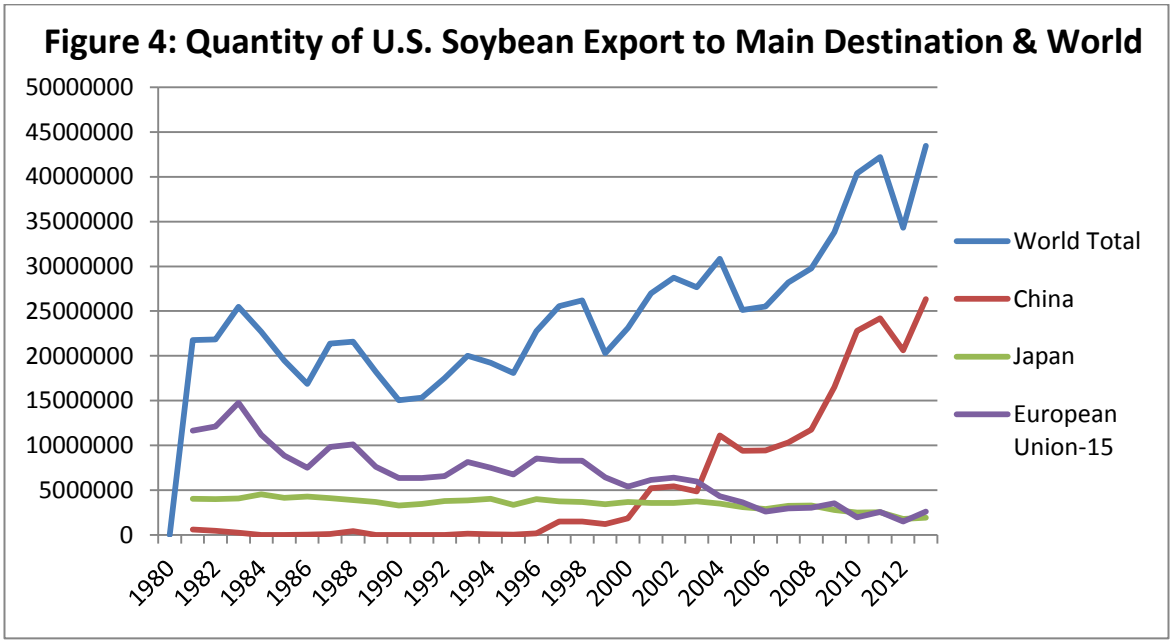
Figure 2 illustrates production of corn and soybeans achieved by the U.S. and other leading export countries.



According to the National Corn Growers Association, 75% of U.S. corn is consumed domestically and about 20% of the U.S. corn is exported. In recent years, strong demand for ethanol production has resulted in higher corn prices and has provided incentives to increase corn acreage (USDA). Also back in 2007, there was a cutback on acreages planted for soybeans since demand for corn rose dramatically due to use of corn for producing ethanol. Over the last 30 years U.S. soybean exports have increased from 26 million metric tons (MMT) to 48 MMT, but due to dramatic increases in soybean production in Brazil and Argentina, the U.S. share of world exports has fallen from 60 percent to 30 percent (Ray, 2008).

Figures 3 and 4 show U.S. corn and soybean quantity exports to the top three U.S. importing countries, China, Japan, and EU, and the world from 1980 to 2012.





This study looks at the demand for U.S. corn and soybeans from three main destinations China, Japan, and EU.

Background and literature review:

Researches have been conducted on U.S. export demand for different commodities in the agricultural sector, (Guci, 2008; Hossain, 2009; Hooy, 2010; Jones, 1988). This paper, however, focuses on U.S. corn and soybean export demand functions, which are the main commodities in agriculture exports from U.S. to the world.

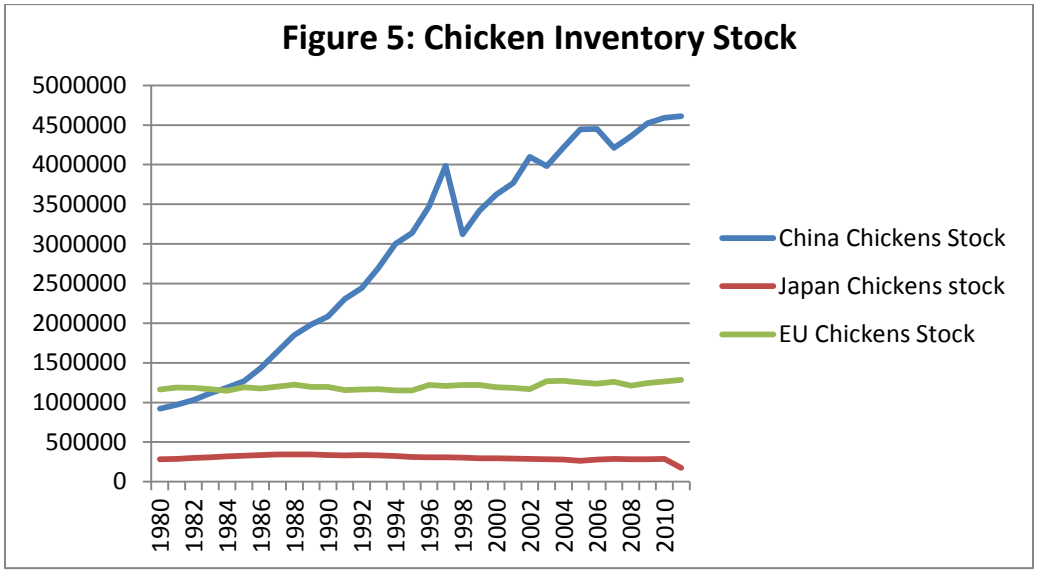
Konandrea, Bushnei, and Green (1978) show the relation between U.S. export demand and the exchange rate. Their research focuses on estimation of export demand functions for the U.S. wheat. Their results indicate that exchange rate changes have had a significant impact on the U.S. wheat exports. Onunkwo and Epperson (2000) have identified the major factors affecting the export demand for U.S. pecans and the impacts of federal promotion programs on the foreign demand for U.S. pecans. Their results indicate that the U.S. pecan industry can benefit considerably from increased export promotion to overcome obstacles such as import quotas or other unfair trade practices by other nations. They performed a similar study on U.S. export demand for almonds in 2001, with results similar results to their U.S. pecan study.

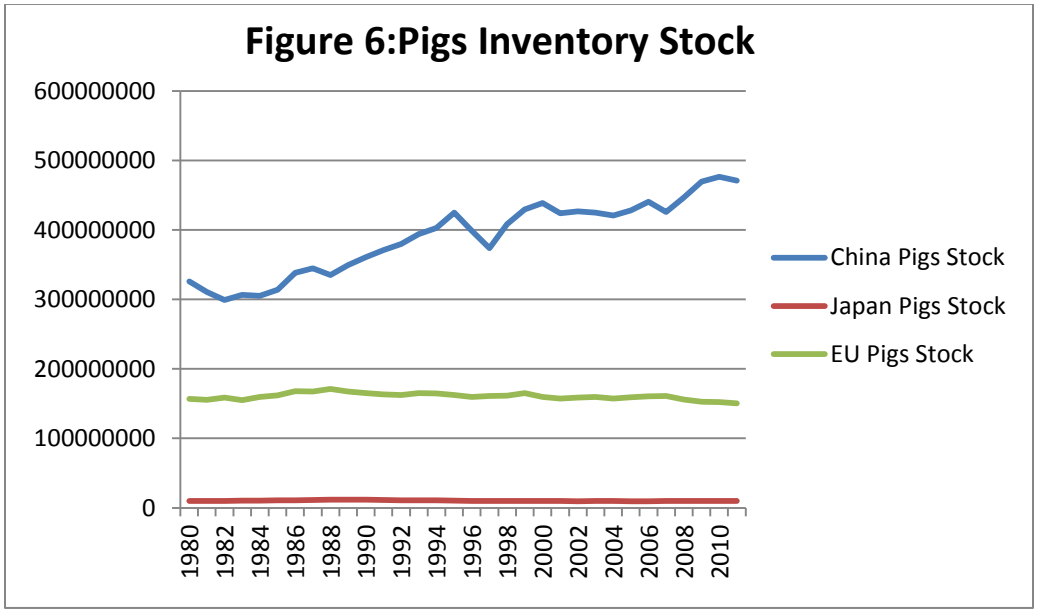
Agricultural economists determine commodity prices through their demand, supply and exchange rate. Haniotis, Baffes, and Ames (1988) argue the reasons for decline in export demand in agriculture market back in 1986 to be old and wrong policy implications, lower than normal levels of stock and government intervention in agricultural trade that caused confusion in the market, and caused an increase in demand and decrease in supply, which in return increases prices in the market. Jayasinghe, Beghin, and Moschini (2009) using export demand function and gravity model from data on 48 countries investigate the determinants of world demand for U.S.

corn seeds, and the cost of export trade to different destination. They conclude all trade costs matter, mostly tariffs, and have a negative impact on U.S. corn seed exports.

Corn and soybeans are inputs to feed for livestock such as pigs and poultry. Nations such as china, Japan and EU have high imports of such grains form the U.S. in order to secure their livestock feed on top of their own demand for such crops. Therefore, quantity of their livestock has also a direct effect on the quantity imports from the U.S.

Following figures show quantity of livestock in each of those three nations.





China has had a growing livestock sector for both chicken and pigs since 1980, compared to the steady numbers in the other two nations. This is due to China's growing population development, which requires more crops to feed their livestock as well as their human population. The same is true for Japan and EU. These livestock numbers are a major factor that determines each nation's imports.

Corn and soybeans are inputs for feed for livestock such as pigs and poultry. Nations such as china, Japan and EU have high imports of grains from the U.S. in order to secure livestock feed to supplement their own productive. Therefore, the quantity of livestock also has a direct effect on the quantity imported from the U.S.

The Model and Data

There are three main variables used in export demand functions (Guci, 2008 and Hooy and Choong, 2010). First is the product price which is the main explanatory variable; second is foreign income which represents economic activity and purchasing power of trading country; and the third is the exchange rates which is a relative price that is crucial in affecting imports.

For our purpose, Ordinary Least Square regression is used for the estimation. We use the actual data to observe the effects of these three factors on export demand of U.S. corn and soybeans plus quantity of livestock from each importing nation. The import demand function for U.S. exports is estimated with a Log-Log structure;

$$lnq_i = \alpha_0 + \alpha_1 lnp_{ic} + \alpha_2 lngdp_i + \alpha_3 lnp_{is} + \alpha_4 lnex + \alpha_5 lnpigst_i + \alpha_6 lnpoulst_i + \varepsilon$$

The Log-Log form provides an advantage because coefficients are elasticity. A Durbin Watson test was later used to detect autocorrelation.

In the above equation q is the quantity of U.S. corn and soybean exports to each of the three destination, while subscript i refer to the i^{th} country, p_{ic} and p_{is} is the price in U.S. dollar

for corn and soybeans respectively, gdp is Gross Domestic Product representing each country's income, ex stands for the exchange rates in the nation's currency per U.S. dollar in real value. First difference is also been taken to obtain a meaningful sample, every country was estimate a separate equation as it appears in the models below, Jpn stands for Japan, Chn stand for China and EU stands for the European Union.

Annual time series data from 1980 to 2011 was used for the estimation. Data for export price of corn and soybeans was collected from FAO; GDP of each country came from USDA; and Exchange rate data came from IMP, Division of Trade Statistics.

Results

Table 1 shows the results for Japanese corn imports:

Table 1 Japan Corn Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	15.05840	6.88294	2.19	0.0382
lnjpncornp	**1**	-0.09261	0.16506	-0.56	0.5797
lnjpnsoybp	**1**	0.19530	0.19426	1.01	0.3244
lnjpngdp	**1**	0.17530	0.05819	3.01	0.0059
lnjpnex	**1**	0.12644	0.16052	0.79	0.4383
lnjpnpigst	**1**	-0.60473	0.38213	-1.58	0.1261
lnjpnpost	**1**	0.38506	0.21015	1.83	0.0788

Parameter estimates of Japan corn model confirm the anticipated results in terms of signs and significance level. Given that the functional form was log-log the price coefficients are elasticity. Export price is statistically insignificant but it has the correct sign and shows an inverse relationship between quantity demanded and price. This indicates increasing the U.S.

corn price by 1% would result in a decrease of imported demand by 0.09%. The GDP coefficient is statistically significant and has the correct sign. GDP has a direct relationship with quantity exported by the U.S.; a 1% increase in Japan GDP would increase Japan quantity imported by 0.17%. The exchange rate coefficient is positive showing a direct relationship with demand. A 1% decrease in U.S. dollar against Japan yen would increase the demand for U.S. corn by 0.13%. The result for price of soybeans a cross price is statistically insignificant and the sign is positive, confirming a substitute relationship with corn. The coefficient for Japanese pig inventory has a unexpected sign but it is statistically insignificant. The poultry coefficient is statistically significant and has the correct sign a 1% increase in the quantity of poultry would increase demand for imported corn by 0.39%.

Parameter estimates for the Chinese corn import model are presented in table 2

Table 2 China Corn Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	-4.73527	18.64761	-0.25	0.8020
lnchncornp	**1**	-0.91607	0.15862	-5.78	<.0001
lnchnsoybp	**1**	1.08161	0.29775	3.63	0.0016
lnchngdp	**1**	-0.45441	0.16686	-2.72	0.0127
lnchnex	**1**	-0.13266	0.35343	-0.38	0.7112
lnchnpigst	**1**	0.73029	1.11416	0.66	0.5193
lnchnpost	**1**	1.12575	0.40275	2.80	0.0108

The results meet expectations in terms of signs and standard errors. Export price is statistically significant and has the correct sign. Its sign shows an inverse relationship between quantity demanded and quantity export. The estimated price elasticity for corn shows that

holding everything else constant, 1% increase in corn price will decrease the import by 0.92% which implies corn relatively inelastic in China. The coefficient for GDP is statistically significant but it an unexpected negative sign. The exchange rate coefficient is statistically insignificant and has a negative sign. The coefficient for the price of soybean as shows it is a substitute product that is highly significant and confirms the anticipated result on U.S. exports of corn. A 1% increase in the price of soybeans increases demand for U.S. corn by 1.08%. The coefficient for China's pig inventory has the expected sing but it is not statistically significant. However, the coefficient for poultry inventory is statistically significant and has the correct sign. A 1% increase in China's poultry inventory would increase demand for imported corn by 1.13%.

Table 3 shows the results for EU corn imports:

Table 3 EU Corn Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	331.10350	231.44486	1.43	0.1649
lneucornp	**1**	-3.69229	1.59864	-2.31	0.0295
lneusoybp	**1**	7.20248	1.97986	3.64	0.0012
lneugdp	**1**	-3.07156	0.53108	-5.78	<.0001
lneuex	**1**	-3.87584	1.61359	-2.40	0.0241
lneupigst	**1**	5.92469	9.81989	0.60	0.5517
lneupost	**1**	-25.81048	9.10183	-2.84	0.0089

Parameter estimates for the EU corn model confirm most of the anticipated results in terms of signs and significance level. The coefficient for Export price is statistically significant and its sign shows an inverse relationship between price and quantity exported. The estimated

price elasticity for corn shows that holding everything else constant, 1% increase in corn price will decrease the import by 3.7% which implies corn elastic in EU. The coefficient for GDP is statistically significant but doesn't have the expected sign. The coefficient for Exchange rate is statistically significant and has a negative sign, as anticipated. Result for price of soybeans is statistically significant, has the right sign and confirms the anticipated result that shows direct relationship with quantity export of U.S. corn. As price of soybean increase, imported quantity demand for U.S. corn increase. EU pigs' livestock variable has the expected sing but it is statistically insignificant. EU poultry livestock is statistically significant, but doesn't have the expected sign.

Table 4 shows the results for Japan soybean imports:

Table 4 Japan soybean Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	31.48499	4.40534	7.15	<.0001
lnjpncornp	**1**	0.24231	0.10564	2.29	0.0305
lnjpnsoybp	**1**	-0.54578	0.12433	-4.39	0.0002
lnjpngdp	**1**	-0.19663	0.03725	-5.28	<.0001
lnjpnex	**1**	-0.24491	0.10274	-2.38	0.0250
lnjpnpigst	**1**	-1.22885	0.24458	-5.02	<.0001
lnjpnpost	**1**	0.96063	0.13451	7.14	<.0001

Parameter estimates of Japans' soybean model confirm the anticipated results in terms of signs. Export price is statistically significant and has the right sign and shows an inverse relationship between quantity demanded and quantity exported, which indicates increasing price of U.S. soybean would result in decrease of imported demand. This implies soybean is inelastic

in Japan. GDP result is statistically significant but don't have the anticipated sign. Exchange rate variable is statistically significant and has the expected sign as anticipated, which has an inverse relationship with demand. A 1% increase in U.S. exchange rate would decrease the demand by 0.24%. Price of corn has positive sign, that indicates corn is a good substitute product for soybean, result is statistically significant, and confirms the anticipated result that shows direct relationship with quantity export of U.S. soybeans. As price of U.S soybean increase, import demand for U.S. corn increases. Japan pigs' livestock variable is statistically significant but doesn't have the right sign. However Japan poultry livestock result is statistically significant and has the right sign. A 1% increase in Japans' poultry livestock quantity would increase demand for imported corn by 0.9%.

Parameter estimates for the Chinese soybean import model are presented in table 5.

Table 5 China Soybean Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	149.97204	77.25020	1.94	0.0658
lnchncornp	**1**	0.83642	0.65712	1.27	0.2170
lnchnsoybp	**1**	-3.27255	1.23349	-2.65	0.0149
lnchngdp	**1**	2.54190	0.69123	3.68	0.0014
lnchnex	**1**	-3.02857	1.46414	-2.07	0.0511
lnchnpigst	**1**	-10.66224	4.61557	-2.31	0.0311
lnchnpost	**1**	1.70480	1.66843	1.02	0.3185

Parameter estimates of Chinas' soybean model also have mixed results. Export price is statistically significant and its sign shows an inverse relationship between quantity demanded and quantity exported. It shows increasing price of U.S. soybean would result in decrease of

imported demand. That indicates soybean is relatively elastic in China. GDP result is statistically significant and has the anticipated sign, GDP has direct relationship with quantity exported by U.S. which illustrate an increase in China GDP would increase China quantity imported from the U.S. Exchange rate variable is statistically significant and has the expected sign which has inverse relationship with demand, therefore an increase in U.S. exchange rate would decrease the demand. Such an impact shows China as a price sensitive nation due to its high population when it comes to its agricultural goods. Results for price of corn as substitute product are statistically insignificant, but have the expected sign. Result for China pigs' livestock variable is statistically significant but doesn't have the right sign. Chinas' poultry livestock result is statistically insignificant but do have the right sign.

Table 6 shows the results for EU soybean imports:

Table 6 EU Soybean Import

Parameter Estimates					
Variable	**DF**	**Parameter Estimate**	**Standard Error**	**t Value**	**Pr > |t|**
Intercept	**1**	115.17972	47.25281	2.44	0.0222
lneucornp	**1**	-0.53056	0.32638	-1.63	0.1166
lneusoybp	**1**	-0.18732	0.40422	-0.00	0.9996
lneugdp	**1**	-0.54335	0.10843	-5.01	<.0001
lneuex	**1**	-0.51003	0.32944	-1.55	0.1341
lneupigst	**1**	-0.53272	2.00487	-0.27	0.7926
lneupost	**1**	-5.06376	1.85827	-2.72	0.0116

Parameter estimates of EU soybean model are also mixed. Export price is statistically insignificant and its sign shows an inverse relationship between quantity demanded and quantity exported, shows increasing price of U.S. soybean by 1% would result in decrease of imported

demand by 0.18%. GDP result is statistically significant but don't have the expected sign. Exchange rate variable is statistically significant and has the expected sign. It has an inverse relationship with demand. An increase in U.S. exchange rate would decrease the imported demand. These results indicate EU is price sensitive when it comes to soybean imports. Result for price of corn is statistically insignificant and doesn't have the right sign. Result for EU pigs' livestock variable is statistically insignificant and don't have the right sign. EU poultry livestock result is statistically significant but doesn't have the right sign.

Conclusions

In this study, we used a log-linear equation to estimate the export demand of U.S. corn and soybeans to three main destinations, China, Japan, and EU. The estimated price coefficients had the expected signs for all three destinations, but two of them were statistically insignificant. Among those, China had the most elastic demand. The GDP coefficients for the corn and soybean models were statistically significant for U.S. exports to Japan, and U.S. soybean exports to China. China also had the highest income elasticity in the soybean model.

The parameter estimates for soybean price as a cross price was statistically significant for China and EU. The parameter estimates for corn price as cross price was statistically significant only for Japan. The positive sign revealed that soybean is a substitute good for corn in these countries and vice versa, as expected. The sign for the case of corn used in EU was negative. This indicates that corn is a complement for soybeans. This result indicates the use of soybeans and corn in EU in feed for livestock.

Soybeans and corn have different applications. Soybean can be used as a substitute product for corn. Oil is produced out of soybeans, and the by-product of soybeans is used as feed for livestock. Corn is mainly used to feed livestock in EU; therefore, soybean would be a good

substitute for corn because its byproduct is used to feed livestock. In this case though, corn is a complement product. Soybean alone is not used to feed livestock; it is mixed with corn in order to feed livestock.

The exchange rate had a negative coefficient, which was expected, in all three destinations except for corn exports to Japan. In case of U.S. corn export, only EU was statistically significant and had the right sign, estimated coefficients for China and Japan were statistically insignificant, but China had the expected sign. It seems China and EU are price sensitive and could substitute Argentinian and Brazilian corn and soybeans for American products. In the soybean export model for the EU, the exchange rate coefficient was not statistically insignificant.

The results illustrate that when price increases Chines demand for U.S. corn would decrease. As China's GDP increases, consumer demand for U.S. soybean also increases. (Not very Insightful)

The U.S. has enjoyed a higher market share for decades because it is a technologically advanced country and a more efficient producer. Other reasons for that high market share could be high managerial skills of farmers and marketers, adequate infrastructure such as better roads, more efficient banking system, and more transparent government regulations, and higher efficiency and productivity—The U.S. has the highest productivity in the world, giving the U.S. advantage to achieve lower prices and higher market share for commodities. Now the U.S. is experiencing a loss in export market shares to major destinations due to growing rivals in the world market such as Brazil and Argentina which can undercut U.S. market shares.

References

Onunkwo, I. M. and Epperson, J. E. “Export Demand for U.S. Almonds: Impacts of U.S. Export Promotion Programs.” Journal of Food Distribution Research, March 2001.

Armah, B.K. and Epperson J.E. “Export Demand for US Orange Juice: Impacts of US Export Promotion Programs.” Agribusiness, 13(1), (1997) 1–10.

Onunkwo, I.M. and Epperson, J.E. “Export Demand for U.S. Pecans: Impacts of U.S. Export Promotion Programs.” University of Georgia, Agribusiness, 16(2), (2000) 253–265.

Konandreas, P. Bushneil, P. and Green, R. “Estimation of Export Demand Functions for U.S. Wheat.” Western Journal of Agricultural Economics, 3(1), (July 1978) 39-49.

Haniotis, T. Baffes, J. and Ames, G.W. “The Demand and Supply of U.S. Agricultural Exports : The Case of Wheat, Corn and Soybean.” Southern Journal of Agricultural Economics, December 1988.

Jayasinghe, S. Beghin, J.C. and Moschini, G.C. “Determinants of World Demand for U.S. Corn Seeds: The Role of Trade Costs.” Center for Agricultural and Rural Development Iowa State University, January 2009.

Guci L., “EXCHANGE RATES AND THE EXPORT DEMAND FOR U.S. GRAPEFRUIT JUICE.” Research Report, (2008).

Hooy C.W., and Choong C.K. “Export Demand within SAARC Members: DOES Exchange Rate Volatility MATTER?.” Int. Journal of Economics and Management 4(2) (2010): 373–390.

Hossain A.A. “Structural change in the export demand function for Indonesia: Estimation, analysis and policy implications.” Journal of Policy Modeling 31 (2009) 260–271.

USDA,(http://www.ers.usda.gov/topics/crops/soybeans-oil-crops/trade.aspx#.UcC1iuesjPY), retrieve 10/10/2012.

USDA,(http://www.ers.usda.gov/topics/crops/corn/trade.aspx#.UcDt7-esjPY),retrieves 3/5/2013.

Ray, D. E. "Future US soybean exports will be largely determined by China and Brazil." The Agricultural Policy Analysis Center, University of Tennessee, (http://mfu.org/node/507), retrieve 2008.

Reed Michael R., International Trade in Agricultural Products (Prentice Hall, 2001).