An Economic Analysis of the United Soybean Board's Demand- and Supply-Enhancing Programs (2014-2018)

(Preliminary draft)

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Executive Summary

U.S. soybean farmers fund demand- and supply-enhancing activities to bolster the industry in domestic and international markets. Established under *the Soybean Promotion, Research and Consumer Information Act of 1990,* the United Soybean Board (USB) is a commodity program that promotes U.S.-grown soybeans in areas such as research, consumer information and industry data. Its overall goal is to strengthen the soybean industry's position in the marketplace.

The following study was carried out in accordance with the 1996 legislation that requires an independent evaluation of the effectiveness of the program. The primary objectives include, (1) determining whether USB-funded activities increased consumption and production of soybeans and soy products in the U.S. and foreign markets; (2) measuring the benefits of USB activities in terms of incremental industry profitability and comparing them with the cost of the checkoff to calculate a rate of return on investment (BCR) to its stakeholders.

To address these two objectives, econometric models of the domestic and international soybean markets were constructed. The models allowed us to net out the impacts of other important factors such as; other crops, substitute commodities, income, exchange rates, and economic conditions in importing countries, besides USB activities affecting soybean and soy-product demand. The study finds that USB's activities have had a positive and significant impact on soybean demand between 2014 and 2018. The main highlights of the study suggest that:

- USB investments in demand-enhancing activities have led to a 4.2% increase in soybean demand within the U.S.
    - Investments in soybean meal and oil demand have led to a 1.2% increase in meal demand and 2% increase in oil demand, respectively.
- Continued investments in soybean production research has led to a 7.7% increase in soybean supply over the last five years.
- USB investments and partnership with FAS and QSSB's in the export market, have also been significantly positive.
    - The overall soybean demand in the export market grew by 16.3%. Soybean meal exports grew by 17.6% and soybean oil exports by 31.2%.
- Collectively, the overall net marginal BCR for all four USB activities (including foreign market development) is $12.34.
    - The highest net marginal BCR for any of the four USB activities are for domestic demand-enhancing research and export promotion, where an extra dollar invested returned $18.18 and $17.95, respectively.
    - The lowest return is for domestic promotion, which returned $4.

Results from this study suggest that USB might consider reallocating some of its budget into demand-enhancing research and export promotion, given their higher return on investments.

An Economic Analysis of the United Soybean Board's Demand- and Supply-Enhancing Programs

U.S. soybean producers have a long history of collectively funding demand- and supply-enhancing activities both in the domestic and international markets in order to increase the health and competitiveness of their industry. Prior to 1991, these efforts were pursued by various voluntary state checkoff programs who invested in their own programs and also contributed to the American Soybean Association (ASA). However, with the passage of the 1990 Farm Bill, a national mandatory checkoff program was established for U.S. soybean producers. Under the so-called *Soybean Promotion, Research and Consumer Information Act of 1990*, soybean producers are required to pay 0.5% of the marketprice of each bushel of soybeans sold to fund demand- and supply-enhancing promotion and research, with 50% of the proceeds funding the United Soybean Board (USB), which is the national soybean organization created to carry out these promotion and research activities. Along with USB, the other 50% of funds raised by this mandatory checkoff program are used to fund Qualified State Soybean Board (QSSB) organizations.

Under existing agricultural legislation, USB is required to have an independent analysis of the economic effectiveness of the program conducted at least once every five years. With almost $1 billion spent on checkoff programs each year by U.S. farms and firms, the government wants stakeholders to have independent information on the effectiveness of these programs. Accordingly, the purpose of the research reported here is to conduct such an economic evaluation for the most recent five-year period of performance for USB.

Objective and Scope

The primary purpose of this study is to provide an independent economic evaluation of the effectiveness and impacts of USB marketing and research programs over the past five years, from 2014 to 2018. Specifically, this study has two general objectives:

1. To measure whether the USB promotion and research activities increased consumption of soybeans and soy products (soybean meal and soybean oil) in the United States and foreign markets compared to what would have occurred in the absence of these activities.

2. To measure the benefits of the USB activities in terms of incremental profitability for the entire soybean industry and compare these benefits with the cost of the checkoff to compute a rate of return on investment of this campaign to its stakeholders.

To address these two goals, four important questions are addressed regarding the USB promotion and research campaigns:

1. What is the overall responsiveness of soybeans and soy-products demand and supply to the USB checkoff program?
2. What is the responsiveness of soybeans and soy-products demand and supply to specific USB domestic promotion, export promotion, demand-enhancing research and production research activities?
3. What is the overall marginal benefit-cost ratio (BCR) for the USB checkoff program to the stakeholders of the program?
4. What are the marginal BCRs for specific USB domestic promotion, export promotion, demand-enhancing research and production research activities?

In this study, the impacts of all factors affecting domestic and foreign soybean and soy-product demand ("demand drivers") and supply ("supply drivers") for which data are available are measured statistically. In this way, we can net out the impacts of other demand and supply drivers (e.g., soybean price, exchange rates, consumer income, technology) besides USB demand- and supply-enhancing activities affecting soybean and soy-product demand over time. In addition, the profitability of the incremental sales generated by USB activities is estimated. The benefits (profits) to soybean producers are estimated using an "Equilibrium Displacement Model," which enables computation of a marginal benefit-cost ratio for each individual program and all programs combined. These benefits to soybean producers are compared with the costs associated with USB. Based on the estimated impacts from the demand models, an overall marginal BCR and activity-specific marginal BCRs are derived.

This independent evaluation is carried out by Dr. Harry M. Kaiser, who is the Gellert Family Professor of Applied Economics and Management at Cornell University. Dr. Kaiser is a national and internationally renowned expert in the economics of generic advertising and promotion programs. Dr. Kaiser has extensive experience in conducting economic evaluation studies of domestic and international checkoff programs. He has written 135 refereed journal articles, five books, 17 book chapters and over 150 research bulletins, and received $8 million in research grants in the area of agricultural marketing with an emphasis on promotion programs.

USB Program Expenditures

USB was implemented in 1991 as part of the 1990 Farm Bill to "implement a program of promotion, research, consumer information, and industry information designed to strengthen the soybean industry's position in the market place, to maintain and expand existing domestic and foreign markets and uses for soybeans and soybean products and to develop new markets and uses for soybeans and soybean products."[1] Collectively, this program raises just over $100 million in recent years on an annual basis for both national and international activities.

USB invests in a variety of activities to accomplish its overall objective of improving the demand for U.S. soybeans and soy products and the efficiency of soybean production. In this report, the promotion and research activities are divided into four categories:

1. Domestic soybean and soy-product promotion
2. Foreign market development (aka export promotion) of U.S. soybean and soy products
3. Demand-enhancing research for soybeans and soy products
4. Production-enhancing research for soybeans and soy products

The first three activities are intended to increase the demand for soybeans and soy products. The goal of these activities is to increase demand, price and producer profits. Production research is intended to increase the supply of soybeans, improve production efficiency and reduce producers' costs of production.

[1] Soybean Promotion, Research and Consumer Information Act, Section 1966(b) (1990) (codified as amended at 7 U.S.C. 6301-6311 [1991]).

Figure 1 presents the domestic promotion expenditures for USB from 1995 through 2018. Since 1995, there has been a general upward trend in domestic promotion expenditures. While there has been more variation recently in domestic promotion spending, it currently is over 2 times higher than it was in the mid-1990s.

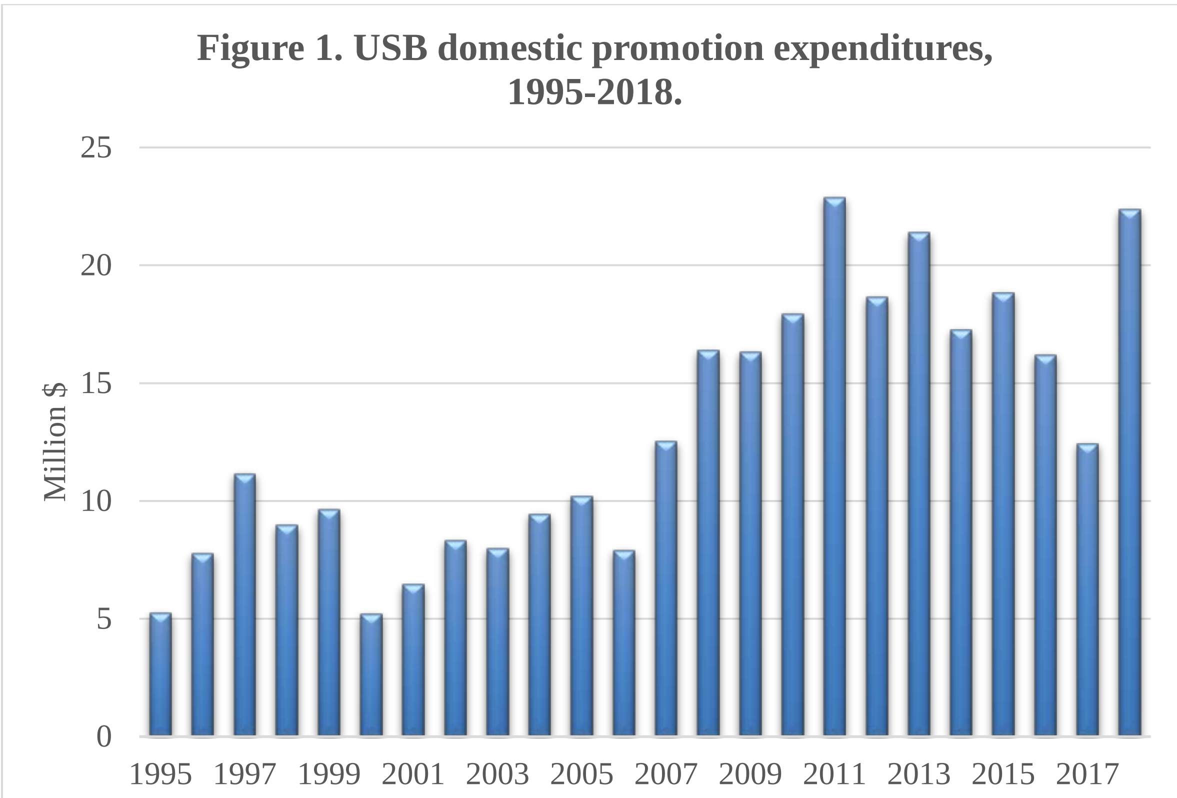

Figure 2 presents USB spending on demand-enhancing research from 1995 through 2018. Spending for this category of USB activities generally increased from 1995 to 2014, but since then has declined significantly. Demand-enhancing research has a lagged effect on demand since it takes time for research discovery and bringing new discoveries to market. Indeed, in this study, the finding is that expenditures on demand-enhancing research take about 12 years, on average, before they have an impact on soybean demand.

Figure 2. USB expenditures on demand-enhancing research, 1995-2018.

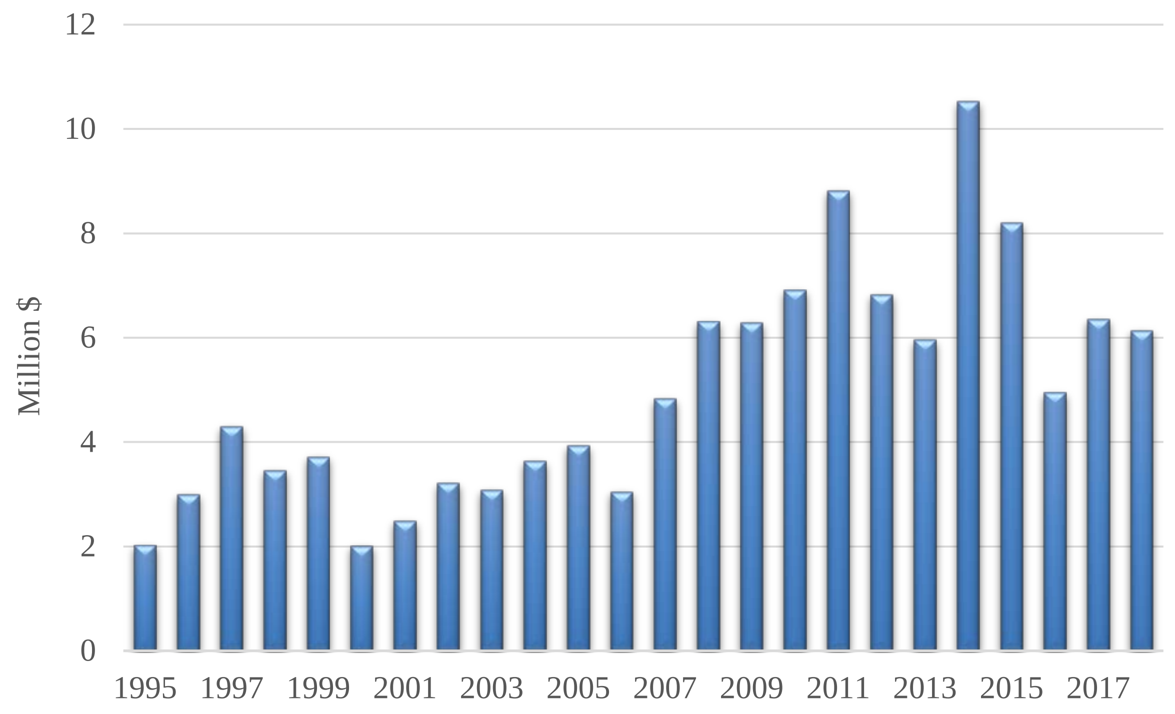

Figure 3 presents U.S. soybean and soy-product export promotion expenditures by USB and USSEC partnerships (Foreign Agricultural Service [FAS] and QSSB). USSEC receives funding primarily from these three parties (USB, FAS and QSSBs) and cooperating industry to help build a preference for U.S. soybeans and soybean products in foreign markets. U.S. soybean export promotion has grown considerably over this time period, increasing by over 220% since 1995.

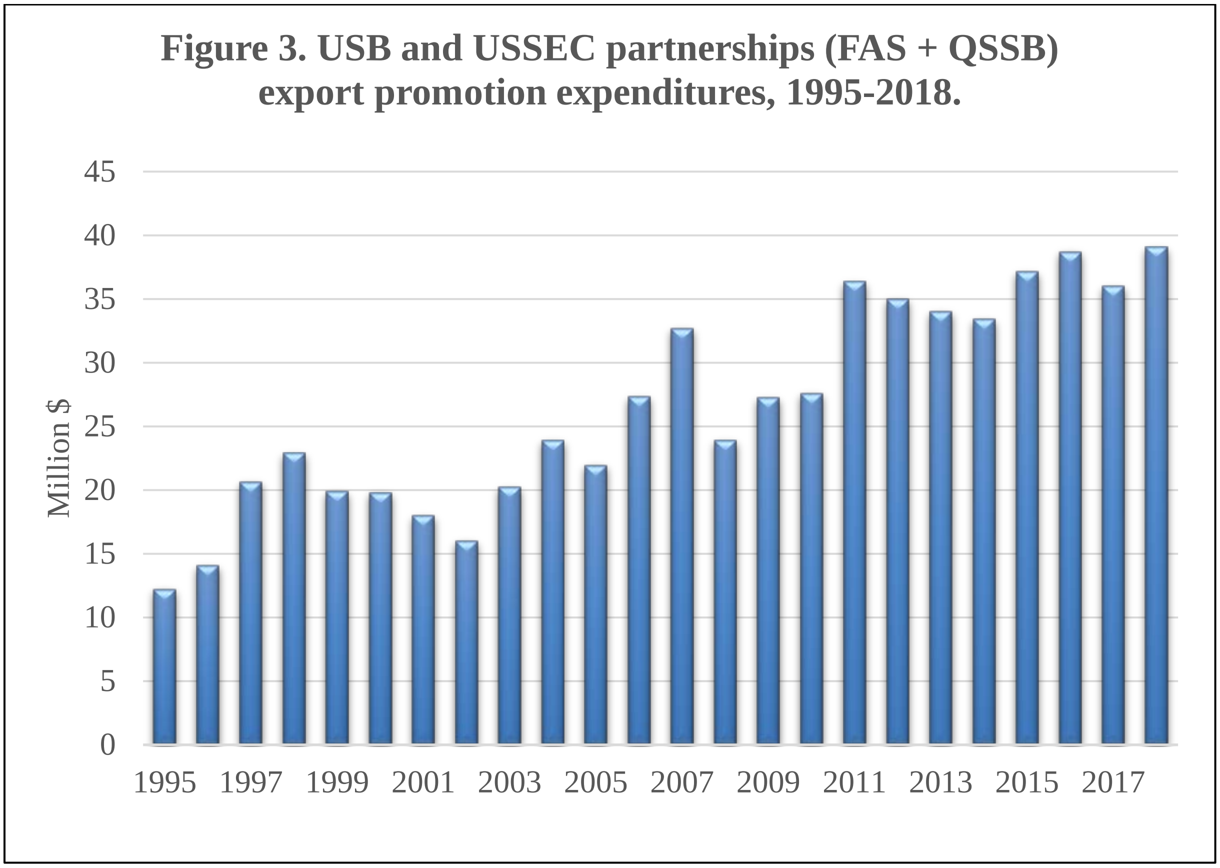

Figure 4 presents the combined spending on production research by USB and state-level QSSB organizations from 1995 to 2018. Overall, this category of spending greatly increased for most of this period. For example, production research spending in 2014 and 2015 was almost 5 times greater than in 1995 and 1996. Similar to demand-enhancing research, production research also has a lagged effect. In this study, the lag is about 14 years, on average, before these expenditures have an impact on soybean supply.

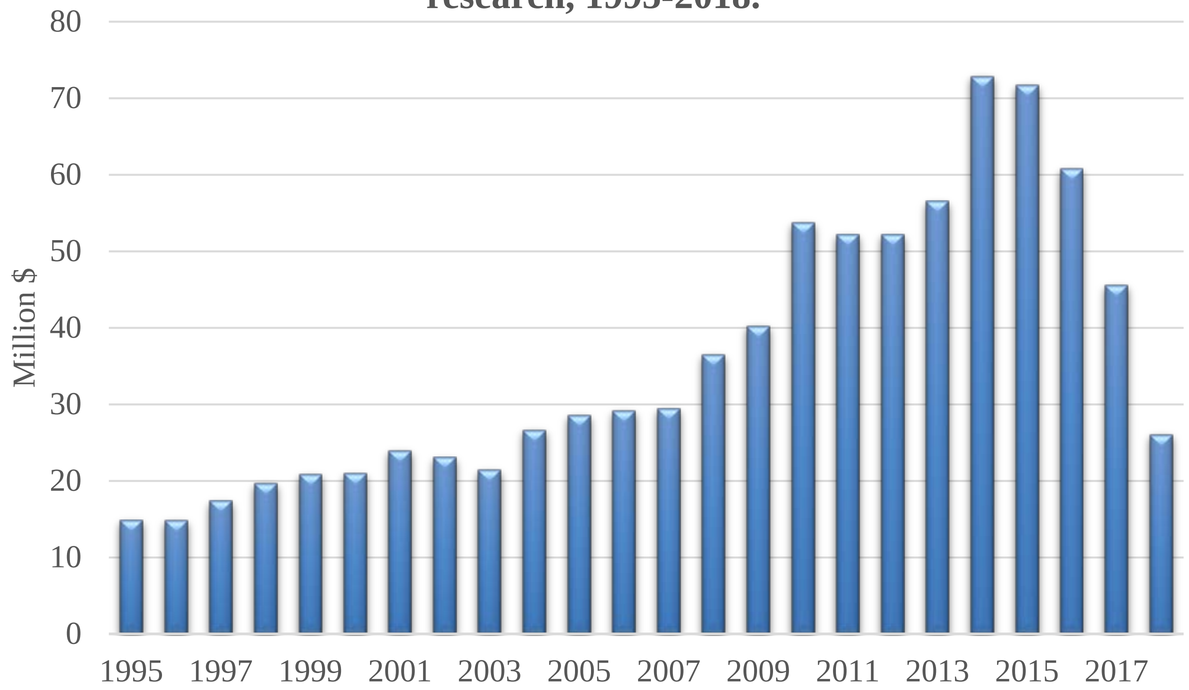

Figure 4. USB and QSSB expenditures on production research, 1995-2018.

Data Limitations

This analysis is based on secondary data from government sources, private venders, USB and researchers at Texas A&M University who conducted previous (2014) USB Return on Investment evaluation studies. The accuracy of the results depends primarily on the quality of this secondary data, the bulk of which mainly measures supply and demand drivers for soybeans and soy products. While these data are judged to be the best available for this economic evaluation, there are errors in data from any data source, including the data used in this study.

There are four potential limitations in the data used in this study, three relating to expenditures by the USB and the final relating to the lack of data on private firm and federal government spending on research and promotion activities.

The first is that the domestic promotion and demand-enhancing research expenditure data obtained for 2012 through 2018 only included USB funding and did not include funding by the QSSBs. These data are unavailable for this study. In reality, the QSSBs also invest in domestic promotion and demand-enhancing research activities. Therefore, the estimated domestic promotion and demand-enhancing research elasticities in this study likely overstate the true impact of USB since QSSB contributions are not included, and the estimated elasticity likely pick up some of the QSSB's promotion impacts.

Relatedly, this study relied on two different sets of data for expenditures on production research, demand-enhancing research and domestic promotion. The annual data from 1980-2011 come from a previous economic evaluation study of USB by researchers at Texas A&M.[2] While these researchers very generously shared their data for this study, it is not perfectly comparable to the annual data generated by USB staff for the past seven years: 2012-2018. For example, the Texas A&M study combined domestic promotion expenditures with demand-enhancing expenditures by USB, while the more recent data breaks the two out separately. Because we wanted to measure the separate impacts of the two activities, we assumed that the average percentage allocation of promotion vs. demand-enhancing research in the past seven years (2012-2018) also held for the 1980-2011 data. For the 2012-2018 period, 27.8% of these expenditures were allocated to demand-enhancing research, and 72.2% of the expenditures were allocated to domestic promotion. To merge these results with the older data, the same proportions (27.8% and

[2] Williams, Capps & Lee. (2014). The Return to Soybean Checkoff Investments, Texas A&M University.

72.2%) were used to split the 1980-2011 data into demand-enhancing research and domestic promotion expenditures.

The third limitation is that the 1980-2011 production research expenditures include QSSB and USB investments while the 2012-2018 data only include USB expenditures. In this study, we want to account for combined QSSB and USB spending on production research in order to get an accurate estimate of the impact of production research on soybean supply. To estimate production research expenditures that include both the QSSBs and USB for 2012-2018, the percentage change in spending from year to year for just USB for 2012-2018 was applied to the 2011 joint expenditures (QSSB and USB) for 2012-2018. Fortunately, this limitation is completely mitigated in this study because the econometric model indicated a 14-year lag in production research and, consequently, the production research expenditures for 2012-2018 are not even considered in the model.

Finally, we did not have access to data on expenditures by private companies nor the federal and state government in promoting and conducting research/development on soybeans and soy products domestically and in the export market. Both industry and government spend a significant amount of money on promoting U.S. soybeans and soy products domestically as well as abroad, and similarly invest in research and development of soybeans and soy products. In addition, the government, e.g., the Agricultural Research Service of the USDA, spends considerable money on research and development that enhances soybean and soy-product production. For this report, we did not have access to annual expenditures by these entities. It is therefore likely that the estimated impacts for USB and its partners' promotion and research activities capture some of this private and government research and promotion activities as well. Accordingly, the estimates reported here are likely upper bound estimates of USB's impacts.

Methodology

This study quantifies the relationship between the various promotion and research activities of USB and the domestic demand and supply and international demand for U.S. soybeans and soy products. Several econometric models are estimated. The econometric approach quantifies economic relationships using economic theory and statistical procedures with data. It enables one to simultaneously account for the impact of a variety of factors affecting demand and supply for a commodity. By casting the economic evaluation in this type of framework, one can filter out the effect of other factors and, hence, quantify directly the net impact of USB's activities on soybean demand and supply.

The three econometric models to be estimated include: (1) domestic soybean (and soybean meal and soybean oil) demand; (2) domestic soybean farm-level supply; and (3) U.S. soybean

(soybean meal and soybean oil) import demand. The first two models are estimated with annual time series data from 1980 through 2018. The third model is estimated with panel data for 10 countries/regions and the most recent five years of time series data. The three econometric models are used to test whether various activities funded by USB — such as domestic promotion, demand-enhancing research production research and export promotion — have a statistically significant impact on soybean (soybean meal and soybean oil) demand and supply. A detailed discussion of the econometric model and the results are presented in the Appendix of this report. Here, we focus on a general overview of the model and a discussion of the results.

To compare the relative importance of each factor on soybean demand and supply, the results from the econometric models are converted into "elasticities." An elasticity measures the percentage change in demand or supply given a 1% change in a specific demand or supply driver, holding all other factors constant. For example, the computed own price elasticity of demand measures the percentage change in soybean quantity demanded given a 1% change in soybean price, holding constant all other soybean demand drivers. Since elasticities are calculated for each demand and supply factor in each model, one can compare them to determine which factors have the largest impact on demand or supply.

Domestic Soybean (Soybean Meal and Soybean Oil) Demand

Three econometric domestic demand equations are separately estimated for (1) whole soybeans, (2) soybean meal and (3) soybean oil products. The following demand drivers are included to ascertain their impacts on the farm-level demand (measured as U.S. commercial disappearance of soybeans) for whole soybeans:

1. Soybean price in $ per bushel
2. Farm price index for soybean substitute commodities, including sunflowers, flaxseed, cottonseed, peanuts, corn and linseed3

[3] More recently, both canola and distillers dried grains with solubles (DDGS) have become important substitutes for soybeans and soy products. Unfortunately, price data on both of these products is difficult to find prior to 1991, and

3. U.S. pork plus poultry production
4. Commercial disappearance of soybeans in the previous year
5. USB domestic promotion expenditures on whole soybeans, soybean meal and soybean oil
6. USB expenditures on demand-enhancing research

The soybean price is expected to be negatively related to farm-level soybean demand, i.e., a lower price results in higher quantity demanded reflecting the law of demand. The farm price index for soybean substitute commodities are included because they represent the most important substitutes for soybeans. The relationship between soybean demand and this price index is expected to be positive because these commodities are substitutes for soybeans, e.g., an increase in the substitute price index results in an increase in soybean demand because soybeans are now relatively less expensive. Commercial disappearance of soybeans in the previous year is included to capture habit formation, and it provides an explicit dynamic dimension to the model, i.e., demand in the current year is correlated to demand in the previous year.

Finally, and most relevant here, two major USB demand-enhancing activities are separately included in the domestic demand model for soybeans. The first is domestic promotion expenditures by USB that are intended to increase the demand for soybeans and soy products. The second is expenditures on research projects that are intended to increase the demand for soybeans and soy products such as new product development. Since there is a lagged effect between when a research project ultimately impacts demand, various lengths of lags are run for research expenditures, and the lag length that results in the best statistical fit (e.g., highest coefficient of determination, best t-values) is selected for the final model. Likewise, some of the promotion activities also have a lag impact on demand, and similar procedures are used for promotion expenditures. All monetary variables in the model are deflated by the Consumer Price Index for all items to remove the effects of inflation.

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since the data used to estimate the domestic demand models date back to 1980, these two substitutes are not included in the model.

Similar procedures are used to estimate demand models for soybean meal and soybean oil. The same demand drivers are included in each model as are included for the soybean demand model, with one exception. Instead of soybean price, the wholesale soybean meal price is included in the soybean meal demand model, and the wholesale soybean oil price is included in the soybean oil demand model. More details are provided on these demand models in the Appendix.

Domestic Soybean Supply

The farm-level soybean supply (measured as U.S. soybean production) model includes the following supply drivers:

1. Soybean price in $ per bushel
2. Corn price in $ per bushel
3. Index of prices paid by farmers in the crop sector
4. Linear time trend variable to capture increased efficiency in soybean production due to technological progress and improvements in management ability
5. Soybean production in the previous year
6. USB and QSSB expenditures on farm-level, supply-enhancing research

The soybean price is expected to be positively related to farm-level soybean supply, i.e., a higher price results in higher quantity supplied, reflecting the law of supply. The corn price is included because corn is a competing commodity. The relationship between soybean supply and the corn price is expected to be negative because an increase in the corn price should result in a decrease in soybean supply since soybeans are now relatively less profitable than corn. The soybean and corn prices are included in the model as the ratio of the soybean to corn price. A distributed lag specification for this price ratio is used as a proxy of soybean producers' price expectations. Various lag lengths are run, and the lag length that results in the best statistical fit is used as the final model.

The index of prices paid by farmers is included as a measure of soybean costs, and the relationship is expected to be negative, i.e., as costs increase, soybean supply decreases. The trend term is included to capture changes in technology and managerial efficiency over time. Soybean production in the previous year is included to capture the dynamic link between production in consecutive years.

Finally, and most relevant here, USB and QSSB production research expenditures are included in the supply model for soybeans. Production research is expected to increase the supply of soybeans. Since there is lagged effect between when a research project ultimately impacts supply, various lengths of lags are run for research expenditures, and the lag length that results in the best statistical fit is selected for the final model.

The following data sources are used for all the variables in the domestic demand and supply models: commercial disappearance, production, price and cost data come from Soybeans and Oil Crops report from the Economic Research Service of the USDA; the Index of Prices Paid by farmers and corn prices come from Agricultural Prices published by the National Agricultural Statistics Service of USDA; and USB expenditures on domestic promotion, demand-enhancing research and production research come from USB and from the Texas A&M previous evaluation study.

U.S. Soybean (Soybean Meal and Soybean Oil) Import Demand

Using panel (both time series and importing region-level) data, an import demand model for U.S. soybean and soy products is estimated. Data on key demand drivers for U.S. soybean and soy-products imports to selected regions are collected and used on an annual basis over the period 2014-2018 for the following 10 importing regions: China, Japan, South Korea, Taiwan, Southeast Asia, Europe, the Americas, Middle East and North Africa (MENA), Asia Subcontinent and the rest of the world (ROW).

The import demand equation for U.S. soybeans (soybean meal and soybean oil) is estimated with imports of U.S. soybeans (or soybean meal or soybean oil) as the dependent variable, which is measured on a volume basis for each calendar year for each region. The following import demand drivers are included to ascertain their impacts on import demand for U.S. soybeans (soybean meal and soybean oil):

1. Unit value (price) of annual soybean (soybean meal and soybean oil) imports from the U.S. to each importing region in dollars per pound
2. Unit value (price) of annual soybean (soybean meal and soybean oil) imports from the ROW exporters to each importing region in dollars per pound
3. Average annual GDP for each importing region
4. Average annual real exchange rate (ER) of each importing region's currency relative to U.S. dollar

5. Imports of soybeans (soybean meal and soybean oil) in the previous year for each importing region
6. Trend variable to capture omitted variable effects
7. Indicator variable to capture impact of U.S.-China tariff increase in 2018
8. Total annual U.S. soybean and soy-product export promotion expenditures by the USB and USSEC partnerships (FAS + QSSB) to each importing region.

Both the U.S. and ROW soybean (soybean meal and soybean oil) prices are computed as the total value of imports divided by the total quantity of imports. Hence, price is computed as a unit value measure. The U.S. price is expected to be negatively related to the volume of imports from the U.S. in each importing region, i.e., a lower price results in higher U.S. import quantity demanded, reflecting the law of demand. The import price of all competing regions is included because these regions are the chief competitors for U.S. soybeans and soy products. The relationship between the ROW price and the import demand for U.S. soybeans and soy products is expected to be positive because ROW soybeans is a close substitute with U.S. soybeans.

The relationship between GDP and the demand for U.S. soybeans (soybean meal and soybean oil) is expected to be positive, i.e., as regions become wealthier, the demand for U.S. soybeans (soybean meal and soybean oil) should increase. The ER has been shown to be an important determinant of the demand for U.S. imports. The relationship between ER and the import demand for U.S. soybeans (soybean meal and soybean oil) is expected to be negative. As the U.S. dollar becomes cheaper, U.S. soybeans (soybean meal and soybean oil) become relatively cheaper, and hence import demand increases. Imports in the previous year are included to capture dynamic effects of international trade rigidities, i.e., imports from the U.S. last year should be highly correlated with imports from the U.S. this year. A linear trend variable is included to capture the net impact of other potential import demand drivers not included in the model. An indicator variable, equal to 1 for China in 2018 and zero otherwise, is included to capture the impact of the trade war between China and the U.S. in 2018, which decimated U.S. soybean import volume to China.

U.S. export promotion expenditures in each region are included in the U.S. import demand model for soybeans. These expenditures include funds from three sources — USB, QSSB and FAS — and are treated as one variable called U.S. soybean/soy-product export promotion. U.S. export promotion is expected to increase the import demand of soybeans. All monetary variables in the model are deflated by the Consumer Price Index for all items in each country/region to remove the effects of inflation.

The following data sources are used for the variables in the import demand model: the quantity, value and therefore price of U.S. and ROW soybean and soy-product imports come from the FAS Global Agricultural Trade System (GATS). Importing country GDP, exchange rates and Consumer Price Indices come from the Economic Research Service, USDA, international macroeconomic data. Annual soybean export promotion expenditures are provided by USB.

Econometric Results

Domestic Soybean Demand and Supply

The domestic demand and supply models are estimated with annual national data from 1980 through 2018. All equations are estimated using two different functional forms: (1) linear and (2) log-linear. The log-linear model has the best statistical fit for all the models in terms of coefficient of variation and best t-values and is the functional form used for the final models.

Soybean demand. The estimated elasticities for the farm-level soybean demand model are summarized in Table 1 (the full econometric output is listed in the Appendix). The coefficient of variation (R^2) indicates that the explanatory variables explain 94% of the variations in annual farm-level demand for soybeans. The elasticity signs are consistent with economic theory and all estimated coefficients (except for the lagged commercial disappearance and the substitute price index, which are not statistically significant and therefore omitted from the final model) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table 1. Soybean demand elasticities.

		95% Confidence Interval	
Demand Factor	**Elasticity**	*Lower bound*	*Upper bound*
Own price	-0.239	-0.309	-0.169
Pork + poultry production	0.631	0.609	0.653
USB domestic promotion	0.022	0.013	0.030
USB demand-enhancing research (lagged 12 years)	0.020	0.015	0.024

The own price elasticity (all elasticities that follow are based on the average for the entire period, 1980-2018) is negative and equal to -0.239. The interpretation of this is a 1% increase in the farm soybean price, holding all other demand factors constant, leads to a 0.239% decrease in soybean quantity. Pork plus poultry production has a positive elasticity value indicating that as poultry and pork production increases, so does the demand for soybeans. Specifically, a 1% increase in pork plus poultry production, holding all other demand factors constant, increases soybean demand by 0.631%. This is the most important demand driver for soybeans.

Both domestic promotion and demand-enhancing research activities by USB have a positive and statistically significant impact on U.S. soybean demand. Holding all other demand factors constant, a 1% increase in promotion expenditures increased soybean demand by 0.022%. A 1% increase in lagged demand-enhancing research expenditures increased soybean demand by 0.02%. The lag length is 12 years on demand-enhancing research, which means that it takes 12 years, on average, for such research to have an impact on demand.

Another way to view the estimated elasticities for USB promotion and demand-enhancing research is in terms of their total impact on soybean demand. That is, had there not been any domestic promotion by USB, farm-level soybean demand would have been 2.2% (0.022 x 100 = 2.2%) lower than it actually was over this period.[4] Had there not been any USB-sponsored, demand-enhancing research, farm-level soybean demand would have been 2% (0.02 x 100 = 2%) lower than it actually was over this period.

Because there is error inherent in any statistical model, the lower bound of the 95% confidence interval (based on a one-sided test) is computed for the demand-enhancing research and promotion elasticities.[5] The lower bound can be interpreted as the lowest value of the estimated

[4] This calculation follows from multiplying the elasticity value by 100% in order to get an estimated of the total impact of USB. In other words, since an elasticity is a percentage measure of how demand (or supply) changes given a 1% change in an explanatory variable, multiplying the elasticity value by 100% gives an estimate of how demand (or supply) would change, given a 100% change in the explanatory variable and holding constant all other factors.

[5] The lower-bound confidence intervals for all estimated promotion and research elasticities computed in this study are based on a one-sided t-test since our alternative hypothesis is that the true promotion elasticity is greater than zero rather than not equal to zero.

elasticity where one can be confident that the true population elasticity would be at or above it 95% of the time. The lower bound of the one-sided 95% confidence interval for the promotion elasticity is 0.013. The lower bound of the one-sided 95% confidence interval for the demand-enhancing research elasticity is 0.015. In other words, 95% of the time, the true promotion elasticity lies at or above 0.013, and 95% of the time the true demand-enhancing research elasticity lies at or above 0.015.

Soybean supply. The estimated elasticities for the soybean supply model are summarized in Table 2. The explanatory variables explain 92% of the variations in annual supply for soybeans. The elasticity signs are consistent with economic theory, and all estimated coefficients (except for the index of prices paid by farmers and soybean production in the previous year, which are both omitted from the model since they are not significant) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table 2. Soybean supply elasticities.

Supply Factor	Elasticity	95% Confidence interval	
		Lower bound	*Upper bound*
Soybean-corn price ratio	0.943	0.745	1.141
Time trend	0.018	0.010	0.026
USB production research (lagged 14 years)	0.077	0.069	0.085

The estimated own price elasticity is positive and equal to 0.94. The polynomial distributed lag model includes the current price and price lags for the three previous years in its formulation. The interpretation of this is a 1% increase in the farm soybean price, holding all other supply factors constant, leads to a 0.94% increase in soybean quantity supplied. Since the corn price is used as the denominator in the soybean-corn price ratio, its elasticity value is exactly the negative of the own price elasticity, namely -0.94. That is, a 1% increase in the corn price leads to a 0.94% decrease in soybean supply, holding all other supply drivers constant. The estimated coefficient on the trend term is positive and statistically significant, indicating positive technological improvements over the period 1980-2018. Specifically, the estimated coefficient for the trend term indicates that holding all other variables constant, technological improvements have increased soybean supply by 1.8% per year, on average, since 1980.

Production research activities by USB and QSSBs had a positive and statistically significant impact (at the 0.065% level based on a one-tailed t-test) on U.S. soybean supply. Holding all other demand factors constant, a 1% increase in promotion expenditures increased soybean demand by 0.077%. The lag length for production research is 14 years, which is longer than that found for demand-enhancing research.[6] The lower bound of the one-sided 95% confidence interval on the production research elasticity is 0.069.

Another way to view the estimated elasticities for USB and QSSB production research is in terms of their total impact on soybean supply. That is, had there not been any USB- and QSSB-sponsored production research, soybean supply would have been 7.7% (0.077 x 100 = 7.7%) lower than it actually was over this period.

It is quite likely that the estimated elasticity of 0.077 for USB plus QSSB production research is biased upward due to the omission of significant spending by both the federal government and private companies on soybean research and development. While we do not have time series annual data on these expenditures, a recent estimate provided by USB is that the private industry (e.g., Indigo, Benson Hill, Monsanto, Pioneer, Syngenta) spends $775 million annually on soybean and soy-product research and development. In addition, the USDA spends about $100 million per year on this, while the soybean checkoffs spend $55 million annually. In other words, the soybean checkoffs only make up about 5.9% of the total funding of soybean research and development. As such, the estimated impact of 7.7% likely overstates the contribution of USB. Hence, this important caveat should be noted in interpreting this finding.

Soybean meal demand. The estimated elasticities for the wholesale soybean meal demand

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[6] There is a large body of economic literature measuring the economic returns to agricultural research and development by the government and private industry in the United States. These studies aim to measure the social and private rate of return on agricultural research, and one of the key issues in doing this is estimating the lag length of time between when research is initiated and when it begins to have an impact on agricultural production. An excellent review of this literature is provided by a publication entitled, "Research Lags Revisited: Concepts and Evidence from U.S. Agriculture," a 2008 publication by Julian Alston, Philip Pardey and Vernon Ruttan. In this paper, the authors report that about 21% (370 estimates) of all studies find an agriculture research lag length between 0 and 10 years; 28% (490 estimates) find a lag length of 11-20 years; and another 20% (358 estimates) find a lag length of 21-30 years. Therefore, estimates here of 12 years for demand-enhancing research and 14 years for production research fall within the range of previous studies. It should be noted that the 12- and 14-year lag lengths estimated in this study should be thought of as the average minimum time for soybean research to have an impact, and the impacts last substantially longer than this.

model are summarized in Table 3. The explanatory variables explain 89% of the variations in annual demand for soybean meal. The elasticity signs are consistent with economic theory, and all estimated coefficients (except for the substitute price index and lagged commercial disappearance of soybean meal, which are not significant and therefore omitted from the model) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The estimated own price elasticity is negative and equal to -0.16. The interpretation of this is a 1% increase in the wholesale soybean meal price, holding all other demand factors constant, leads to a 0.16% decrease in soybean meal quantity demanded. Pork plus poultry production has a positive elasticity value indicating that as poultry and pork production increases, so does the demand for soybean meal. Specifically, a 1% increase in pork plus poultry production, holding all other demand factors constant, increases soybean meal demand by 0.54%.

Table 3. Soybean meal demand elasticities.

		95% Confidence Interval	
Demand Factor	**Elasticity**	*Lower bound*	*Upper bound*
Own price	-0.160	-0.205	-0.114
Pork + poultry production	0.537	0.404	0.671
USB domestic promotion	0.006	0.004	0.008
USB demand-enhancing research (lagged 12 years)	0.006	0.002	0.010

Domestic promotion and demand-enhancing research activities by USB had a positive and statistically significant impact (significant at the 0.055% level based on a one-sided t-test) on U.S. soybean meal demand. Holding all other demand factors constant, a 1% increase in promotion expenditures increased soybean meal demand by 0.006%. Similarly, a 1% increase in lagged demand-enhancing research expenditures increased soybean meal demand by 0.006%. The lag length is 12 years on demand-enhancing research, which means that it takes about 12 years, on average, for such research to have an impact on soybean meal demand. Extrapolating these results, had there not been any USB-sponsored, demand-enhancing research, soybean meal demand would have been 0.6% lower than it actually was over this period. Similarly, had there not been any USB-sponsored domestic promotion, soybean meal demand would have been 0.6% lower than it actually was over this period. The lower bound of the one-sided 95% confidence interval for promotion and demand-enhancing research are 0.004 and 0.002, respectively.

Soybean oil demand. The estimated elasticities for the wholesale soybean oil demand model are summarized in Table 4. The R^2 indicates that the explanatory variables explain 90% of the variations in annual demand for soybean oil. The elasticity signs are consistent with economic theory, and all estimated coefficients (except for pork plus poultry production, which is not and is omitted from the model; additionally, demand-enhancing research, while positive, is not statistically significant) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The estimated coefficient on lagged soybean oil demand (measured as commercial disappearance) is 0.515, which is statistically significant from zero. This indicates that there is a positive correlation between soybean oil demand in the previous year and current soybean oil demand. This estimate is used to derive the long-run elasticities (LRE) by using the following formula:

Long-run elasticity = (1/(1-0.515)) short-run elasticity (SRE)= 2.06 x SRE, where SRE is the short-run elasticity.

Table 4. Soybean oil demand elasticities.

		95% Confidence Interval	
Demand Factor	**Elasticity**	*Lower bound*	*Upper bound*
Own price	-0.120	-0.205	-0.035
Substitute commodity price	0.120	0.035	0.205
Lagged commercial disappearance	0.515	0.355	0.675
USB domestic promotion	0.007	0.005	0.009
USB demand-enhancing research (lagged 12 years)	0.003	-0.001	0.007

The estimated short-run own price elasticity is negative and equal to -0.12, while the long-run elasticity is -0.247. The interpretation of this is a 1% increase in the wholesale soybean oil price, holding all other demand factors constant, leads to a 0.12% decrease in soybean oil quantity demanded in the short run and a 0.247% decrease in the long run. Since the ratio of the soybean oil price to the price index of substitute commodities is used, the cross-price elasticity of demand with respect to substitutes is the opposite sign of the own price elasticity, i.e., 0.12 in the short run and 0.247 in the long. That is, a 1% increase in the price index for soybean oil substitutes, holding all other demand factors constant, results in a 0.12% increase in soybean oil demand in the short run and a 0.247% increase in the long run.

Both domestic promotion and demand-enhancing research activities by USB had a positive impact on U.S. soybean oil demand, but only promotion is statistically significant (at the 0.055% significance level based on a one-sided t-test). Holding all other demand factors constant, a 1% increase in promotion expenditures increased soybean oil demand by 0.007% in the short run and 0.014% in the long run. A distributed lag model (PDL) with current promotion expenditures and two years of lagged values is the best fit. A 1% increase in lagged demand-enhancing research expenditures increased soybean demand by 0.003% in the short run and 0.006% in the long run. The lag length is 12 years for demand-enhancing research, which means that it takes about 12 years, on average, for such research to have an impact on soybean oil demand. Extrapolating the long-run results, had there not been any domestic promotion by USB, soybean oil demand would have been 1.4% lower than it actually was over this period in the long run. Had there not been any USB-sponsored, demand-enhancing research, soybean oil demand would have been 0.6% lower than it actually was over this period. The lower bound of the one-sided 95% confidence intervals for promotion and demand-enhancing research are 0.005 and -0.001, respectively.

Import Soybean (Soybean Meal and Soybean Oil) Demand

The import demand equation for U.S. soybeans (soybean meal and soybean oil) is estimated for the 10 regions with time series data from 2014 through 2018. All equations are estimated using two different functional forms: (1) linear and (2) log-linear. As is the case with the domestic supply and demand models, the log-linear specification had the best fit for all three of the import demand models. A fixed effect model is estimated with the panel data structure with cross-sectional GLS weights applied.

Soybean import demand. The estimated elasticities for the soybean import demand model are summarized in Table 5. The explanatory variables explain 98% of the variations in U.S. soybean imports to the 10 regions over the past five years. The elasticity signs are consistent with economic theory, and most estimated coefficients (except imports in the previous year, which are omitted from the final model) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

The import demand model for soybeans has its own price elasticity of demand of -1.68, which means a 1% increase in the U.S. price relative to the ROW price for soybeans would result in an 1.68% decrease in U.S. soybean imports, holding all other import demand drivers constant. Since the ratio of the U.S. price to the ROW price is used, the cross-price elasticity of demand with respect to the ROW price is the opposite sign of the own price elasticity. Specifically, a 1% increase in ROW price would result in a 1.68% increase in U.S. soybean imports, holding constant all other demand drivers. GDP is the most important demand driver for U.S. soybean imports. Holding all other drivers constant, a 1% increase in importing countries GDP increases U.S.

soybean imports by 4.65%. The indicator variable for U.S.-China tariffs in 2018 is also negative and statistically significant. Specifically, in 2018, the tariff resulted in a 19.9% decrease in U.S. exports of soybeans.

Table 5. Soybean import demand elasticities.

Import Demand Factor	Elasticity	95% Confidence Interval *Lower bound*	*Upper bound*
U.S. price	-1.684	-2.009	-1.360
ROW price	1.684	1.359	2.009
GDP	4.650	4.420	0.699
Exchange rate	-0.630	-0.945	-0.315
Tariff	-0.200	-0.219	-0.181
USB and USSEC partnerships FAS + QSSB	0.163	0.106	0.221

The export promotion expenditures funded through USSEC partnerships (USB, FAS and QSSB) had a positive and statistically significant impact on U.S. soybean import demand. Holding all other demand factors constant, a 1% increase in combined U.S. export promotion expenditures increased soybean import demand by 0.16%. Again, another way to view the estimated export promotion elasticity is in terms of its total impact on soybean import demand. That is, had there not been any U.S. soybean and soy-product export promotion, U.S. soybean exports would have been 16.3% (0.163 x 100 = 16.3%) lower than they actually were over this period. The lower bound of the one-sided 95% confidence interval for export promotion is 0.106.

Soybean meal and soybean oil import demand. The estimated elasticities for the soybean meal and soybean oil import demand models are summarized in Tables 6 and 7. The explanatory variables explain 99% of the variations in U.S. soybean meal and soybean oil imports to the 10 regions over the past five years. The elasticity signs are consistent with economic theory, and all estimated coefficients (except imports in the previous year and exchange rates for soybean meal, and ROW price, GDP, and exchange rates for soybean oil) are statistically significant. Several econometric diagnostic tests performed indicate no statistical problems with the model.

Table 6. Soybean meal import demand elasticities.

Import Demand Factor	Elasticity	95% Confidence Interval: *Lower bound*	95% Confidence Interval: *Upper bound*
U.S. price	-2.822	-3.283	-2.362
ROW price	1.028	0.928	1.128
GDP	3.632	2.742	4.522
Time trend	-0.724	-0.905	-0.542
USB and USSEC partnerships FAS + QSSB	0.176	0.096	0.255

The estimated own price elasticity of U.S. soybean meal and soybean oil import demand is elastic and statistically significant. Specifically, a 1% increase in the U.S. soybean meal and soybean oil price, holding all other factors constant, decreases soybean meal import quantity demanded by 2.822% and soybean oil import quantity demanded by 1.762%. Competing country soybean meal price has a positive impact on U.S. soybean meal imports but is not significant for soybean oil import demand. A 1% increase in the ROW price increases U.S. soybean meal imports by 1.028%, holding all other demand drivers constant. Importing country GDP is positively associated with U.S. soybean meal imports but is not significant for soybean oil. A 1% increase in an importer's GDP increases U.S. soybean meal imports by 3.632%, holding other demand drivers constant. The time trend term is negative for both soybean meal and soybean oil. The tariff indicator variable is negative, as expected, for soybean oil, but is not significant for soybean meal import demand and therefore not included in the model. Specifically, in 2018, the tariff resulted in a 14.5% decrease in U.S. exports of soybean oil.

Table 7. Soybean oil import demand elasticities.

Import Demand Factor	Elasticity	95% Confidence Interval: *Lower bound*	95% Confidence Interval: *Upper bound*
U.S. price	-1.762	-2.019	-1.505
Time trend	-0.298	-0.427	-0.169
Tariff	-0.145	-3.147	-1.075
USB and USSEC partnerships FAS + QSSB	0.312	0.152	0.472

U.S. export promotion has a positive and statistically significant impact for both soybean meal and soybean oil import demand. A 1% increase in soybean (and soy-product) export promotion expenditures, holding all other import demand factors constant, increases soybean meal imports by 0.176% and soybean oil imports by 0.312%. Alternatively, had there not been any U.S. soybean export promotion, U.S. soybean meal exports would have been 17.6% lower, and U.S. soybean oil exports would have been 31.2% lower than they actually were. The lower bound of the one-sided 95% confidence intervals for export promotion of soybean meal and soybean oil import demand is 0.096 and 0.152, respectively.

Equilibrium Displacement Model

The net benefits of each of the four USB activities are measured through simulation of an equilibrium displacement model (EDM) using a marginal BCR analysis. That is, the endogenous variables in the model such as prices and quantities are simulated under two scenarios: (1) baseline scenario where all exogenous variables (e.g., USB domestic promotion expenditures) are set equal to historical levels; and (2) counterfactual scenario where USB expenditures are increased by 1% above their historical levels. The endogenous variables are then determined under both scenarios to determine the impact of a 1% increase in expenditure levels on prices, quantities and producer profits (producer surplus).[7] To compute the corresponding net marginal BCR, the increase in producer surplus due to the 1% simulated increase in USB expenditures is divided by the 1% increase in costs associated with each activity.

The EDM is a static model that assumes instantaneous adjustment (see details of the model in the Appendix). The crucial parameters to the model are the own price elasticities of demand and supply and the elasticities for the four USB activities. In the EDM, the estimated coefficients from the econometric model are used.

The EDM is simulated for the most recent five-year period, 2014-2018. The focus here is on computing a net marginal BCR, which is based on a small change (1%) between two equilibrium levels.

[7] Producer surplus is a measure used by economists that is similar to profitability. Technically, it is defined as the total revenue (price times quantity sold) minus the area of the supply curve under the price.

Simulation Results. How do these marginal benefits compare with the marginal costs? To answer this question, the following net marginal BCR is computed for each USB activity:

$$BCR = (\Delta PS - \Delta Costs)/\Delta Costs$$

Where: ΔPS is the change in producer surplus (i.e., incremental profit) associated with the 1% increase in the USB activity, and ΔCost is the respective 1% change in cost. The interpretation of a net marginal BCR is that it measures the net return (in dollars) of an *extra* dollar invested in promotion or research by USB. For the two activities that had long lag lengths before fruition of the benefits, the lagged costs were put in current (2018) dollars rather than the nominal dollars spent 10-14 years previously.

Table 8 lists the impact of a 1% increase in each of the four USB activities as well as their combined impact on soybean price, market soybean volume, USB costs and producer profits. The last column gives the net marginal BCR for each activity.

USB domestic promotion has a positive impact on the soybean price and market volume. A 1% increase in domestic promotion expenditures increases the soybean price by 0.0021% and volume of soybeans marketed domestically by 0.021%, on average, over the past five years. The resulting increase in price and volume increases industrywide soybean producer profits by $942,745 at a USB cost of $174,176, which results in a net marginal BCR of 4.41:1. In other words, an extra dollar invested in USB domestic promotion returns $4.41 in profit to soybean producers.

USB domestic expenditures on demand-enhancing activities has the largest impact of all activities. Specifically, a 1% increase in demand-enhancing research expenditures increases the soybean price by 0.0019% and market volume by 0.0191%. This results in an increase in industrywide soybean profits of $856,895 at a cost to USB of $44,683.[8] This results in a net

[8] Since demand-enhancing research expenditures are lagged for 12 years, the costs in the BCR are lagged 12 years and expressed in 2018 dollars. Likewise, since production research expenditures are lagged 14 years, the costs in the BCR for production research are lagged 14 years and expressed in 2018 dollars.

marginal BCR of 18.18:1. In other words, an extra $1 spent by USB on demand-enhancing research would return $18.18 in profit to soybean producers.

A 1% increase in production research increases the quantity of soybeans supplied by an average of 0.0701% but decreases the price by 0.0074%. The result is an increase in producer profits of $3.361 million at a cost of $322,689[9] and a net marginal BCR of 9.42:1.

A 1% increase in U.S. soybean export promotion expenditures increases the soybean price by 0.017% and volume of U.S. soybeans exports by 0.0188%, on average, over the past five years. The resulting increase in price and export volume increases industrywide soybean producer profits by $6.984 million at a cost of $368,610, which results in a net marginal BCR of 17.95:1. In other words, an extra dollar invested in U.S. soybean export promotion returned $17.95 in profit to soybean producers.

Table 8. Impacts of 1% increase in USB expenditures on soybean price, volume and profit.

USB Marketing Activity	% impact soybean price	% impact soybean volume	Change in costs	Change in profits	Net Marginal BCR
Domestic promotion	0.0021%	0.0210%	174,176	942,745	4.41
Demand-enhancing research	0.0019%	0.0191%	44,683	856,895	18.18
Production research	-0.0074%	0.0701%	322,689	3,361,367	9.42
Export promotion	0.0170%	0.0188%	368,610	6,983,618	17.95
All activities combined	0.0136%	0.1290%	910,158	12,144,626	12.34

[9] Since supply-enhancing research expenditures are lagged for 14 years, the costs in the BCR are lagged 14 years and expressed in 2018 dollars.

Overall, a 1% increase in all four USB activities combined increases the soybean price by 0.0136% and market volume by 0.129%. This results in an increase in soybean producer profits of $12.145 million at a cost of $910,158. In other words, an extra dollar invested in all four activities returns $12.34 in profit to soybean producers.

All these numbers presented are “point estimates,” which are estimates rather than exact measures. That is, there is uncertainty about the precision of these estimates, and therefore it is useful to construct confidence intervals around these point estimates. It is especially important to estimate the lower-bound confidence interval for the BCR. Collectively, the lower-bound 95% confidence interval for the net marginal BCR is 8.74. Since the lower bound of this estimate is still substantially above zero, this provides additional empirical evidence that the USB checkoff program has been a profitable venture for soybean producers.

Appendix. Econometric Models

This Appendix presents the complete econometric output for all supply and demand models used in this study and describes the equilibrium displacement model. For the domestic demand side, the three econometric equations to be estimated include: (1) farm-level domestic soybean demand, (2) wholesale soybean meal demand, and (3) wholesale soybean oil demand. On the supply side, a soybean supply function is estimated. In addition, three econometric equations are estimated for U.S. soybean imports from other countries: (1) import demand function for U.S. soybeans, (2) import demand function for U.S. soybean meal, and (3) import demand function for U.S. soybean oil. In the output that follows, LOG is the natural logarithmic operator.

A. Domestic Soybean Demand

The soybean demand equation is estimated in logarithmic form, with annual data from 1985-2018, and has the following econometric results:

Dependent Variable: LOG(SBQ)

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed prob.
LOG(SBP/CPI)	-0.238947	0.067317	-3.549565	0.00095
LOG(PORK+POULTRY)	0.630710	0.021270	29.65323	0.00000
LOG((100+PROMO)/CPI)	0.021599	0.007966	2.711501	0.00655
LOG(((100+RESEARCHDEMAND(-12)))/CPI(-12))	0.019633	0.004598	4.270285	0.00015
AR(1)	0.564836	0.144395	3.911748	0.00040

R-squared	0.944238	Mean dependent var	8.012903
Adjusted R-squared	0.933617	S.D. dependent var	0.195682
S.E. of regression	0.050417	Akaike info criterion	-2.965929
Sum squared resid	0.053380	Schwarz criterion	-2.723987
Log likelihood	43.55707	Hannan-Quinn criter.	-2.896258
Durbin-Watson stat	1.882411		
Inverted AR Roots	.56		

In this table, SBQ is domestic commercial disappearance of soybeans in million bushels; SBP is the soybean price per bushel; CPI is the Consumer Price Index for all items; PORK is U.S. pork production; POULTRY is U.S. poultry production; SUNFLOWERP is the sunflower price; PROMO is soybean, soybean oil and soybean meal promotion USB expenditures; and RESEARCHDEMAND is USB expenditures on demand-enhancing research. The model with the best result had the following lag structures. For USB promotion, expenditures on current year (with no lags) had the best fit. For demand-enhancing research, USB expenditures lagging 12 and 13 years resulted in the best fit. Since the log of zero is undefined, and there are zero values for some promotion and research years, a small number ($100) is added to these variables.

B. Soybean Supply

The soybean supply equation is estimated in logarithmic form, with annual data from 1985-2018, and has the following econometric results:

Dependent Variable: LOG(PROD)

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	5.838523	0.568929	10.26231	0.00000
T	0.017532	0.003906	4.488184	0.00010
LOG(RESEARCHSUPPLY2(-14)/CPI(-14))	0.077445	0.048977	1.581231	0.06475
PDL01	0.392417	0.078301	5.011624	0.00005
PDL02	-0.099390	0.021500	-4.622853	0.00010

R-squared	0.918886	Mean dependent var	8.031074
Adjusted R-squared	0.902663	S.D. dependent var	0.195413
S.E. of regression	0.060967	Akaike info criterion	-2.580118
Sum squared resid	0.074339	Schwarz criterion	-2.336343
Log likelihood	37.25148	Hannan-Quinn criter.	-2.512505
F-statistic	56.64130	Durbin-Watson stat	1.830843
Prob(F-statistic)	0.000000		

Lag Distribution of LOG(SBP/CORNP)	i	Coefficient	Std. Error	t-Statistic
.　　　*　|	0	0.29303	0.05789	5.06223
.　　　　*|	1	0.38728	0.07732	5.00852
.　　　*　|	2	0.28274	0.07120	3.97125
* .　　　　|	3	-0.02057	0.09434	-0.21802
Sum of Lags		0.94248	0.23733	3.97125

In the table, PROD is annual soybean production, T is a time trend variable equal to 1 for 1985, 2 for 1986, etc., SBP is the soybean price, CORNP is the corn price and RESEARCHSUPPLY is USB and QSSB production research expenditures. A lag length of 14 years for research expenditures had the best statistical fit. A distributed lag model for the expected soybean to corn price ratio is estimated, and the best lag structure is current, one-year lagged, two-year lagged and three-year lagged price ratios.

C. Domestic Soybean Meal Demand

The soybean meal demand equation is estimated in logarithmic form, with annual data from 1985-2018, and has the following econometric results:

Dependent Variable: LOG(MEALQ)

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	4.665222	1.372931	3.398002	0.00130
LOG(MEALP/CPI)	-0.159530	0.043453	-3.671337	0.00065
LOG(POULTRY+PORK)	0.537104	0.128645	4.175087	0.00020
LOG((100+RESEARCHDEMAND(-12))/CPI(-12))	0.006269	0.003775	1.660795	0.05545
PDL01	0.002405	0.001462	1.645787	0.05700

R-squared	0.918372	Mean dependent var	10.58482
Adjusted R-squared	0.903531	S.D. dependent var	0.125438
S.E. of regression	0.038960	Akaike info criterion	-3.486963
Sum squared resid	0.033394	Schwarz criterion	-3.246993
Log likelihood	52.07399	Hannan-Quinn criter.	-3.415607
F-statistic	61.87896	Durbin-Watson stat	1.662573
Prob(F-statistic)	0.000000		

Lag Distribution of LOG((100+PROMO2)/CPI)	i	Coefficient	Std. Error	t-Statistic
. * |	0	0.00180	0.00110	1.64579
. * |	1	0.00241	0.00146	1.64579
. * |	2	0.00180	0.00110	1.64579
Sum of Lags		0.00601	0.00365	1.64579

In the table, MEALQ is annual soybean meal domestic commercial disappearance, MEALP is the wholesale price for soybean meal, and all other variables are previously defined. USB demand-enhancing research expenditures lagging 12 years had the best statistical fit. A distributed lag model for soybean, soybean meal and soybean oil promotion expenditures with current, one-year lag and two-year lag had the best statistical fit. Since the log of zero is undefined, and there are zero values for some promotion and research years, a small number ($100) is added to these variables.

D. Domestic Soybean Oil Demand

The soybean oil demand equation is estimated in logarithmic form, with annual data from 1985-2018, and has the following econometric results:

Dependent Variable: LOG(OILQ)

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	4.727476	1.486372	2.988025	0.0035
LOG(OILP/((SUNFLOWERP+FLAXSEEDP)/2))	-0.120198	0.081712	-1.508356	0.0732
LOG(OILQ(-1))	0.515118	0.154606	3.140201	0.0025
LOG((100+RESEARCHDEMAND(-11))/CPI(-11))	0.003039	0.003499	0.893771	0.1908
PDL01	-0.004976	0.006168	-0.757103	0.2287
PDL02	0.002661	0.002563	0.979247	0.1693

R-squared	0.888097	Mean dependent var	9.838126
Adjusted R-squared	0.861453	S.D. dependent var	0.152440
S.E. of regression	0.052519	Akaike info criterion	-2.867886
Sum squared resid	0.060681	Schwarz criterion	-2.582414
Log likelihood	46.15041	Hannan-Quinn criter.	-2.780615
F-statistic	41.09518	Durbin-Watson stat	1.745222
Prob(F-statistic)	0.000000		

Lag Distribution of LOG(((100+PROMO))/CPI)		i	Coefficient	Std. Error	t-Statistic
* . |		0	-0.00232	0.00364	-0.58184
. * |		1	0.00069	0.00248	0.30850
. * |		2	0.00902	0.00519	1.66530
	Sum of Lags		0.00740	0.00450	1.56671

In this table, OILQ is annual soybean oil domestic commercial disappearance, OILP is the wholesale price for soybean oil, SUNFLOWERP is the sunflower price, FLAXSEEDP is the flaxseed price, and all other variables are previously defined. USB demand-enhancing research expenditures lagging 11 years had the best statistical fit. A distributed lag model for soybean, soybean meal and soybean oil promotion expenditures with current, one-year lag and two-year lag had the best statistical fit. Since the log of zero is undefined, and there are zero values for some promotion and research years, a small number ($100) is added to these variables.

E. Import Demand for U.S. Soybeans

The soybean import demand equation is estimated in linear form, with panel data from 2014-2018 for 10 importing regions, and has the following econometric results:

Dependent Variable: LOG(USQ)
Method: Panel EGLS (Cross-section weights)
Cross-section SUR (PCSE) standard errors & covariance (no d.f. correction)
Convergence achieved after 25 total coef iterations

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	-21.52466	1.991521	-10.80815	0.00000
LOG(USP/ROWP)	-1.684126	0.314459	-5.355637	0.00000
LOG(PROMO/CPI)	0.163450	0.055740	2.932348	0.00365
LOG(GDP)	4.646467	0.223244	20.81345	0.00000
TARIFF	-2.081163	0.183889	-11.31752	0.00000
LOG(ER)	-0.630406	0.304838	-2.068003	0.02480
AR(1)	-0.578048	0.131304	-4.402354	0.00010

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.987926	Mean dependent var	20.30852
Adjusted R-squared	0.980379	S.D. dependent var	6.544652
S.E. of regression	0.196542	Sum squared resid	0.927094
F-statistic	130.9113	Durbin-Watson stat	2.580901
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.970388	Mean dependent var	14.99809
Sum squared resid	1.167406	Durbin-Watson stat	2.201849

Inverted AR Roots	-.58

In this table, USQ is the import volume of U.S. soybeans to each importing region, USP is the U.S. soybean price, ROWP is the rest-of-the-world soybean price, PROMO is U.S. soybean export expenditures in the importing region, CPI is the Consumer Price Index for all items in the importing region, GDP is Gross Domestic Product in the importing region, TARIFF is the tariffs imposed by China on U.S. soybean imports in 2018, ER is the exchange rate of the U.S. dollar to the region's currency, and AR(1) is an autoregressive error 1 process.

F. Import Demand for U.S. Soybean Meal

The soybean meal import demand equation is estimated in logarithmic form, with panel data from 2014-2018 for 10 importing regions, and has the following econometric results:

Dependent Variable: LOG(MEALQ)
Method: Panel EGLS (Cross-section weights)
Total panel (balanced) observations: 50
Linear estimation after one-step weighting matrix
Cross-section SUR (PCSE) standard errors & covariance (no d.f correction)

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	-15.37419	6.284312	-2.446440	0.00980
LOG(USPMEAL/CPI)	-2.822456	0.453537	-6.223207	0.00000
LOG(ROWPMEAL/CPI)	1.027550	0.098628	10.41840	0.00000
LOG(GDP)	3.631878	0.876552	4.143370	0.00010
LOG(PROMO/CPI)	0.175571	0.078531	2.235677	0.01595
LOG(T)	-0.723745	0.178568	-4.053039	0.00015

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.993937	Mean dependent var	26.34363
Adjusted R-squared	0.991512	S.D. dependent var	27.59600
S.E. of regression	0.455503	Sum squared resid	7.261916
F-statistic	409.8363	Durbin-Watson stat	1.920617
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.961870	Mean dependent var	12.39225
Sum squared resid.	8.344680	Durbin-Watson stat	1.966593

In this table, MEALQ is the import volume of U.S. soybean meal to each importing region, USPMEAL is the U.S. soybean meal price, ROWPMEAL is the soybean meal price from the rest of the world, and all other variables are as previously defined.

G. Import Demand for U.S. Soybean Oil

The soybean oil import demand equation is estimated in logarithmic form, with panel data from 2014-2018 for 10 importing regions, and has the following econometric results:

Dependent Variable: LOG(OILQ)
Method: Panel EGLS (Cross-section weights)
Total panel (balanced) observations: 40
Iterate coefficients after one-step weighting matrix
Cross-section SUR (PCSE) standard errors & covariance (no d.f. correction)

Convergence achieved after 17 total coef iterations

Variable	Coefficient	Std. Error	t-Statistic	1-Tailed Prob.
C	10.21537	1.750055	5.837173	0.00000
LOG(USPOIL/CPI)	-1.761654	0.249702	-7.055022	0.00000
LOG(PROMO/CPI)	0.312116	0.155081	2.012594	0.02750
LOG(T)	-0.297530	0.125257	-2.375360	0.01275
TARIFF	-2.111107	1.005976	-2.098566	0.02305

Effects Specification

Cross-section fixed (dummy variables)

Weighted Statistics

R-squared	0.991733	Mean dependent var	19.82669
Adjusted R-squared	0.987103	S.D. dependent var	22.61719
S.E. of regression	0.678974	Sum squared resid	11.52515
F-statistic	214.2066	Durbin-Watson stat	1.699985
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.968558	Mean dependent var	9.018109
Sum squared resid	12.48234	Durbin-Watson stat	1.706420

Inverted AR Roots	.13

In this table, OILQ is the import volume of U.S. soybean oil to each importing region, USPOIL is the U.S. soybean oil price, and all other variables are as previously defined.

H. Equilibrium Displacement Model

The net benefits of each of the four USB activities are measured through simulation of an equilibrium displacement model (EDM) using a marginal analysis. That is, the endogenous variables in the model such as prices and quantities are simulated under two scenarios: (1) baseline scenario where all exogenous variables (e.g., USB expenditures) are set equal to historical levels, and (2) counterfactual scenario where USB expenditures are increased by 1% above their historical levels. The endogenous variables are then determined under both scenarios to determine the impact of a 1% increase in expenditure levels on prices, quantities and producer profits (producer surplus).[10] To compute the corresponding marginal benefit-cost ratio (BCR), the increase in producer surplus due to the 1% simulated increase in USB expenditures is divided by the 1% increase in costs associate with each activity.

The EDM consists of five equations and endogenous variables as follows (for simplicity, the only exogenous variables presented are for the four USB activities):

(1)	Qfd = f(SBP | SBPROMOTION, DEMRESEARCH)	Farm soybean demand
(2)	Qfs = f(SBP | SUPRESEARCH)	Farm soybean supply
(3)	Qx = f (USSBP | EXPROM)	Export soybean demand
(4)	USSBP = f(SBP)	Export price-farm price linkage
(5)	Qfs = Qfd + Qx	Market-clearing condition

Where the five endogenous variables are defined as follows: Qfd is farm-level soybean demand, Qfs is farm soybean supply, SBP is soybean price ($/bu), Qx is export soybean demand and USSBP is the U.S. price FOB soybean exports ($/bu). The export price-farm price linkage equation is estimated using annual data from 1980-2018 and is the following:

[10] Producer surplus is a measure used by economists that is similar to profitability or net revenue. Technically, it is defined as the total revenue (price times quantity sold) minus the area of the supply curve under the price.

USSBP = 1.112 SBP

(64.93) R^2=0.91

where values in parentheses are t-values and R^2 is the coefficient of determination.

The exogenous variables are defined as follows: SBPROMOTION is domestic promotion expenditures by USB, DEMRESEARCH is USB expenditures on demand-enhancing research, SUPRESEARCH is USB expenditures on production research, and EXPROM is USB and FAS and QSSB expenditures on foreign market development. The EDM transforms these five equations by taking the logarithmic differential of each equation, setting them equal to zero, and then solving the five equations for the five endogenous variable values.

The EDM is a static model that assumes instantaneous adjustment. The crucial parameters to the model are the own price elasticities of demand and supply and the elasticities for the four USB activities. In the EDM, the estimated coefficients from the econometric model are used. For variables that had a carryover effect such as demand-enhancing and production research, the long-run elasticities are used. Also, for the models that included a lagged dependent variable, the long-run elasticities are used.

The EDM is simulated for the most recent five-year period, 2014-2018. The focus here is on computing a marginal BCR, which is based on a small change (1%) between two equilibrium levels.

The net marginal BCR is computed as:

$$BCR = (\Delta PS - \Delta Costs)/\Delta Costs$$

Where: ΔPS is the change in producer surplus (i.e., incremental profit) associated with the 1% increase in the USB activity, and ΔCost is the respective change in cost. In the case of both research activities that had a long length of lag, the costs that were incurred 12 or 14 years ago were put in current dollars.

i. Data

Annual Data Used in Domestic Demand and Supply Models

YEAR	CORN PRICE $/BU	COTTONSEED PRICE $/TON	CPI FOR ALL ITEMS 1980-92=100	FLAXSEED Oil PRICE $/BU	REAL GDP 2012 $	LINSEED OIL PRICE CENTS/LB	SOYBEAN MEAL PRICE $/TON
1980	3.11	129.00	82	7.20	4,904.9	30.02	235.13
1981	2.50	86.00	91	6.67	5,024.4	30.01	196.62
1982	2.55	77.00	97	5.17	5,135.4	25.19	200.94
1983	3.21	166.00	100	6.84	5,312.4	30.12	203.21
1984	2.63	99.50	104	6.09	5,677.0	32.60	136.40
1985	2.23	66.00	108	5.05	5,847.9	31.14	166.20
1986	1.50	80.00	110	3.47	6,070.0	26.34	177.31
1987	1.94	82.50	114	3.39	6,204.1	24.71	239.35
1988	2.54	119.00	118	7.56	6,495.9	39.38	252.40
1989	2.36	105.00	124	7.20	6,686.4	40.20	186.48
1990	2.28	121.00	131	5.27	6,817.5	38.04	181.38
1991	2.37	71.00	136	3.52	6,866.9	32.00	189.21
1992	2.07	97.50	140	4.12	7,153.1	31.50	193.75
1993	2.50	113.00	144	4.25	7,271.4	31.78	192.86
1994	2.26	101.00	148	4.63	7,470.5	33.73	162.60
1995	3.24	106.00	152	5.25	7,719.0	36.54	235.90
1996	2.71	126.00	157	6.21	7,964.2	35.97	270.90
1997	2.43	121.00	161	5.75	8,255.8	36.33	185.30
1998	1.94	129.00	163	5.25	8,740.6	36.42	138.55
1999	1.82	89.00	167	3.79	9,025.9	35.83	167.70
2000	1.85	105.00	172	3.30	9,479.5	36.00	173.61
2001	1.97	90.50	177	4.29	9,740.2	38.10	167.72
2002	2.32	101.00	180	5.77	10,034.7	39.86	181.58
2003	2.42	117.00	184	5.88	10,301.5	42.00	256.05
2004	2.06	107.00	189	8.07	10,645.9	59.49	182.90
2005	2.00	96.00	195	5.94	10,811.7	53.99	174.17
2006	3.04	111.00	202	5.80	11,242.1	44.37	205.44
2007	4.20	162.00	207	13.00	11,500.5	70.31	335.94
2008	4.06	223.00	215	12.70	11,610.8	86.52	331.17
2009	3.55	158.00	215	8.15	11,592.0	67.49	311.27

2010	5.18	161.00	218	12.20	11,822.1	90.00	345.52
2011	6.22	260.00	225	13.90	12,099.9	90.00	395.53
2012	6.89	252.00	230	13.80	12,500.8	90.00	468.11
2013	4.46	246.00	233	13.80	12,339.1	90.00	489.94
2014	3.70	194.00	237	11.80	12,838.1	90.00	368.49
2015	3.61	227.00	237	8.95	13,366.5	90.00	324.56
2016	3.36	195.00	240	8.00	13,595.5	90.00	316.88
2017	3.36	142.00	245	9.53	13,949.3	90.00	345.02
2018	3.55	155.00	251	9.75	14,341.4	90.00	315.00

Annual Data Used in Domestic Demand and Supply Models

YEAR	Soybean meal com Disappearance 1,000 SHORT TONS	Soybean oil com Disappearance MIL LBS	Soybean oil Price CENTS/LB	Peanut Price CENTS/LB	Pork Production MIL LBS	Poultry Production MIL LBS
1980	24,375	10,744	22.73	25.10	14,699	14,234
1981	24,622	11,613	18.95	26.90	16,006	15,141
1982	26,415	11,882	20.62	25.10	14,422	15,189
1983	22,975	11,403	30.55	24.70	13,223	15,566
1984	24,397	11,576	29.52	27.90	14,331	16,171
1985	25,126	11,311	18.02	24.30	11,779	16,950
1986	27,730	12,020	15.36	29.20	12,688	18,010
1987	28,147	12,801	22.67	28.00	13,248	19,842
1988	24,940	12,252	21.09	27.90	13,393	20,624
1989	27,610	13,435	22.28	28.00	15,451	22,079
1990	28,408	12,944	20.98	34.70	16,617	23,676
1991	29,955	13,892	19.13	28.30	15,873	24,927
1992	30,484	14,473	21.24	30.00	14,229	26,446
1993	30,644	14,471	26.96	30.40	15,199	27,587
1994	33,266	15,597	27.51	28.90	14,812	29,395
1995	32,638	14,457	24.70	29.30	14,807	30,692
1996	34,333	16,300	22.51	28.10	14,063	32,333
1997	38,234	18,341	25.83	28.30	14,374	33,298
1998	37,796	18,024	19.80	28.40	15,684	33,696
1999	37,700	17,434	15.59	25.40	15,813	35,620
2000	39,350	17,719	14.09	27.40	15,354	36,458
2001	40,583	19,352	16.46	23.40	15,999	37,343
2002	38,388	19,344	22.04	18.24	17,233	38,500
2003	36,619	17,802	29.97	19.25	17,088	38,902
2004	40,902	18,763	23.01	18.90	17,696	40,022
2005	41,243	19,112	23.41	17.30	17,849	41,386
2006	43,159	20,451	31.02	17.70	17,118	41,686
2007	42,474	21,246	52.03	20.50	17,274	42,608
2008	39,249	18,459	32.16	23.00	19,010	43,713
2009	41,800	19,173	35.95	21.70	19,308	41,674
2010	39,382	19,777	53.20	22.50	18,952	43,058
2011	41,302	19,974	51.90	31.80	19,162	43,514
2012	40,145	20,951	47.13	30.10	19,685	43,523
2013	41,092	20,785	38.23	24.90	19,966	44,159
2014	45,384	20,974	31.60	22.00	20,529	44,842
2015	45,072	22,405	29.86	19.30	20,704	46,197
2016	45,000	22,418	32.55	19.70	21,074	47,226
2017	49,371	23,823	30.04	22.90	21,962	48,178
2018	49,702	24,855	30.00	21.50	23,367	49,016

Annual Data Used in Domestic Demand and Supply Models

YEAR	SOYBEAN PRODUCTION mil bu	USB DEMAND ENHANCING RES $	PRODUCTION RESEARCH $	SOYBEAN PRICE $/BU	USB SOYBEAN PROMOTION $
1980	1,798	0	3,488,869	7.6	0
1981	1,989	0	3,585,526	6.07	0
1982	2,190	0	3,952,515	5.71	0
1983	1,636	0	4,244,451	7.83	0
1984	1,861	0	3,737,441	5.84	0
1985	2,099	0	3,311,160	5.05	0
1986	1,943	0	3,799,524	4.78	0
1987	1,938	0	4,607,575	5.88	0
1988	1,549	0	3,303,995	7.42	0
1989	1,924	0	3,730,415	5.69	0
1990	1,926	0	4,454,527	5.74	0
1991	1,987	0	4,577,898	5.58	0
1992	2,190	0	9,753,065	5.56	0
1993	1,870	0	11,447,321	6.4	0
1994	2,515	353,140	13,063,648	5.48	917,149
1995	2,174	2,019,585	14,866,439	6.72	5,245,108
1996	2,380	2,992,872	14,828,351	7.35	7,772,855
1997	2,689	4,293,719	17,373,603	6.47	11,151,314
1998	2,741	3,453,809	19,689,447	4.93	8,969,965
1999	2,654	3,713,279	20,846,311	4.63	9,643,840
2000	2,758	2,005,270	20,957,224	4.54	5,207,931
2001	2,891	2,482,880	23,932,656	4.38	6,448,344
2002	2,756	3,206,441	23,066,359	5.53	8,327,519
2003	2,454	3,074,101	21,431,064	7.34	7,983,817
2004	3,124	3,633,547	26,623,899	5.74	9,436,766
2005	3,068	3,925,270	28,556,552	5.66	10,194,406
2006	3,197	3,044,095	29,144,044	6.43	7,905,888
2007	2,677	4,823,912	29,411,599	10.1	12,528,289
2008	2,967	6,307,843	36,477,529	9.97	16,382,240
2009	3,361	6,286,242	40,231,946	9.59	16,326,140
2010	3,331	6,906,025	53,742,192	11.3	17,935,792
2011	3,097	8,810,747	52,170,823	12.5	22,882,587
2012	3,042	6,821,795	52,170,823	14.4	18,660,923
2013	3,357	5,957,273	56,526,667	13	21,379,303
2014	3,928	10,524,288	72,856,989	10.1	17,261,602
2015	3,927	8,195,749	71,714,231	8.95	18,836,177
2016	4,296	4,940,662	60,747,604	9.47	16,197,796
2017	4,412	6,350,235	45,539,477	9.33	12,423,974
2018	4,544	6,133,595	26,051,429	8.6	22,368,542

Annual Data Used in Domestic Demand and Supply Models

Year	Soybean Com disappear Mil bu	Sunflower Price Cents/lb	Index of Price paid 1910-14=100	Trend Variable #
1980	1,843	26.95	798.0	1
1981	2,048	24.89	855.0	2
1982	2,100	21.38	886.0	3
1983	1,805	32.33	883.0	4
1984	1,721	30.01	900.0	5
1985	1,880	19.10	874.0	6
1986	2,042	15.99	835.0	7
1987	2,073	23.49	854.0	8
1988	1,673	22.66	911.0	9
1989	1,868	24.37	959.0	10
1990	1,839	23.67	990.0	11
1991	2,040	21.63	1,001.0	12
1992	2,179	25.37	1,005.0	13
1993	1,959	31.08	1,037.0	14
1994	2,395	28.10	1,052.0	15
1995	2,330	25.40	1,051.0	16
1996	2,441	22.64	1,118.0	17
1997	2,626	27.00	1,151.0	18
1998	2,596	20.10	1,092.0	19
1999	2,716	16.68	1,073.0	20
2000	2,804	15.89	1,117.0	21
2001	2,933	23.25	1,158.0	22
2002	2,791	33.11	1,154.0	23
2003	2,525	33.41	1,203.0	24
2004	2,986	43.78	1,284.0	25
2005	2,878	37.72	1,361.0	26
2006	3,081	58.03	1,434.0	27
2007	3,056	91.15	1,552.0	28
2008	3,047	50.24	1,839.0	29
2009	3,363	52.80	1,766.0	30
2010	3,282	86.12	1,825.0	31
2011	3,159	83.20	2,082.0	32
2012	3,111	65.87	2,193.0	33
2013	3,477	59.12	2,237.0	34
2014	3,863	66.72	2,376.0	35
2015	3,944	57.81	2,331.0	36
2016	4,213	53.54	2,178.0	37

2017	4,298	54.57	2,176.0	38
2018	4,102	55.00	2,214.0	39

Notes:

1. Production research expenditures are combined for USB + QSSB. For 1980-2011, data come from the previous Texas A&M USB evaluation study. The original data for 2012-2018 included only USB expenditures. To make the 2012-2018 data comparable and include USB + QSSB production research expenditures, the annual rate of change in the USB expenditures was applied to the latest year of the Texas A&M data (2011), and applied to 2012-2018, i.e.,

   2012 Production Research = 2011 Production Research x Rate of Change (USB) 2011-12

   2013 Production Research = 2012 Production Research x Rate of Change (USB) 2012-13

   And so on.

2. The annual expenditures from 1980-2011 for domestic USB promotion included demand-enhancing research expenditures. However, the 2012-2018 USB data split domestic promotion out between promotion and demand-enhancing research. In order to split out the 1980-2011 data into domestic promotion and demand-enhancing research, the average proportion of USB spending between the two categories for 2012-2018 was applied to the 1980-2011 data. Those proportions were 27.8% spent on demand-enhancing research and 72.2% spent on domestic promotion.

3. The export promotion data include expenditures from three sources: USB, QSSBs and FAS.

Panel Data Used in Export Demand Models

YEAR	REGION	Consumer Price index 2010=100	Exchange Rates 2010 BASE YEAR	GDP 2010 $	US Soybean meal Imports TONS	US Soybean oil Imports TONS	USB+FAS+ QSSB Export Promotion $
2014	China	114	5.8	8,333	18,890	150,112	4,339,709
2015		116	5.8	8,908	11,431	17,259	4,988,197
2016		118	6.2	9,505	25,692	143,269	5,377,965
2017		120	6.3	10,161	13,907	30,332	4,914,633
2018		123	6.3	10,832	24,543	888	4,698,595
2014	Japan	103	111.9	5,916	210,965	4,180	1,310,417
2015		104	127.0	5,996	174,401	2,584	1,382,076
2016		103	115.7	6,053	158,381	2,681	1,281,413
2017		104	121.3	6,156	249,987	2,732	1,394,818
2018		105	119.6	6,222	330,619	2,543	1,553,794
2014	Korea	109	1,048.2	1,234	166,837	36,384	758,605
2015		110	1,119.5	1,269	5,325	48,930	849,405
2016		111	1,151.8	1,306	14,075	81,697	829,462
2017		113	1,124.0	1,346	6,767	264,506	587,119
2018		115	1,087.3	1,382	20,717	281,161	901,040
2014	Taiwan	105	31.2	505	22,751	150	508,163
2015		105	32.9	509	11,422	60	757,604
2016		106	33.5	516	31,173	17	328,180
2017		107	32.1	531	23,995	4	576,427
2018		108	31.5	544	22,556	43	908,207
2014	SE Asia	119	161.0	2,414	2,141,910	5,552	4,402,806
2015		123	171.4	2,524	2,751,215	307	4,846,979
2016		125	173.1	2,640	2,677,311	371	4,436,854

2017		129	179.3	2,776	2,846,279	586	4,503,439
2018		133	179.0	2,917	3,794,800	4,542	4,886,174
2014	Europe	107	99.2	18,729	1,136,146	217	1,236,395
2015		107	116.4	19,154	897,249	133	3,240,499
2016		108	120.5	19,523	157,722	579	3,792,604
2017		110	120.2	19,987	225,862	313	2,551,840
2018		112	115.2	20,414	849,529	822	2,961,071
2014	Americas	116	12.4	1,533	1,994,225	246,771	3,981,540
2015	Columbia+	119	14.4	1,583	2,760,674	264,334	4,456,136
2016	Mexico	123	16.7	1,625	2,851,185	332,324	6,424,736
2017		130	16.3	1,658	2,572,023	330,666	3,947,305
2018		136	16.4	1,696	2,989,287	277,551	4,582,389
2014	MENA	123	5.2	391	238,756	53,404	1,476,022
2015	Tunisia	130	5.7	407	309,215	110,945	1,322,890
2016	Egypt	139	6.0	419	278,171	37,504	600,788
2017	Morocco	159	6.9	436	209,109	30,432	2,361,824
2018		173	6.5	454	565,836	11,799	1,514,586
2014	Asia subcontinent	139	62.2	2,470	44,995	594	167,144
2015	Pakistan	146	60.9	2,662	101,058	13,136	1,007,227
2016	India	153	60.3	2,848	146,761	7,812	1,377,486
2017	Bangladesh	159	59.2	3,036	237,797	7,603	1,295,515
2018		168	60.2	3,252	51,857	11,458	1,745,231
2014	ROW	117	99.8	17,017	4,305,293	399,771	15,231,307
2015		121	108.9	17,174	4,372,270	504,345	14,279,462
2016		127	113.3	17,365	4,198,764	401,744	14,249,048
2017		136	113.4	17,754	4,198,990	403,429	13,868,254
2018		169	112.0	18,143	4,209,871	517,925	15,311,213

Panel Data Used in Export Demand Mod

YEAR	REGION	REST OF WORLD SOYBEAN PRICE $/TON	REST OF WORLD SOYMEAL PRICE $/TON	REST OF WORLD SOY OIL PRICE $/TON	TREND VARIABLE #	U.S.- CHINA TRADE WAR INDICATOR VARIABLE #	US SOYBEAN PRICE $/TON
2014	China	563.90	565.09	1,319.21	1	0	469.58
2015		425.90	454.78	1,185.84	2	0	384.78
2016		405.00	424.80	1,102.05	3	0	393.96
2017		414.90	448.90	1,040.82	4	0	385.76
2018		379.44	494.48	2,741.25	5	1	378.76
2014	Japan	648.10	603.20	1,558.80	1	0	546.78
2015		525.50	481.30	1,526.60	2	0	437.36
2016		487.80	424.80	1,662.00	3	0	424.21
2017		465.60	403.00	1,892.40	4	0	423.43
2018		504.30	460.90	1,294.40	5	0	408.68
2014	Korea	634.80	560.50	965.70	1	0	515.72
2015		488.40	443.00	813.50	2	0	449.12
2016		449.70	388.20	777.10	3	0	436.38
2017		460.40	385.40	861.50	4	0	435.02
2018		469.30	415.10	823.90	5	0	390.77
2014	Taiwan	568.31	580.80	1,022.30	1	0	499.47
2015		433.70	614.00	759.90	2	0	429.19
2016		418.40	580.60	1,264.50	3	0	385.42
2017		422.80	593.60	1,480.70	4	0	404.81
2018		377.50	417.47	626.03	5	0	377.50
2014	SE Asia	585.47	565.86	1,053.05	1	0	520.20
2015		449.89	486.06	902.70	2	0	412.87
2016		418.69	402.88	854.89	3	0	393.90
2017		431.80	390.85	916.26	4	0	388.27
2018		427.27	428.80	884.37	5	0	377.72
2014	Europe	536.10	541.50	925.00	1	0	461.50
2015		412.30	420.60	750.70	2	0	381.45
2016		400.60	383.50	785.60	3	0	388.02
2017		406.50	375.20	836.40	4	0	377.69
2018		404.40	430.30	773.60	5	0	352.57
2014	Americas	532.03	605.94	1,541.85	1	0	508.69
2015	Columbia+	404.87	507.60	1,481.69	2	0	398.01
2016	Mexico	401.41	455.03	1,076.18	3	0	401.45
2017		398.78	418.96	914.62	4	0	402.53
2018		386.40	578.46	1,025.42	5	0	376.31
2014	MENA	458.30	283.53	991.02	1	0	480.60
2015	Tunisia	383.10	637.21	1,117.38	2	0	372.76
2016	Egypt	403.51	433.25	1,036.46	3	0	389.35
2017	Morocco	373.43	414.89	1,069.34	4	0	372.20
2018		358.94	435.21	1,041.02	5	0	357.06
2014	Asia subcontinent	788.73	576.12	1,662.08	1	0	502.35
2015	Pakistan	450.69	534.55	1,441.30	2	0	394.53
2016	India	519.78	506.11	987.87	3	0	391.52

2017	Bangladesh	502.92	417.68	1,221.68	4	0	373.51
2018		487.64	459.93	1,242.56	5	0	359.87
2014	ROW	565.66	575.12	996.38	1	0	481.49
2015		433.50	463.41	850.64	2	0	391.72
2016		420.30	414.99	830.43	3	0	395.16
2017		419.02	396.80	866.01	4	0	388.26
2018		435.34	414.51	823.24	5	0	369.37

Panel Data Used in Export Demand Models

YEAR	REGION	SOYMEAL PRICE $/TON	SOY OIL PRICE $/TON	SOYBEAN IMPORTS TONS
2014	China	566.8	876.70	30,827,882
2015		531.2	769.10	27,258,629
2016		390.6	723.90	36,051,023
2017		481.9	806.50	31,688,893
2018		475	1,827.50	8,235,317
2014	Japan	663	2,452.30	1,835,802
2015		506.2	2,302.50	2,395,079
2016		495.1	2,057.60	2,358,419
2017		429.2	2,534.10	2,299,038
2018		444.9	2,278.90	2,268,969
2014	Korea	557.2	740.10	693,909
2015		789.5	764.70	496,121
2016		656.9	815.00	520,684
2017		737.8	782.10	676,902
2018		558.7	744.00	837,727
2014	Taiwan	519.1	1,548.90	1,444,639
2015		564	1,753.00	1,346,229
2016		460.6	2,065.00	1,503,084
2017		524.1	3,013.40	1,447,092
2018		544.3	760.00	2,261,542
2014	SE Asia	521.9	1,026.80	3,523,281
2015		425.7	1,722.00	3,526,145
2016		390.6	1,788.30	4,979,146
2017		372	1,500.60	5,023,171
2018		405.7	801.30	6,280,389
2014	Europe	529.7	1,708.40	4,029,711
2015		436.6	2,807.80	4,974,733
2016		464.3	1,373.70	4,894,500
2017		429.6	1,774.80	4,333,373
2018		405.7	1,645.10	8,728,766
2014	Americas	532.2	941.60	3,865,715
2015	Columbia+	399.8	909.30	4,098,464
2016	Mexico	375.9	881.30	4,128,177
2017		362	837.50	4,437,258
2018		377.9	862.90	5,523,198
2014	MENA	532.435902	823.09	2,031,092
2015	Tunisia	434.7131482	762.20	1,533,123
2016	Egypt	347.2431176	696.01	1,312,136
2017	Morocco	343.4432219	772.38	2,092,623
2018		394.7377723	672.60	5,430,052
2014	Asia subcontinent	589.4641861	1,373.21	328,421

2015	Pakistan	447.3195953	772.52	1,103,703
2016	India	399.9089676	805.67	950,571
2017	Bangladesh	363.8825635	665.25	2,188,684
2018		435.195952	698.72	2,928,613
2014	ROW	539.3925064	950.89	4,852,008
2015		410.007822	881.61	5,517,809
2016		386.3894662	864.48	5,227,405
2017		361.4341916	849.29	5,511,675
2018		379.2676463	839.87	9,224,243