UPSTREAM TRANSMISSION EFFECTS OF GENERIC ADVERTISING AND

PROMOTION: THE CASE OF SOYBEANS

A Dissertation

by

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ABSTRACT

This dissertation aims at analyzing the effects of various assumptions that may affect the upstream transmission of the benefits of commodity checkoff programs. Despite the amount of econometric research on evaluation of the effects of checkoff programs for producer benefits, little empirical research has focused on the various simplifying assumptions often made in those analyses that may influence the rate and extent of the retail-to-farm transmission of generic advertising and promotion effects. The first part of this study is a qualitative analysis of the world soybean and soybean products markets. Then the conceptual model is proposed and discussed. A model of world soybean and soybean markets has been developed which relaxes all of the simplifying assumptions often made in analyses of commodity checkoff programs. The model is used to analyze the implications of those assumptions for the upstream transmission of the returns of the soybean checkoff program to producers.

After estimating the econometric parameters of the model, the model has been simulated over history as a means of model validation. Then the model has been simulated again assuming that the U.S. soybean checkoff program had not existed over history. The differences from the simulation results by the baseline simulation are considered as the base case against which all other simulation results are compared. The base case results indicate that the soybean checkoff program has been highly effective over the study period returning $6.9 in revenue to soybean producers for every checkoff dollar spent.

This upstream transmission of the benefits of the soybean checkoff program is analyzed through a series of simulations with the world soybean model in which the simplifying assumptions made by other checkoff program analyses. These are imposed on the model including the assumptions of no supply response, no price response, no government intervention, no free riders, no domestic supply chain linkages, no global supply chain linkages, no checkoff investments in production research and no promotion programs at multiple levels of the supply chain. The results of the scenario simulations provide the evidence that simplifying assumptions made in checkoff program analyses can seriously bias the calculation of the benefit-cost ratios (BCRs) for checkoff programs. Some assumptions have a tendency of overestimating the BCR for checkoff programs while others have a tendency of underestimating the BCR calculation. The implication of these findings is that analyses of checkoff programs must consider carefully the simplifying assumptions made to avoid seriously under- or over-estimating the returns of those programs to producers.

DEDICATION

This dissertation is dedicated to my wife, Yoon Jeong

You are the love of my life, my strength, and support.

I want to dedicate this to my son, Ayden

You have brought the most joy to my life and

Have been a source of great learning and healing.

I also want to dedicate this to my parents.

Thank you for all of your love, support, and sacrifice throughout my life.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Williams for guiding and supporting me over the years. Without him, the accomplishment of this dissertation would otherwise have remained a castle in the air. All along, he guided me to overcome all the problems and difficulties I encountered as a student and a researcher. It is unimaginable how much time and effort he had to spend to discuss, proofread and correct all my works. You have set an example of excellence as a researcher, mentor, instructor, and role model. Thanks to my committee members, Drs. Rosson, Salin, and Nixon for their guidance and support throughout the course of this research. Dr. Welch also contributed to this research, for which I am very thankful.

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CHAPTER I

INTRODUCTION

To enhance the profitability and competitiveness of the agricultural commodities they grow, producers of many agricultural commodities cooperatively invest in funding research and demand promotion programs, commonly known as "checkoff" programs. The promotion messages of many of these groups have become well known among American consumers. "Got Milk?" "Orange Juice: Healthy, Pure, and Simple." "Cotton: The Fabric of Our Lives." "Beef. It's What's for Dinner." "American Lamb from American Land." "Pork. The Other White Meat." These and other familiar promotion messages by various commodity groups are parts of the efforts of these groups to impact the demand for their agricultural commodities. Such messages are generic in nature and the system for funding them is referred to as commodity checkoff programs. There is some type of organization for nearly every agricultural commodity to enhance producer welfare. The funding comes from associated producers funded through fees on sales. Although the funds collected by checkoff groups are often used to promote demand through both generic advertising and the development of new uses of the associated commodities, many checkoff programs also fund research intended to reduce production costs and/or enhance yields (Williams and Capps, 2006).

The major strategic concern of commodity checkoff groups is that those who pay for the generic advertising and promotion programs operate at the front end of often lengthy supply chains while the consumers they hope to influence are downstream at the opposite end. To promote sales of their commodities, therefore, checkoff groups often advertise at the retail end of the supply chain to enhance demand under the assumption that sufficient benefits will migrate upstream to the farm level to more than cover the cost of the advertising and promotion. However, for commodities such as soybeans with lengthy supply chains, the retail-to-farm transmission of the effects of generic advertising and promotion is a major uncertainty. For this reason, the 1996 Farm Bill requires periodic evaluation of the effectiveness of and returns to federally mandated commodity checkoff programs.

The federal requirement to evaluate checkoff programs has spawned widespread analysis of these programs, many of which are reviewed in the following section. Most such studies have taken an econometric modeling approach and provide numerical measures of the impacts of checkoff programs on the demand and, to a much lesser extent, the supply of checkoff commodities along with some type of benefit-cost analysis. Although substantial scholarly effort has been devoted to examining farm level impacts, much of this literature is silent on the upstream transmission of generic advertising and promotion effects.

Wohlgenant (2006) discusses various factors that can influence the rate and extent of the retail-to-farm transmission of generic advertising and promotion effects, including (1) the supply response all along the supply chain to higher farm prices induced by generic advertising and promotion; (2) government intervention in supporting farm prices and influencing farm supply; (3) free-rider effects of imports; and (4) cross-commodity effects (the so-called "spillover" effects) of generic promotion. To this list could be added various other factors that can influence the upstream transmission of generic advertising and promotion effects such as the growing globalization of agricultural and food supply chains and the practice of many checkoff groups to simultaneously fund advertising and promotion at various levels in the supply chain (wholesale, retail, foreign markets) as well as supply-enhancing research.

Little empirical research has focused on the relationship between downstream checkoff promotion efforts and any resulting upstream benefits or the upstream transmission of such benefits. As Wohlgenant (2006) observes, most evaluations of checkoff programs make some assumptions about the share of the generic advertising returns that transmit from the retail level where checkoff promotion generally occurs upstream to producers with little concern for the assumptions that can affect the efficiency and effectiveness of transmission of those returns along the supply chain. Ignoring the effects of such assumptions on the upstream transmission of the benefits of generic promotion programs could have serious consequences for the measurement of the producer returns from checkoff programs. Research is needed to examine the extent of the impact of the many assumptions that can affect the upstream transmission of the returns to checkoff promotion, including those discussed by Wholgenant and others. Any significant impact of one or more of these assumptions on the upstream transmission of benefits would cast serious doubt on the efficacy of the returns to producers from checkoff promotion as reported by many studies of checkoff programs.

Purpose and Objectives

The overall objective of this dissertation is to examine the upstream transmission of checkoff programs with emphasis on the effects of specific assumptions that could affect the extent and effectiveness of the transmission of those effects from the market level where the promotion occurs through the supply chain to the farm level of the market. The soybean checkoff program will be the focus of the study for various reasons. First, the U.S. soybean market is an integral component of an extensive world soybean market that will allow the analysis to consider the global supply chain effects of the transmission of soybean checkoff expenditures in both domestic and foreign markets. Second, soybean checkoff expenditures are made at various levels of the market, including domestic wholesale and retail (soyoil and soymeal), processing (soybeans), foreign (soybeans, soymeal, and soyoil), and farm (soybeans) which will allow for an analysis of how the market effects of checkoff expenditures at different market levels interact and affect the transmission of benefits to producers.

Specifically, the objectives of this study include the following:

(1) Develop a simultaneous, non-spatial price equilibrium, econometric simulation model of world soybean and soybean products markets that includes adequate disaggregation to account for the markets effects of the U.S. soybean checkoff program by country (exporting and importing), by commodity (soybeans, soymeal, and soyoil), by market level (farm, wholesale, retail, international), and by market activity (production, consumption, prices, etc.);

(2) Develop a database of soybean checkoff expenditures over time which is disaggregated by country (exporting and importing), by commodity (soybeans, soymeal, and soyoil), by market level (farm, wholesale, retail, international), and by promotion activity (production research, domestic promotion, and international market promotion);

(3) Use the world soybean model and accompanying checkoff expenditure database to econometrically measure the relationship between the demand for soybeans and products in the U.S. and foreign markets and promotion expenditures in those markets as well as between soybean production by region in the United States and soybean research expenditures funded by the soybean checkoff program.

(4) Validate the econometric world soybean model including the effects of the soybean checkoff program through historical simulation over the period of 1980/81 (the earliest year for which soybean checkoff data are available) though 2012/2013 to determine how closely the model tracks history as determined by various validation statistics such as the Theil inequality coefficients, the Theil decomposition coefficients, root mean squared error, etc.

(5) Use the validated world soybean and soybean products simulation model to simulate the removal of U.S. soybean checkoff promotion expenditures to measure the effects of those expenditures over time on U.S. and world soybean markets, including the effects on soybean and soybean product production,

processing, consumption, prices, trade and world market share of the U.S. and its major export competitors.

(6) Use the results of the historical simulation of the removal of the soybean checkoff expenditures to measure the overall returns transmitted to U.S. soybean producers from U.S. soybean checkoff programs over time.

(7) Conduct various scenario analyses with the model of world soybean markets intended to isolate and compare the effects of various assumptions that could affect the transmission of the returns of the soybean checkoff program to soybean producers, including all of the following and compare those results to the standard share-of-the-retail-dollar assumption often made in studies of checkoff programs:

  (a) the effects of no supply response;

  (b) the effects of no price response;

  (c) the effects of no government intervention in supporting farm prices and influencing farm supply;

  (d) no free-rider gains to Brazil and Argentina;

  (e) no domestic supply chain effects;

  (f) no global supply chain effects;

  (g) no checkoff investments in production research (only in demand promotion), and

  (h) no promotion programs at multiple levels of the supply chain (promotion occurs at only the retail level of the market).

Literature Review

A large number of studies of the effectiveness of the generic advertising and promotion efforts of commodity checkoff programs have been done over the years. For example, domestic and/or international promotion programs have been found to have a positive and significant benefit for U.S. producers for various livestock products (see, for example, Rosson, Hammig, and Jones 1986; Halliburton and Henneberry 1993a; Halliburton and Henneberry 1995b; Goddard and Conboy 1993; Le, Kaiser, and Tomek 1997; Comeau, Mittelhammer, and Wahl 1997; Chung and Kaiser 1998; Ward 1999; Kinnucan 1999; Davis et al. 2001; Capps and Williams 2008; Williams, Capps, and Dang 2010), tobacco (Rosson, Hammig, and Jones 1986), peanuts (Halliburton and Henneberry 1993b), almonds (Halliburton and Henneberry 1995a; Kinnucan and Christian 1997), raisins (Kaiser, Liu, and Consignado 2003), pecans (Onunkwo and Epperson 2000; Moore et al. 2009), grapefruit (Fuller, Bello, and Capps 1992), apples (Richards, Ispelen, and Kagan 1997), citrus fruit (McClelland, Polopolous, and Myers 1971; Lee, Myers, and Forsee 1979; Armah and Epperson 1997; Williams, Capps, and Bessler 2004; Williams, Capps, and Palma 2008), cotton (Ding and Kinnucan 1996; Kinnucan, Xiao, and Yu 2000; Beach et al. 2002; Capps and Williams 2006), rice (Rusmevichientong and Kaiser 2009), wheat (Halliburton and Henneberry 1995b; Henneberry and Lu 2000; Adhikari et al. 2003), and soybeans (Williams, Myers, and Callaham 1982; Williams 1985; Williams 1999; Lim, Shumway, and Love 2000; Williams, Shumway, and Love 2002; Williams, Capps, and Bessler 2009) to list only a few.

The majority of these studies have used three types of econometric models: (1) single demand equation, (2) demand system, or (3) structural system. Each model type has both advantages and disadvantages.

The objective of the single demand equation studies is to derive a direct measure of the effect of promotion on the relevant demand variable. For example, using a set of single export demand equations for U.S. frozen concentrated orange juice for France, United Kingdom, Germany, Japan, and Netherlands, Armah and Epperson (1997) found a statistically significant export demand response to U.S. foreign advertising of orange juice. Kaiser, Liu, and Consignada (2003) developed single equation raisin import demand models and found a statistically significant effect of the California raisin industry's export promotion programs in Japan and in the United Kingdom. Rusmevichientong and Kaiser (2009) conducted an analysis of the responsiveness of U.S. rice export demand with respect to U.S. rice export promotion. From their single demand equation estimation, they found that rice promotion expenditures have a positive and statistically significant impact on U.S. rice exports to the world market. Schmit and Kaiser (1998) examined the effectiveness of generic egg advertising in the U.S. demand. Generic advertising were found to have positively and significantly affected per capita egg demand. Capps and Williams (2008) conduct an analysis of the effectiveness of the lamb advertising and promotion program of the American Lamb Board using a single lamb demand equation. Their statistical results indicate that the lamb checkoff program has had a positive and significant impact on U.S. lamb demand.

Unfortunately, the single equation model has a limitation since it is restricted to one particular market and assumes no price response. For example, if South Korean soybean import demand increases as a result of foreign promotion expenditures, the increase in demand would be expected to lead to a higher price of soybeans in South Korea that would lead to some reduction in the total increase in South Korean soybean import demand. However, if the model used is a single equation demand function, then the price is assumed to be exogenous so that the measured increase in soybean demand distorts the effect of promotion because the price effects on demand are not taken into account. In essence, such models assume a perfectly price elastic supply of the commodity.

If, however, the supply of the commodity is actually price inelastic, then promotion can lead only to a price increase. The use of a single equation demand model in this case would lead to the erroneous conclusion that promotion leads to a quantity increase when, in fact, the promotion would more likely lead to a price increase rather than a quantity increase. Because the single equation model only accounts for the demand for a commodity in a single market rather than the whole supply chain, any non-zero supply response of producers, government intervention, free-rider effects are ignored.

In demand system models, the objective is to measure the effect of promotion on commodities that are closely related in demand. For example, Comeau, Mittelhammer, Wahl (1997) investigated the effectiveness of advertising and promotion efforts in Japanese markets for meats by using an inverse almost ideal demand system. Richards, Ispelen, and Kagan (1997) used a two-stage almost ideal demand system to investigate the effectiveness of export promotion in increasing both the total consumption of apples in import markets of Singapore and the United Kingdom as well as the U.S. share of exports to those markets.

Although demand system models account for cross commodity and potential spillover effects, the measurement of the effects of promotion using such models is still problematic because supply is still assumed to be exogenous. Consequently, any price effects and price-induced supply response are still ignored. Demand systems also typically fail to account for the transmission of benefits up the supply chain and the complications of government intervention in commodity markets.

Structural, supply chain models, however, attempt to correct for the deficiencies of single demand and demand system models by explicitly modeling the supply response and market linkages from the retail to the farm level of the commodity market of interest, including international trade and price linkages. Few studies have taken a structural, supply-chain approach to measuring the effects of checkoff programs. Williams (1985) was among the first to apply this approach using a 96-equation econometric simulation model of world soybean and product markets that accounted for the supplies, demands, prices, and trade of whole soybeans, soymeal and soyoil in the United States and seven other major trading regions of the world to measure the effects of the soybean checkoff program. Updated versions of the model have been used for subsequent analyses of the U.S. soybean checkoff program (Williams 1999; Williams 2012; Williams, Shumway, and Love 2002; Williams, Capps, and Bessler 2009; Williams et al. 1998). The structural, supply chain approach has also been used to analyze the checkoff programs for cotton (Williams and Capps 2011), orange juice (Williams, Capps, and Bessler 2004), and pork (Davis et al. 2001).

Although several studies have estimated the impacts of generic advertising and promotion efforts of commodity checkoff programs, as Wohlgenant (2006) observes, research has not focused on the retail-to-farm price transmission process in estimating the rates of return to these programs. To date, the effects of the various assumptions that may affect the upstream transmission of the benefits of commodity checkoff programs have not been empirically analyzed. This study is an attempt to specifically address this gap on the literature.

Organization of Remaining Chapters

The remainder of this dissertation is organized as follows. Chapter II will provide a background, descriptive analysis of the soybean and soybean product industries of key exporting and importing countries and regions with a focus on the agricultural policies of each region. Chapter II will also provide an historical overview of the generic advertising and promotion administered by the U.S. soybean checkoff program.

Chapter III will propose and discuss the conceptual model, data, and other relevant conceptual issues. In that chapter, the effects of the generic advertising and promotion on U.S. soybean producers will be examined graphically. One of the contributions of this dissertation is the development of the world soybean model capable of incorporating the related various assumptions that could affect the transmission of the returns of the soybean checkoff program of each region. The background analysis in Chapter II will help inform the model development.

Chapter IV will provide and discuss the econometric simulation model based on the conceptual model developed in the preceding chapter. Chapter IV will discuss the results of econometrically estimating the parameters of the model. This chapter will also discuss the model validation statistics.

Chapter V will use the econometric model of world soybean markets developed in the previous chapter to simulate and compare the effects of various assumptions that could affect the transmission of the returns of the soybean checkoff program to soybean producers. Chapter VI will include a summary and conclusions of the study and recommendations for future research.

CHAPTER II

BACKGROUND

Soybeans have been a major source of protein supply in East Asia for more than 3,000 years. After the 15th century, soybean cultivation spread from East Asia to much of the rest of Asia, including Japan. In the 18th to 19th centuries, cultivated soybeans were introduced into America and Europe. Before the middle of the 20th century, soybeans were mostly used for food in Asian countries while soybeans were used in whole form primarily as an animal food and a cover crop in non-Asian countries. After the middle of the 20th century, soybean production began to grow in North and South America due to the growth of feed demand. Over the last 50 years, the cultivation of soybeans in the U.S., Brazil, and Argentina increased dramatically. Consequently, these three countries have become the major soybean producers and exporters in the world.

As economic growth has occurred in Asia over the last several decades, the demand for soybean meal in that region for use as a protein feed ingredient to support the rapidly growing livestock inventories and for soybean oil as a cooking medium has also increased substantially. The growth in soybean production in these countries over the years, however, has been insufficient to meet the demand. With the opening of China's market to soybean and soybean products trade in 1995/96, liberalization of world trade under the Uruguay Round Agreement beginning in 1994, and the accession of China to that trade agreement in 2001, Asian soybean imports began to increase dramatically. China has become the world's largest soybean importing country. Japan is also a major Asian soybean importer. The EU-27 is the world's second largest soybean importing country and the largest soymeal importing country given its small soybean production compared to the high demand for feed in the country.

The U.S. Soybean Industry

Before mid-1980s, the U.S. essentially dominated world soybean markets. However, the U.S. share of world soybean exports has decreased in recent years primarily due to increased soybean exports from its South American competitors, Brazil and Argentina. While the U.S. has been the world's top soybean producing country, the general trend in recent years has pointed toward Brazil eventually surpassing the United States, hastened by the 2012 drought that had devastating effects on U.S. soybean production. While Brazilian spring 2013 production of soybean surpassed the U.S. 2012 fall crop, the U.S. will likely return to its previous dominance of the market in the short run. However, over time, U.S. farmers will likely be unable to keep up with the rate at which Brazilian producers are expanding the acres devoted to soybeans. Over the next decade, Brazilian production may well permanently exceed that of the United States. The U.S. is currently the second largest producer of both soymeal and soyoil in the world. Although the U.S. soybean export market share has decreased in recent years, U.S. soybean exports have gradually increased due to the growth of world soybean demand since 1980 (Figure 1).

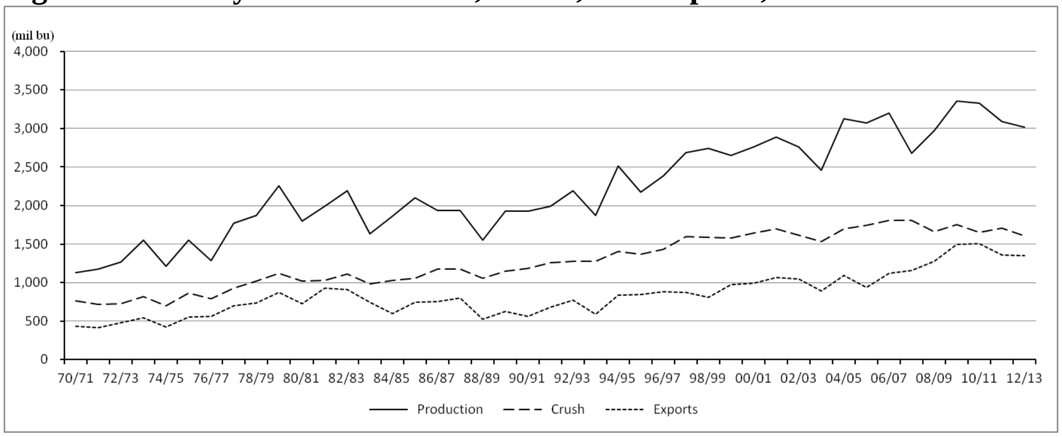
The EU-27, Japan, and China are major buyers of U.S. soybeans. The U.S. share of global exports has substantially diminished in recent years mainly because importers are increasingly switching sources of soybean supply from the U.S. to South American suppliers. At the same time, the recent expansion of U.S. soyoil demand for biofuel production and stable growth in domestic livestock feed demand have focused the U.S. soybean industry increasing on growing domestic needs and limited the supplies of soybeans, soymeal, and soyoil for export.

U.S. Soybean Supply and Demand

Soybeans were introduced into the Cornbelt in the mid-1760s. Soybeans were not a major crop until World War II. At the time, soybeans were largely a nitrogen-fixing rotation crop that was grazed off by livestock. Nevertheless, planted area and production of soybeans gradually increased during the 1920s and 1930s. By 1939, soybean production had reached 90 million bushels. U.S. soybean production dramatically increased during World War II and largely replaced imported fats and oils (Hymowitz 1990). U.S. soybean production jumped from 78 million bushels in 1940/41 to 107.2 million bushels the next year and then 187.5 million bushels in the following year. Prior to 1940, soybean harvested area was less than half of the planted area but increased to 80% ~ 90% in subsequent years.

A continuation of area and yield growth during the 1950s boosted U.S. soybean production from 283.8 million bushels in 1951/52 to 555.1 million bushels in 1960/61. Between the 1960s and the mid-1990s, the U.S. was the unrivaled world exporter of soybeans (Nakajima 2011). U.S. soybean area planted and production grew substantially during 1960s and 1970s. Over that period, U.S. soybean planted area increased three fold from 24.4 million acres in 1960/61 to 71.4 million acres in 1979/80. Over the same period, soybean production increased from 555 million bushels to 2,261 million bushels.

Figure 1. U.S. Soybean Production, Crush, and Exports, 1970/71-2012/13



Source: USDA/NASS 2013; USDA/ERS 2013

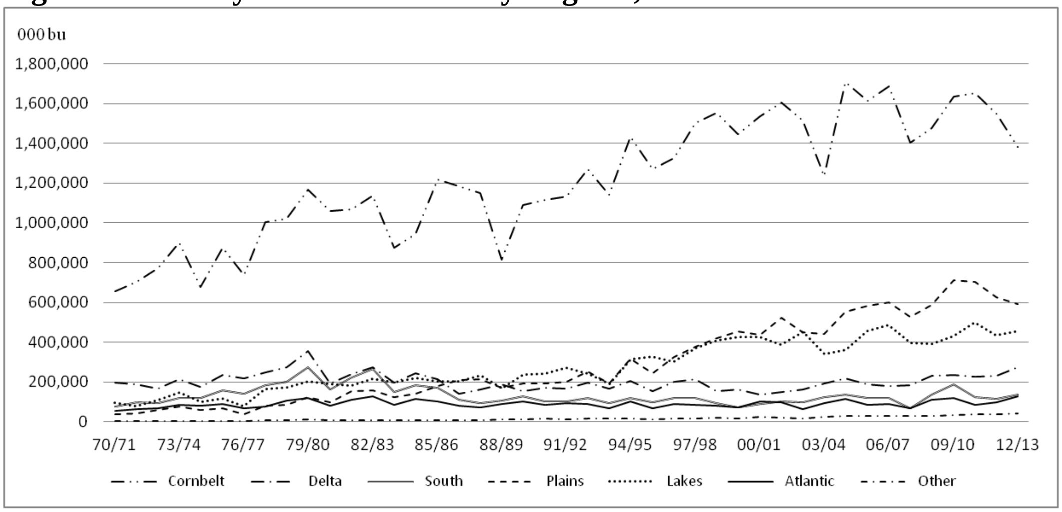
During the 1980s, U.S. soybean planted area stagnated due to farm programs (on the 1981 and 1985 farm bills) which did not include soybeans as program crops but did include the major competing crops like corn and other feed grains, cotton, rice, and wheat under farm programs (Ash, Livezey, and Dohlman 2006). The result was an incentive for farmers to switch from soybeans to program crops. Beginning in the early 1990s, U.S. soybean planted area and production increased as world demands for both soybeans and soybean products were growing. The Federal Agriculture Improvement and Reform Act (1996 Farm Bill) eliminated planting restrictions on crop bases allowing soybean farmers to respond to the growth of soybean prices by expanding soybean plantings (Ash, Livezey, and Dohlman 2006).

Moreover, biotech soybeans were commercially introduced in 1996 and spread rapidly throughout the United States. The introduction of biotech soybeans reduced production costs and improved weed management in the rotation of crops, the result was a further increase in soybean area (Ash, Livezey, and Dohlman 2006). Currently, biotech soybeans occupy more than 90 % of total U.S. soybean production. Since 2000, soybean area planted area has stagnated to a large extent but soybean production has increased slightly due to the some yield growth.

Currently, soybeans are the second most planted field crop in the United States. In 2012/13, U.S. soybean planted area was 77 million acres across 31 states. Total soybean production at 3,015 million bushels. The Cornbelt (Illinois, Indiana, Iowa, Missouri, and Ohio) is by far the largest soybean production region in the U.S. at 1,382 million bushels, followed by the Plains states (Kansas, Nebraska, North Dakota, and South Dakota) at 593 million bushels, the Lakes states (Michigan, Minnesota, and Wisconsin) at 457 million bushels, the Delta states (Arkansas, Louisiana, and Mississippi) at 275 million bushels, the South states (Alabama, Florida, Georgia, Kentucky, Oklahoma, Tennessee, and Texas), the Atlantic states (Delaware, Maryland, North Carolina, South Carolina, and Virginia) , and the Other states (New York, New Jersey, Pennsylvania, and West Virginia) (Figure 2). Iowa is the largest soybean producing state (414 million bushels) with Illinois close behind (384 million bushels).

Favorable weather conditions, the spread of biotech varieties of soybeans, and the expansion of corn-soybean rotation in the mid-1990s have significantly increased soybean planting and soybean production in traditional feed grain states (Cornbelt, Plains, and Lakes). Soybean production in the Plains and Lakes regions has increased particularly sharply since the mid-1990s. Soybean acreage expansion in these regions has come largely at the expense of wheat and corn production.

Figure 2. U.S. Soybean Production by Regions, 1970/71-2012/13



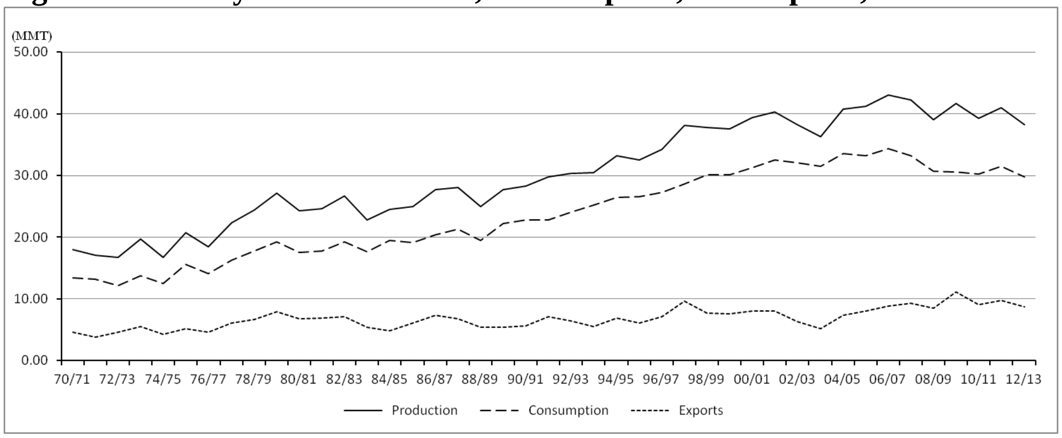
Source: USDA/NASS, 2013

U.S. Soymeal

Soymeal production in the U.S increased steadily until the mid-2000s (Figure 3). Soymeal became an important product in livestock and poultry production following World War II as the most cost-effective source of protein for balanced feed ration production. The growth in domestic meat consumption stimulated the increase in soymeal production over the years. Approximately 70% to 90% of soymeal production has been used for domestic consumption with the rest being exported (Figure 3).

Soymeal exports showed substantial growth beginning in 1997/98 due to the growth of soymeal imports by China. Since the mid-2000s, growth of soymeal consumption and production stagnated due to weakening feed demand.

Figure 3. U.S. Soymeal Production, Consumption, and Exports, 1970/71-2012/13

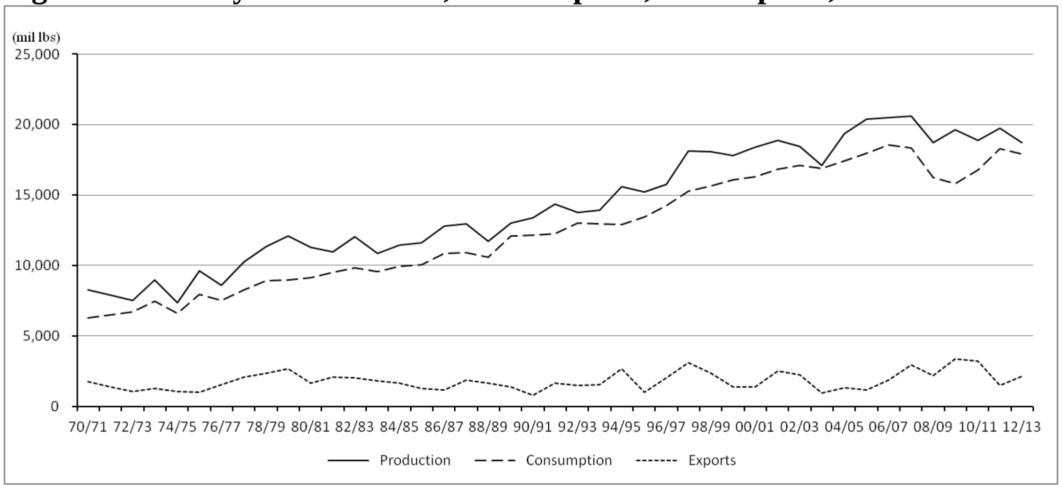


Source: USDA/ERS, 2013

U.S. Soyoil

Most soyoil produced in the U.S. has been used for domestic consumption over the years. Since the 1970s, a steady growth in soyoil demand has pushed soyoil production steadily upwards from 6,292 million lbs in 1976/77 to almost 20,580 million lbs in 2007/08 (Figure 4). A surge in soybean export demand which limited soybean supplies available for crushing limited the production of soyoil and pushed up the soyoil price. At the same time, strong soyoil export demand contributed to the higher domestic price of soyoil and reduced domestic consumption. The U.S. soyoil consumption recovered to 18,300 million lbs in 2011/12. The U.S. soyoil exports have fluctuated for decades between approximately 1,000 and 3,500 million lbs. The share of soyoil production accounted for by exports decreased from 21 % in 1970/71 to 7.4 % in 2011/12.

Figure 4. U.S. Soyoil Production, Consumption, and Exports, 1970/71-2012/13



Source: USDA/ERS, 2013

Biodiesel policies have had an important effect on domestic soyoil consumption (Ash, Livezey, and Dohlman 2006). The nationwide and statewide mandates for biodiesel use were implemented in 2005. The tax incentive for biodiesel production using new vegetable oil was also implemented in the same year. The bioenergy program also subsidized the use of soyoil for producing biodiesel.

U.S. Soybean Policies

Soybeans were a minor crop in U.S. until tWorld War II, thus there were not particular policies for soybeans. During World War II, the increase of soybean acreage was encouraged by high support prices (Goldberg 1952). Soybean prices were supported by simple nonrecourse loans at the farm level (Houck, Ryan and Subotnik 1972). A loan program was the only soybean program for farm price support until early 1990s but the market price was mostly higher than the loan rate (Goldberg 1952; Cochrane and Ryan 1976).

After the early 1990s, the U.S. government made efforts to assist in the development of new markets for soybeans and soybean products. As part of the 1990 Farm Bill, the Soybean Promotion, Research, and Consumer Information Act became effective in 1991. The Act allowed establishment of a national soybean checkoff program through which soybean producers invest in promoting both foreign and domestic demand for soybeans and soybean products (Williams, Shumway, and Love 2002). Soybean checkoff dollars have also been invested in production research to enhance yields and reduce costs.

A loan program for soybeans added marketing loans to existing nonrecourse loans under the 1990 Farm Bill. The marketing loan program that provides payments to cover the difference between the market price and the loan rate (when market price falls below the loan rate) was extended to soybeans (Ash 2001). The 1996 Farm Bill, the Federal Agriculture Improvement and Reform Act, provided acreage flexibility to farmers by introducing fixed payments and eliminating acreage set-aside requirements. As a result, farmers are more able to shift production out of other crops and into soybeans more effectively as market conditions change. Under the 2002 Farm Bill, the Farm Security and Rural Investment Act of 2002, soybean farmers became eligible for direct payment (DP) and countercyclical payments (CCP).

The 2008 Farm Bill, the Food, Conservation, and Energy Act of 2008 reformed U.S. agricultural policy to provide farmers almost complete planting flexibility in deciding which crops to plant (De Gorter 2012). A loan program, direct payment, and countercyclical payments are major policies related to soybeans. The payment rate for soybeans used to make direct payments was $0.44 per bushel. The payment rate used to make countercyclical payments is equal to the difference between the target price ($6.00/bushel) and the effective price. The effective price is equal to the sum of the payment rate ($0.44/bushel) of direct payments and the higher value between the national average market price received by producers during the 12-month marketing year and the national average loan rate for a marketing assistance loan. Currently, the national soybean loan rate for soybeans is $5.00/bu.

Factors influencing Competitiveness in U.S. Soybean Industry

One of the most important challenges in U.S. soybean sector is the emergence of Brazil and Argentina as major competitors to U.S. soybeans in export markets. As mentioned above, major soybean importers have switched the source of at least some of their soybean imports from the U.S. to South American countries. As a result, the U.S. shares of global soybean and product exports have declined substantially over the years.

` In addition to growing competition in export markets, border measures against the importation of biotech soybeans by major soybean importing countries are a major challenge to the U.S. soybean industry. The EU-27 has implemented a zero-tolerance policy on the import of unauthorized biotech soybeans. China requires a safety certificate for each shipment of biotech soybeans. Since most of U.S. soybeans are biotech soybeans, these import policies are limiting the growth of U.S. soybean exports.

Current negotiations under WTO may affect U.S. soybean production. According to proposals coming out of the Doha Development Round, trade-distorting farm program payments will need to be further reduced. For the U.S. soybean sector, this means that policies such as marketing loans and CCPs may need to be modified. At the same time, tariffs on imports of U.S. soyoil and soymeal in import countries would need to be further reduced under a new WTO agreement that would benefit the U.S. soybean sector.

The Brazilian Soybean Industry

In 2011/12, Brazil is the third largest soybean producer in world soybean markets. Brazil is the third largest producer of both soymeal and soyoil in the world. In world soymeal markets, Brazil is currently the fourth largest consumer behind China, EU-27 and the U.S. Brazil is also the third largest consumer of soyoil behind China and the U.S. Between 2001/02 and 2011/12, Brazilian soybean exports grew more rapidly (150%) than those from the U.S. and Argentina, Brazil’s main export competitors.

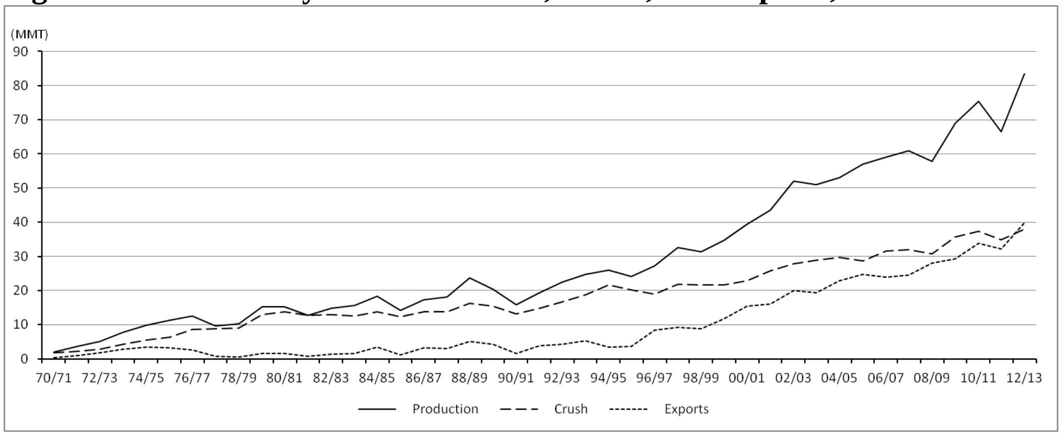
China is Brazil’s largest soybean market, accounting for 67% of total Brazilian soybean exports volume (Salin 2012). Powered by favorable prices and surging demand in for feed in China, its imports of Brazilian soybeans also increased dramatically since 2001/02. Total Brazilian soymeal exports also increased over the period, because of the increase in animal feed demand in the EU, South Korea and Vietnam (USITC 2012).

The EU-27 imports about 70% of Brazilian soymeal. China is Brazil's largest soyoil buyer, accounting for 36% of total Brazilian oil exports in 2011(USITC 2012).

Brazilian Soybean Supply and Demand

Soybeans were brought to Brazil in 1882 by agronomic professor Gustavo Dutra. Two decades later, soybean plantations were introduced into the state of Rio Grande do Sul. (Shurtleff and Aoyagi 2009). The marginal profitability of soybean cultivation restrained the growth of soybeans in Brazil until the 1960s when soybeans were determined to be a suitable crop to plant in rotation with winter wheat. In the early 1970s, El Niño negatively affected the anchovy catch in Peru, reducing the world supply of fish meal, a common protein supplement in livestock rations. At the same time, U.S. soybean production declined sharply due to adverse weather conditions. Facing a sharp increase in the price of soybeans and panic buying particularly by Japanese soybean importers, the U.S. government banned the export of soybeans in 1973 to avoid a domestic shortage. As a result, foreign buyers turned to Brazil to meet their soybean demand requirements. Since the 1980s, soybeans have become a key Brazilian agricultural crop. Brazilian soybean production experienced remarkable growth between 1980/81 and 2011/12 from 15.2 mmt to 66.5 mmt (Figure 5).

Figure 5. Brazilian Soybean Production, Crush, and Exports, 1970/71-2012/13



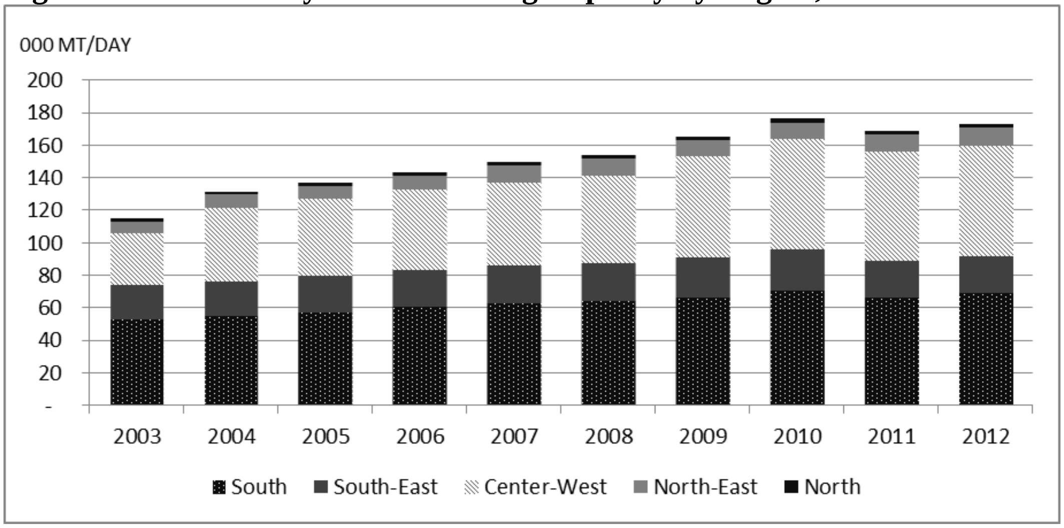
Source: USDA/FAS, 2013

Favorable conditions in international markets and aggressive support policies of the Brazilian government, such as production subsidies and credit incentives, have been the major factors in rapid growth of soybean production in Brazil. Another factor contributing to expansion of soybean production in Brazil was the development of a tropical soybean seed that flourishes in the tropics' shorter day length and wet climate. EMBRAPA (Empresa Brasileira de Pesquisa Agropecuária), a quasi-governmental agency established in 1975, conducted systematic research to develop soybean cultivars with high yields in regions close to the equator. EMBRAPA's research effectively lowered production costs and encouraged the expansion of soybean output in Brazil (Vieira and Williams 1996). Until the mid-1970s, soybean production gained spread primarily in the South and Southeast regions of Brazil that encompass the states of Rio Grande do Sul, Paraná, Santa Catarina, and São Paulo. With favorable soybean market price and introduction of a tropical soybean seed, expansion of soybean cultivation into the Central Brazil region which includes the states of Mato Grosso do Sul, Mato Grosso, Goiás, and the Distrito Federal began in the late 1970s (Vieira and Williams 1996). Since that time, most soybean area expansion in Brazil has occurred in this Central Brazil region. In 2010/11, soybean production in the Central Brazil region represented 45% of the soybean area in Brazil (Salin 2012).

In recent years, distances, lack of infrastructure, transportation costs, political backlash on the continuing deforestation of the Amazon have become obstacles to continued expansion of soybean production in this region, especially Mato Grosso. Consequently, most of the Brazilian soybean area expansion in recent years has taken place in the Northeast region comprised of the states of Maranhão, Tocantins, Piauí, and Bahia (referred to as MATOPIBA). According to Salin (2012), these areas have benefits compared to the Central Brazil region, including close proximity to the coastline and the lack of rainforests. The principal soybean producing states in 2010/11 were Mato Grosso (27.1%), Paraná (20.5%), Rio Grande do Sul (15.4%), and Goiás (10.9%).

Brazil is the third largest processor of soybeans in the world behind China and the U.S. Brazil's soybean processing capacity has increased from 110,560 mt per day in 2002 to 173,441 mt in 2012 (ABIOVE 2012). The processing industry was concentrated in the Southern states of Rio Grande do Sul, Paraná, and Santa Catarina in 1992, with over 60 % of the total oil extraction capacity (Vieira and Williams 1996). In 2012, the processing capacity in the southern region is only 39.8% of total processing capacity in Brazil while the processing capacity in the Central Brazil region jumped to 39% from only 17% in 1992 (Figure 6).

Figure 6. Brazilian Soybean Processing Capacity by Region, 2003-2012

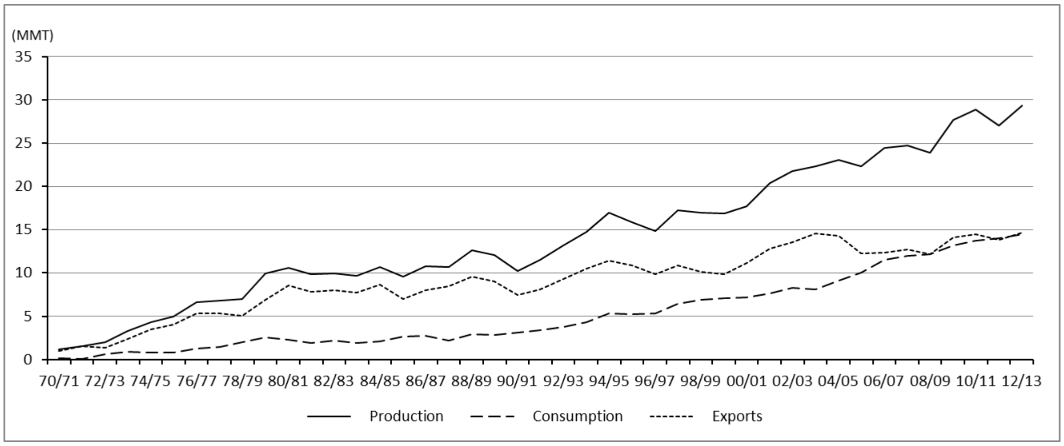


Source: ABIOVE, 2012

Brazilian Soymeal

Soymeal production in Brazil has increased steadily over the last four decades. During the 1970s and 1980s, approximately 20% of Brazilian soymeal production was used for domestic consumption and the rest was exported. Brazilian economic growth and expansion of the Brazilian livestock industry have increased the consumption share of total soymeal production from 30.5% in 1990/91 to 49.4% in 2012/13 (Figure 7).

Figure 7. Brazilian Soymeal Production, Consumption, and Exports, 1970/71-2012/13



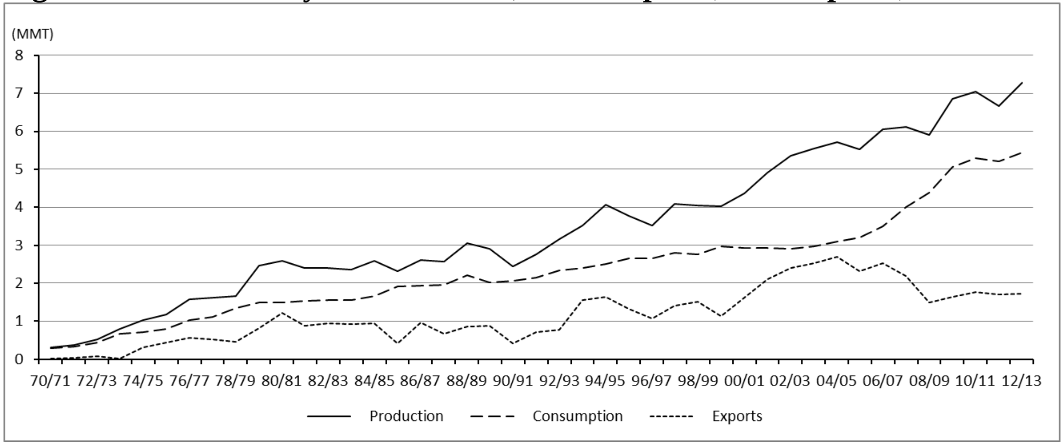
Source: USDA/FAS, 2013

Brazilian Soyoil

Since 1970/71, soyoil production in Brazil has steadily increased from 0.31 mmt to almost 7.3 mmt in 2011/12. Brazil is one of the major soyoil consumers in the world. Soyoil has been widely used as edible oil for cooking and salad dressings and in the manufacture of food products in Brazil.

Brazilian exports of soyoil also steadily increased until the mid-2000s, reflecting increasing world soyoil demand during that period (Figure 8). Subsequently, however, Brazilian soyoil export growth was limited by expanding domestic use as a result of sharply rising biodiesel production in Brazil (USAD/FAS 2008). A 3% biodiesel blend has been mandatory in Brazil since 2008. The proportion of Brazilian soyoil production used for domestic purposes increased from 53.5% in 2004/05 to 78% in 2011/12.

Figure 8. Brazilian Soyoil Production, Consumption, and Exports, 1970/71-2012/13



Source: USDA/FAS, 2013

Brazilian Soybean Policies

The Brazilian government introduced several policies to support expansion of the soybean industry such as agricultural research to boost soybean yields and the minimum price guarantees. The minimum price guarantee for soybeans lasted until 1995. The price guarantee policy contributed to supporting soybean farmers in Midwest regions who face high costs of transporting beans to Brazilian ports where the majority of processors were located. Between the mid-1960s and the 1970s, an aggressive Government agricultural credit incentive program which provided production credit at low interest rates was implemented to support farm income and to enhance exports (Vieira and Williams 1996). However, the overall size of the credit program was sharply reduced at the mid-1980s (USITC 1987).

In the late 1970 s and early 1980s, a devaluation of the Brazilian cruzeiro combined with a soybean export quota provided a strong incentive for Brazil to export soyoil and soymeal rather than soybeans (FAO 1984). The Brazilian government intensified restrictions on soybeans export. Restrictions on soybeans export were aimed to ensure adequate supplies of soybean products for the domestic market and to enhance the acquisition of foreign currency. Brazilian government intended to maximize export earning though the export quota on soybeans and the relatively low export taxes on soymeal and soyoil, compared with domestic sales taxes on both soybean products.

After the end of military rule in 1985, the Brazilian government reformed agricultural policies in an attempt to assist small farmers and domestic consumers rather than the export industry (Schnepf, Dohlman, and Bolling 2001). Nevertheless, soybean production and exports in late 1980s increased significantly. During the early 1990s, a number of negative factors such as the appreciation of the Brazilian cruzeiro and the abolition of the national farm price guarantees impacted the Brazilian soybean industry (Vieira and Williams 1996). At the same time, the international prices of soybeans and products declined and the value-added tax on exports increased. After the late 1990s, Brazil began to slowly reduce or eliminate government intervention in soybean markets resulting in a decline of government support to Brazilian soybean producers. Brazilian government support for agricultural production is currently low compared to that of other major agricultural producing and exporting countries (USITC 2012).

Brazil's complex tax system influences the Brazilian soybean supply chain. The Tax on Circulation of Goods and Services (ICMS) is the most important tax on Brazilian soybean products. The tax rate varies depending on the state and differentiates between primary and processed agricultural products, normally varying between 7% and 12% of the total value of soybean products (USITC 2012). Before 1996, the ICMS applied to all soybeans and soybean products include exports. However, the tax on exports was eliminated by the 1996 Kandir Law (Vieira and Williams 1996). Even so, the ICMS was maintained on domestic sales of soybeans, soymeal and soyoil implying a disincentive to sell soybean products for domestic consumption and an incentive to export them. The ICMS must be paid when soybeans cross state lines even if the processed soybean products (soymeal and soyoil) are exported at a later date, therefore, soybean processing facilities are located in the state in which soybeans are grown to avoid paying the tax (USITC 2012).

Factors influencing Competitiveness in Brazilian Soybean Industry

Brazilian soybean production costs (17-18 cents/kg) in 2010 were estimated to be only 57% to 61% of U.S. costs (30 cents/kg) that year (USITC 2012). Land and seed costs in Brazil are relatively low compared to those costs in competing countries, however, higher inland transportation and freight costs are a competitive disadvantage for soybean producers in Central Brazil who are farther from ports and major domestic markets than producers in the southern region (USITC 2012). To deal with this problem, the Brazilian government has been working on a Growth Acceleration Program together with a National Plan of Logistics and Transportation (PNLT) for the period 2008-2023 to improve the transportation infrastructure that supports soybean production and distribution.

The Argentine Soybean Industry

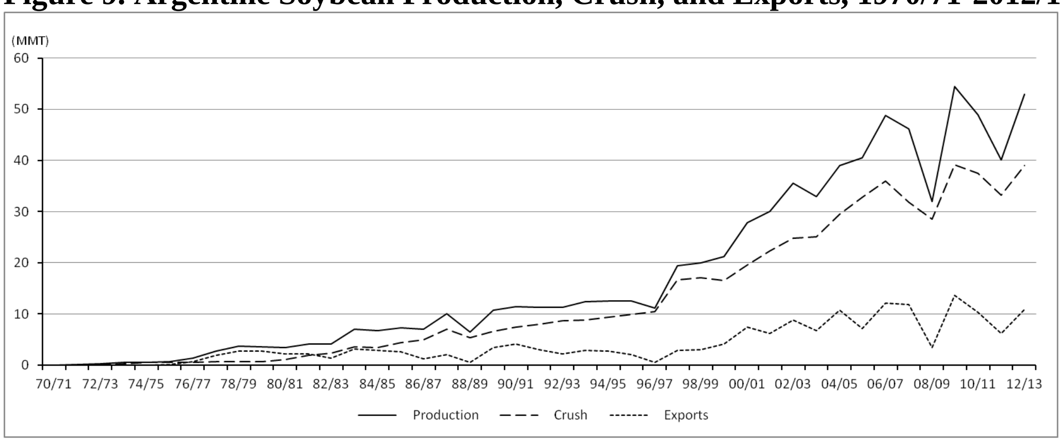
Soybean production in Argentina began to increase rapidly in about the mid-1990s, growing more than 220 % between 1995/96 and 2011/12. Argentina is currently the world's third largest producer of soybeans and the third largest producer of both soymeal and soyoil in the world. Although it is also currently the third largest soybean consumer behind China and the U.S., Argentina is also the third the largest exporter of soybeans. China is the largest importer of Argentine soybeans and soyoil. From 2001/02 to 2011/12, soybean crush in Argentina has increased from 20.9 mmt to 35.9 mmt while Argentine soybean exports have increased from 6 mmt to 7.4 mmt (Figure 9). In 2011/12, 18.4 % of Argentina's soybean production was exported. Exports account for 55.4 % of Argentine soyoil production and 93.2 % of Argentine soymeal production (Figure 10; Figure 11).

Argentine Soybean Supply and Demand

Even though soybean cultivation in Argentina has a long history, soybeans were not economically viable crops in Argentina before the 1960s. However, the sharp increase in the world soybean price in the 1970s following the disastrous anchovy catches in Peru and the U.S. soybean export ban in the early 1970s spurred a more than 60 fold increase in Argentina's soybean production in the 1970s. The dramatic growth of its soybean production during that period catapulted Argentina into third place in world soybean exports behind the U.S. and Brazil.

Throughout the 1970s, the profitability of soybeans relative to corn, sorghum, and barley continued to lead to a substitution of production area away from grains to soybeans (Schnepf, Dohlman, and Bolling 2001). Before the 1990s, Argentina's soybean yields grew a steady 3% annually during the 1970s and 1980s that played a large role in the dramatic rise in Argentina's soybean output (Schnepf, Dohlman, and Bolling 2001). Then, in the late 1990s, the widespread adoption of biotech soybeans stimulated a rapid expansion of the area planted to soybeans in Argentina. Soybean production in Argentina has increased rapidly since that time with the exceptions of 2008/09 and 2011/12 when an historic drought negatively influenced production (Figure 9).

Figure 9. Argentine Soybean Production, Crush, and Exports, 1970/71-2012/13



Source: USDA/FAS, 2013

Over the years, the Argentine agriculture sector has received very little direct government support (Vilella et al. 2009). In 1991, the newly elected government enacted important economic reforms that adopted an open-economy policy and created a more liberal policy regime. The success of these reforms unleashed Argentina's natural comparative advantage in the production of soybeans (Schnepf, Dohlman, and Bolling 2001). The greatest change made during that period was the elimination of all export taxes on processed soybean products. Furthermore, these reforms boosted imports of fertilizer and farm machinery so that farmers could invest heavily in new technologies that improve yields (Schnepf, Dohlman, and Bolling 2001).

Initially, Argentina's soybean area expanded mostly in the central production region, known as the Pampas. The soybean area extended through northern Buenos Aires, southern Santa Fe and southwest Córdoba. By the 1990s, more than half of total soybean area in Argentina was in these regions. Beginning in the late 1990s, soybean area in the northern and northwestern provinces of Argentina (including Santiago del Estero, Chaco, Formosa and Entre Ríos) also expanded with infrastructure improvements and the introduction of new technologies. The infrastructure improvements began to open these provinces to the major ocean ports of Rosario and Buenos Aires via an overland connection to the Parana-Paraguay waterway at Resistencia (Schnepf, Dohlman, and Bolling 2001). The new technologies enabled farmers to attain higher yields with the same number of hectares and laborers. Despite the growth of soybean production in the northern and northwestern provinces, Córdoba, Santa Fe, and Buenos Aires remain the major Argentine soybean production regions, accounting more than 80% of total soybean production in Argentina (SIIA 2013).

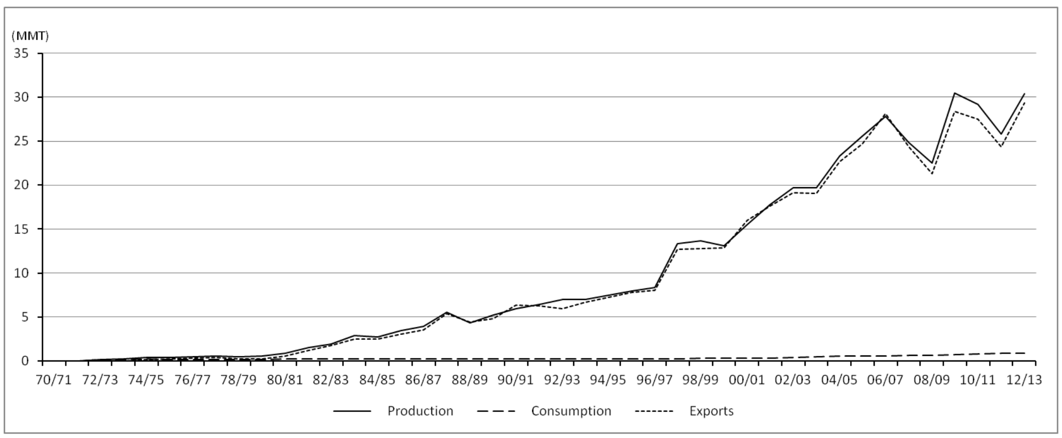
The processing capacity and the quantity of soybeans crushed have grown rapidly in Argentina, responding to increased production. Policy reforms in the early 1990s encouraged private investments in the Argentine soybean processing sector resulting in more efficient technology and larger processing capacity (Schnepf, Dohlman, and Bolling 2001). Currently, Argentina is the third largest processor of soybeans in the world. The volume of soybeans crushed in Argentina has increased from 1.3 mmt in 1981/82 to 20.9 mmt in 2000/01 and 35.9 mmt in 2011/12. The processing industry is concentrated in the provinces of Córdoba, Santa Fe, and Buenos Aire with Santa fe accounting for over 80% of Argentine processing capacity. Argentine processing facilities are oriented toward soymeal and soyoil exports since Argentina has little reason to crush soybeans for its relatively small domestic market. However, by reducing the export tax burden on soymeal and soyoil compared to soybeans, Argentina created an incentive in favor of the domestic processing of soybeans rather than exporting. Since 1990, approximately 10% to 30% of Argentine soybean productions have been exported with the rest crushed in Argentina.

Argentine Soymeal

Argentina has several advantages over the U.S. and Brazil for exporting soybeans and products. Most importantly, soybean production areas are located relatively close to the ports where most of the processing capacity is located, minimizing transportation costs. In addition, the costs of seeds are lower in Argentina because many of Argentina farmers evade payment of the technology fee for biotech soybeans (Schnepf 2003). Furthermore, the average port cost in Argentina is cheaper than that in Brazil (López, Ramos, and Starobinsky 2008).

Argentine exports of soymeal began in the early 1970s. Nearly all soymeal produced in Argentina has been exported over the years. In 1990/91, only 4% of soymeal production was consumed in the domestic market and only 3% in 2011/12 (Figure 10). Argentina's cattle industry is predominantly grass-fed and the poultry and pork industries are relatively small (Schnepf, Dohlman, and Bolling 2001). In 2011/12, soymeal production in Argentina was 27.9 mmt of which 26 mmt was exported.

Figure 10. Argentine Soymeal Production, Consumption, and Exports, 1970/71-2012/13



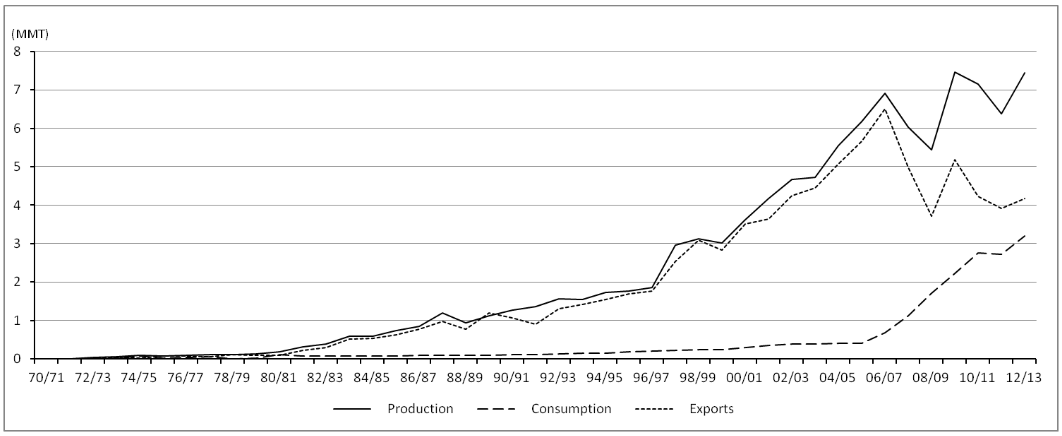
Source: USDA/FAS, 2013

Argentine Soyoil

Argentine soyoil exports also began from the early 1970s. In 1990/91, only 8% of soyoil production was consumed domestically. New laws requiring mandatory usage of biodiesel in the U.S. and the European Union in recent years, however, have boosted investments in the Argentine soyoil market. As a result, the domestic consumption share of soyoil reached 44% in 2011/12 (Figure 11). A Chinese ban on soyoil imports from

Argentina for six months in 2010/11 helped reduce Argentina's soyoil exports that year and generate more domestic use.

Figure 11. Argentine Soyoil Production, Consumption, and Exports, 1970/71-2012/13



Source: USDA/FAS, 2013

Argentine Soybean Policies

Before the 1990s, Argentina's agricultural sector including soybeans was at a considerable competitive disadvantage because of the unstable macroeconomic environment of the country characterized by high inflation, an often overvalued exchange rate, and a heavy external debt burden (Schnepf, Dohlman, and Bolling 2001). Furthermore, at that time, the National Grain Board (JNG) and the National Meat Board promoted the transfer of agricultural sector resources to the industrial sector to help industrial growth by favoring import substitution (Vilella et al 2009; Lence 2010). The import substitution program penalized the Argentine soybean sector by applying tariffs and quantitative restrictions on imported agricultural inputs to encourage the sale of domestically produced inputs and imposing export taxes on soybeans and soybean products to help pay for the growing government debt (Schnepf, Dohlman, and Bolling 2001). The export taxes on soybeans and soybean products and import tariffs on production inputs distorted production incentives and strangled agricultural productivity growth (Schnepf, Dohlman, and Bolling 2001). Despite these obstacles, Argentina's soybean production rose dramatically between 1980 and 1990, mainly due to yield gain. By the early 1990s, Argentina had become the world's largest exporter of soyoil and a major soymeal exporter (Schnepf, Dohlman, and Bolling 2001).

In 1991, the newly elected government instituted major changes in government policies, including the elimination of export taxes on soymeal and soyoil. However, soybeans exports continued to be taxed at a rate of 3.5% to encourage growth of the domestic processing industry. Furthermore, all quantitative restrictions on imported agricultural production inputs were eliminated (Schnepf, Dohlman, and Bolling 2001). In 1992, the Argentine government established an export rebate system designed to encourage soymeal and soyoil exports by reducing the domestic costs of production (whole soybean exports were not made eligible for export rebates). The policy reforms helped Argentine soybean industries increase usage of the imported inputs and expand soybean product exports. Argentina's reform of the agricultural sector was accelerated by the Mercado Común del Sur (MERCOSUR) encompassing Argentina, Brazil, Uruguay, and Paraguay (Schnepf, Dohlman, and Bolling 2001).

A devaluation of the Argentine peso in 2002 along with the rise in the international prices of soybeans and soybean products gave a great impetus to its exports of soybeans and soybean products (Deese and Reeder 2007). In 2002, the Argentine government took advantage of the export surge and applied export taxes to 23.5% on soybeans, to 20.0% on soymeal and to 19.3% for soyoil (Deese and Reeder 2007; Vilella et al. 2009). In 2007, the soybean export tax was raised to 35% and to 44% in 2008. The tax increases met with resistance from Argentine soybean farmers and many in the soybean industry. As a result, the government eased the soybean export tax back to 35% later in 2008. The soybean export tax is currently 35% and 32% for soymeal and soyoil.

Factors influencing Competitiveness in Argentine Soybean Industry

The proximity of Argentine production regions to ports and processing facilities and the relatively lower cost of producing soybeans in Argentina compared to the United States and Brazil enabled the growth of the Argentine soybean industry. Even though the Argentine soybean industry benefits from lower production costs in comparison to the U.S. and Brazil, Argentina's high soybean and soybean product export taxes continue to undermine its global competitiveness. In 2004, Argentina allowed crushers to import soybeans from Paraguay and re-export the soymeal and soyoil by only paying the value added tax, not the full export tax. This policy effectively boosted soybean crushing to utilize available capacity until 2009 when the policy was terminated (Markley 2012).

The Chinese Soybean Industry

In 1995/96, Chinese government began to open its soybean market. As a result, China quickly switched from being a small net importer of soybeans to being a net importer. Chinese soybean imports have subsequently increased dramatically. The U.S., Brazil, and Argentina account for more than 95% of China's soybean imports. China's accession to the WTO in 2001 that obligated China to open its soybean markets to imports was a primary factor in launching the growth in its soybean imports. Between 2001/02 and 2011/12, China's soybean imports increased from 10.4 mmt to 59 mmt, a nearly 500% increase (Figure 12). As a result, China has become the largest soybean importing country in the world.

China is currently the world's largest producer of soymeal and soyoil. China's soymeal production has been sufficient to meet domestic needs so that Chinese soymeal trade is minimal. On the other hand, China's large and rapidly growing demand for soyoil has required growing imports of soyoil. Between 2001/02 and 2011/12, China's soyoil imports increased by almost 172% from 551,000 mt to 1.5 mmt (Figure 14).

Chinese Soybean Supply and Demand

Evidence indicates that soybeans were first domesticated during the Zhou dynasty in about the 11th century B.C in the eastern half of the northern region of China (Hymowitz 1990). Domestication in China probably took place during the Shang dynasty between about 1700 B.C. and 1100 B.C (Williams 2012). Soybean production probably reached southern China by the first century A.D. (Smith 2003).

Before the 1930s, China was by far the world's leading soybean producing country. In 1933, China and Manchuria, an independent state under Japanese control at the time, accounted for 87% of world soybean production (Shurtleff and Aoyagi 2007b). During the late 1930s and early 1940s, Chinese soybean production declined markedly due to revolution in China and the China-Japan war. Following World War II, the socialist Chinese government adopted the first Five Year Plan for the economic development of China that called for intensive industrialization with relatively little capital investment to be made in the agriculture sector (Williams 2012).

In the 1950s, the Chinese government encouraged an increase in agricultural production that resulted in a dramatic increase in the area planted to soybeans (Shurtleff and Aoyagi 2007b). At the time, the major soybean production regions were the central and northeast provinces of China including Shandong, Henan, Heilongjiang, and Anhui (Shurtleff and Aoyagi 2007b). However, during the 1960s, soybean production declined substantially due to the changes in the domestic political environment (Shurtleff and Aoyagi 2007b).

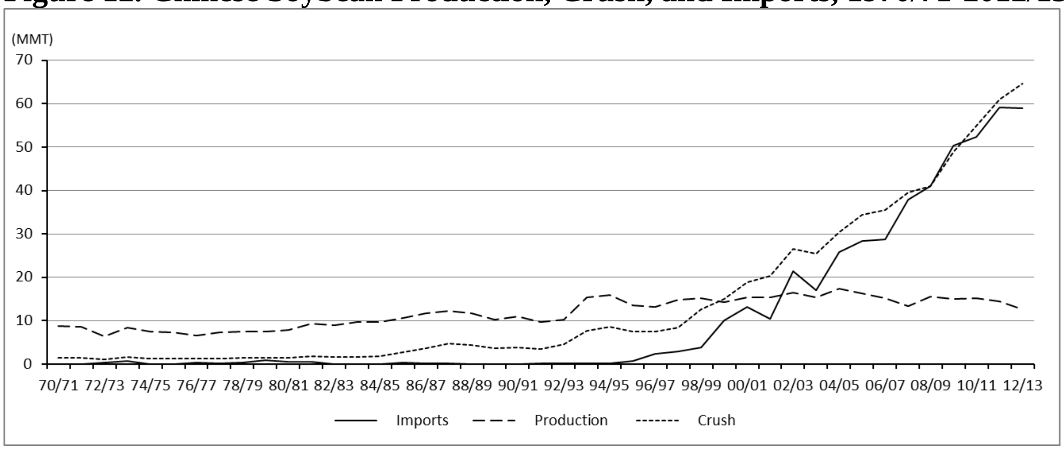
Chinese soybean production and planted area began a slow growth after 1976 once again, mainly because of a change in Chinese government policy that shifted land out of grain production and into cash crops such as soybeans and expanded research and extension work related to soybean production (Shurtleff and Aoyagi 2007b). The gains in Chinese soybean production in the early 1980s occurred mainly in the central provinces of Henan and Anhui. Even so, about 40% of all Chinese soybean production occurred in the northeast provinces of Heilongjiang, Liaoning, and Jilin (Shurtleff and Aoyagi 2007b).

Chinese soybean crush increased more than 34 fold to 61 mmt between 1984/85 and 2011/12. Economic growth after the 1980s increased the domestic demand for vegetable oil and meat creating demand for soybeans for processing. Soybean production gradually increased until the mid-2000s, mainly as the result of some increase in the planted area. Area harvested reached 9.6 million ha in 2005/06. After the mid-2000s, soybean area in China declined sharply primarily due to the low returns to soybean planting (Meador and Xinping 2013) because the Chinese government wants to be self-sufficient in grain production thus government policies reduced the incentives to plant soybeans in favor of more highly subsidized rice, corn and wheat (Lagos and Junyang 2013). Farmers have shifted the acreage away from soybeans toward corn or rice that are more profitable.

In recent years, soybean acreage has tended to decline with unfriendly policies, and the increasing cost of land and other production inputs. In 2011/12, the per hectare profit in Heilongjiang for soybeans ($245) is far below the profit for corn ($637) and rice ($923) (Meador and Xinping 2013). Soybean production in China is still concentrated in the Northeast region (including the Heilongjiang and Jilin provinces) and the Yellow River region (including the Shandong, Henan and Hebei provinces) which together account for about 60% of China's soybean production. However, lower soybean profits relative to competing corn and rice in these two regions have caused a significant decline in soybean area (Meador and Xinping 2011; Meador and Xinping 2012).

China is the fourth largest soybean producer and the largest processor of soybeans in the world. The volume of soybeans processed in China began to grow rapidly in mid-1980s, due mostly to economic growth. Increased income, population growth, and urbanization in China stimulated the growth in demand for soymeal and soyoil (Tuan, Fang, and Cao 2004). The expansion of industrialized feed production during the 1980s and 1990s was an important factor in the rapid growth of Chinese soymeal demand (Tuan, Fang, and Cao 2004). Chinese soybean crush was 1.7 mmt in 1984/85 but reached 61 mmt in 2011/12 (Figure 12). The Chinese oilseed processing industry has the capacity to process 125 mmt per year and over 360,000 mt per day (Meador and Xinping 2013).

Figure 12. Chinese Soybean Production, Crush, and Imports, 1970/71-2012/13



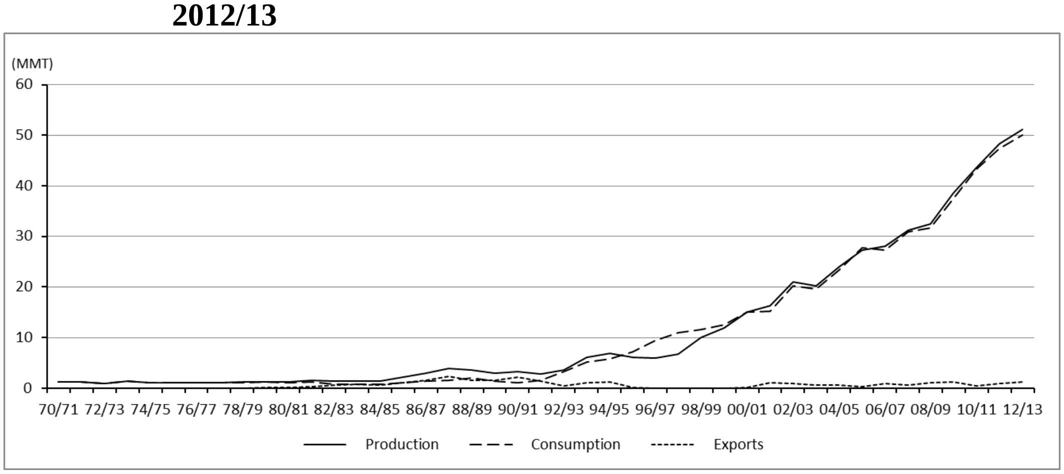
Source: USDA/FAS, 2013

The processing industry was concentrated along the coastal region, with about 80 % of total crush capacity, to facilitate the receipt of imported soybeans (Meador and Xinping 2013). About half of Chinese soybean crush plants in 2012 were located in the East and Northeast coastal provinces of Shandong (28.4%), Jiangsu (15.8%), and Liaoning (5.8%) (Meador and Xinping 2013).

Chinese Soymeal

Before the 1980s, Chinese soymeal production averaged about 1 to 1.5 mmt (Figure 13). In the early 1990s, Chinese soymeal demand and production of soymeal began a steady increase. Domestic soymeal production has come primarily from imported soybeans (Williams 2012). China has been a net exporter of soymeal, except during the period of 1995/96 through 1998/99, primarily because the meal produced from the imported soybeans has been more than sufficient to meet domestic needs. Domestically produced soybeans are destined primarily for food use (Williams 2012). Chinese soymeal production and consumption increased 136% and 211%, respectively, between 2001/02 and 2011/12 (Figure 13).

Figure 13. Chinese Soymeal Production, Consumption, and Exports, 1970/71-2012/13

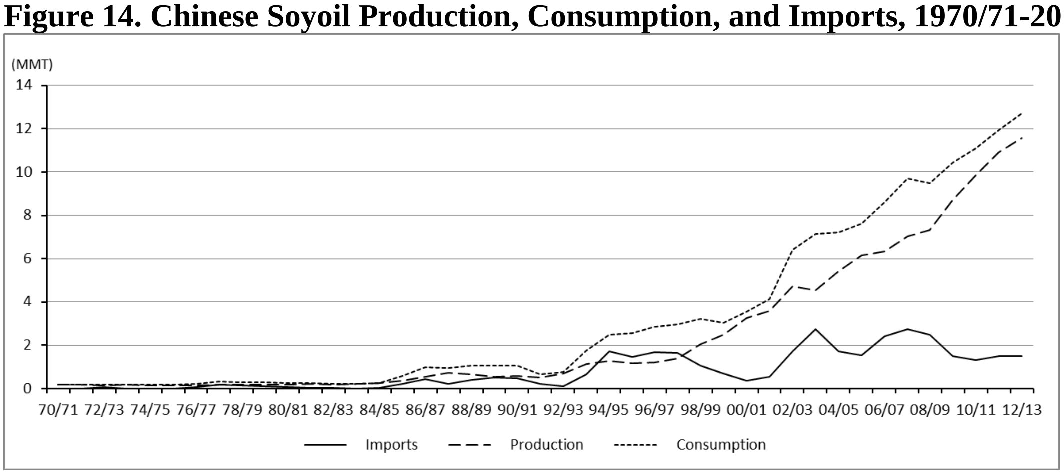


Source: USDA/FAS, 2013

Chinese Soyoil

The dramatic growth in Chinese soyoil supply and demand since the 1980s have been heavily influenced by government soyoil import policies (Tuan, Fang, and Cao 2004). The rapid expansion of domestic crushing capacity reduced soyoil imports beginning in the late 1990s. An outbreak of SARS (Severe Acute Respiratory Syndrome) and avian flu in early 2000s reduced the demand for meat, and therefore, the demand for soymeal as a livestock feed ingredient fell (Tuan, Fang, and Cao 2004). A subsequent surplus of soymeal in the market leads to a decline in the crush of soybeans leading to the need to begin importing soyoil. Chinese soyoil imports, however, are relatively small compared to the domestic production of soyoil. The 2011/12 self-sufficiency ratio for Chinese soyoil was about 86%. The accession of China to the WTO in 2001 contributed to the dramatic growth in the production and consumption of soyoil of 205% and 186%, respectively, between 2001/02 and 2011/12 (Figure 14).

Figure 14. Chinese Soyoil Production, Consumption, and Imports, 1970/71-2012/13



Source: USDA/FAS, 2013

Chinese Soybean Policies

As mentioned earlier, the area planted to soybeans in China was expanded in the 1950s as the result of Chinese government policies to promote agricultural production. However, in the early 1960s, China implemented measures that gradually shifted acreage away from soybeans and industrial crops toward grains (Williams 2012). In the late 1970s, China instituted economic growth policies that resulted in a shift of grain production area back into soybean production along with increased public investments in soybean research (Shurtleff and Aoyagi 2007b).

In 1994, the amount of soymeal imports was only 50,000 mt. The following year the Chinese government lifted the 13% value-added tax (VAT) on imported soymeal to counteract the rapid growth in the demand for soymeal (Tuan, Fang, and Cao 2004). Consequently, Chinese soymeal imports increased until 1997/98 to 4.2 mmt. However, the surge of soymeal imports reduced the demand for soybeans for processing and, thus, a shortage of soyoil supply. Consequently, the Chinese government re-imposed the 13% VAT on imported soymeal in 1999 (Tuan, Fang, and Cao 2004). China became a net exporter of soymeal in 2000/01. In 2004, the Chinese government attempted to encourage soymeal exports by reimbursing the 13% VAT on soymeal exports (Tuan, Fang, and Cao 2004).

In the mid-1990s, the Chinese government reduced soybean import tariff rate to 3% and to 5% for soymeal. Before its accession to the WTO, China had used import quotas and import licensing for soyoil. Under the comprehensive bilateral trade agreement reached between the U.S. and China in 1999, China established tariff-rate quotas (TRQs) for soyoil that increased each year (Hsu and Gale 2001). The total TRQ level for soyoil of 1.7 mmt in 2000 increased to 3.3 mmt in 2005. This measure, along with a reduction in the over-quota tariff to 9% in 2005 from 74% in 2000, facilitated imports of soyoil until the mid-2000s. The soyoil trade was liberalized by 2006, including elimination of monopoly by state trading and tariff-rate quotas.

Prior to the accession of China to the WTO in 2001, China government implemented the biotechnology and food safety regulations referred to as the "Biosafety Administration Regulations on Agricultural Biotech Products" which require labeling of soyoil products containing biotech soybeans, create an approval process for an application for a safety certificate for imports of biotech soybeans, and also require an individual safety certificate for each shipment of biotech soybeans (Tuan, Fang, and Cao 2004). In 2002, the government established testing guidelines and rules for imports of biotech soybeans (Song, Marchant, and Xu 2006). Under these regulations, China granted a safety certificate for importing Monsanto's Roundup Ready biotech soybeans in 2004.

Factors influencing Competitiveness in Chinese Soybean Industry

The poor profitability of growing soybeans in major production areas has continued to shift soybeans acreage to crops that are more profitable. Furthermore, the price gap between domestic produced soybeans and imported soybeans disadvantage processing companies near soybean production regions. The relatively high price of domestic soybeans lowers the competitiveness of inland processing companies compared with processing companies located in southern coastal regions that use imported soybeans. Chinese soybean farmers' competitiveness continues to be undercut by limited arable land and low yields (Meador and Xinping 2011). Furthermore, relatively low returns to soybean production continues to influence farmers to switch to more profitable crops.

The Japanese Soybean Industry

Liberalization of Japanese soybean imports began in 1961. Then, in 1972, the tariff on soybean imports was eliminated. Before World War II, much of Japan's soybean imports originated in Manchuria, now part of China. By the 1960s, however, Japan's soybean imports were primarily from the U.S. Currently, the U.S. supplies 65% to 75% of Japanese soybean imports with the rest coming from Brazil, Canada, and China (Hayashi 2012). Canada and China supply Japan with non-biotech soybeans for food use (Hayashi 2012).

Japan was the fourth largest soybean importing country in 2011/12 behind China, EU-27 and Mexico. The recent high soybean prices and a shift in Japanese consumption patterns leading to reduced soyoil consumption have contributed to a decline in Japanese soybean imports since 2003/04. Although soymeal consumption has been stable since the early 2000s, imports of soymeal have increased to replace the declining production. Japan is currently the fourth largest soymeal consumer in the world behind the EU, Indonesia, and Thailand. Japan imported 2.28 mmt of soymeal in 2011/12 (Figure 16).

The Japanese crushing industry has long been protected by border policy. Consequently, until the early 2000s, the quantity of Japanese soyoil imports was quite small relative to the quantity of soyoil consumed in Japan. Japanese soyoil consumption and production peaked in 2002/03 after which they have both been on the decline. However, soyoil production has declined more rapidly than consumption leading to a slight increase in imports since 2002/03 (Figure 17).

Japanese Soybean Supply and Demand

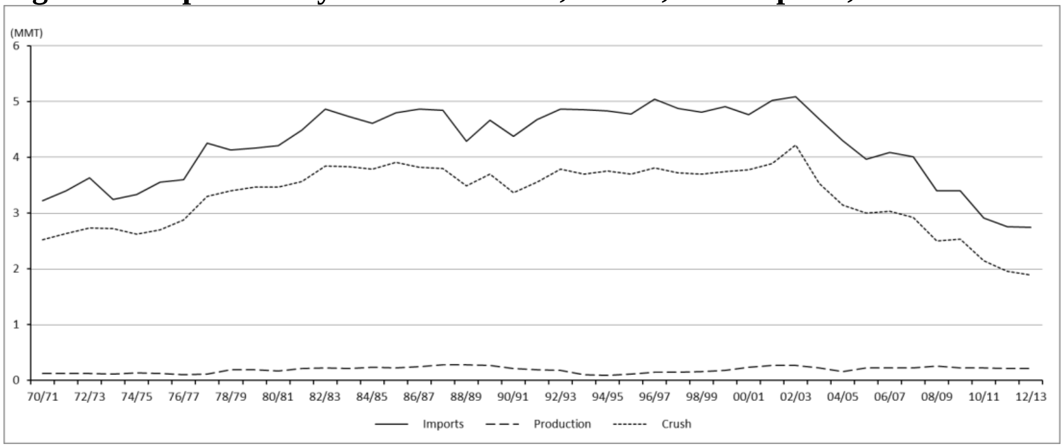
Soybeans have been an important crop for many centuries in Japan. Soybeans are widely used in making miso, soy sauce, tofu, and natto, traditionally important components of Japanese diets. Soybeans have been cultivated in the Japan since the Yayoi period that began in about 300 BC (Takahashi 2009). Soybean cultivation became widespread in Japan during the Kamakura period from 1192 AD to 1333 AD. The spread of Buddhism during that period discouraged the consumption of meat and provided an incentive for the cultivation of soybeans as a protein food source.

Japanese soybean processors have depended on imports for several decades. From the 1930s to 1940s, domestic production accounted for only 30% to 35% of the soybeans processed in Japan, the rest being imported primarily from Manchuria (Nakamura 1961). The area under soybean cultivation in Japan peaked in the late 1940s at more than 400,000 ha. Japan then entered a period of rapid economic growth and liberalization of tariffs with its accession to the GATT in 1955. The liberalization of soybean imports began in 1961 with the tariff on soybean imports finally eliminated in 1972 (Yoon and Lee 1990).

The U.S. became the primary source for Japanese soybean imports in the 1960s. Soybeans were initially used to make traditional foods in Japan. However, after the late 1950s, soybeans began to be used for crushing to make soyoil and soymeal (Nakamura 1961). The Japanese processing industry preferred U.S. to Japanese soybeans because of their higher oil content compared to domestic or Chinese soybeans. During that period, Japanese soybean production declined substantially from 418,000 mt in 1960/60 to only 136,000 mt in 1969/70. Over the same period, soybean imports increased by nearly 300% from 1.2 mmt to 3.3 mmt. By 1970/71, approximately 96 % of all soybeans consumed in Japan were imported, mostly from the U.S.

There was a slight increase in soybean planted area and production from the late 1970s until the late 1980s. However, almost 95% of soybean use continued to be supplied by imports (Figure 15). In the mid-1990s, the Japanese government decided to enforce its rice diversion program due to a high level of rice stocks in government inventories. The objective was to divert rice paddy fields to alternate crops such as soybeans (OECD 2009). Consequently, Japanese soybean planted area and soybean production experienced an increase once again in the late 1990s and the early 2000s. In 2000, the deficiency payments were stopped and soybean planted area has not increased since the mid-2000s. For the last decade, the production area has been at around 130,000 ha to 150,000 ha. Soybean production has been less stable due to soybean yield fluctuations over the years.

Figure 15. Japanese Soybean Production, Crush, and Imports, 1970/71-2012/13



Source: USDA/FAS, 2013

The Central and Northern regions of Japan, including the Hokkaido, Akita, Miyagi, Niigata, and Tochigi prefectures have been the principal soybean producing areas. Hokkaido is the largest soybean prefecture in Japan accounting for about 20 % of production. Most soybeans in Japan are planted into paddy fields except in the Hokkaido, Tohoku and Kanto prefectures.

In 1989/1990, there were 117 crushing factories in Japan (Hamamoto 2002). However, due to shrinking profitability, the number of crushers has declined gradually over the years as companies have consolidated (Nozaki 2000). In 1998/99, there were 88 crushing factories with a total crushing capacity of 8.9 mmt but only 40 crushing factories with a total crushing capacity of 8.6 mmt in 2009/10 (Hayashi 2012).

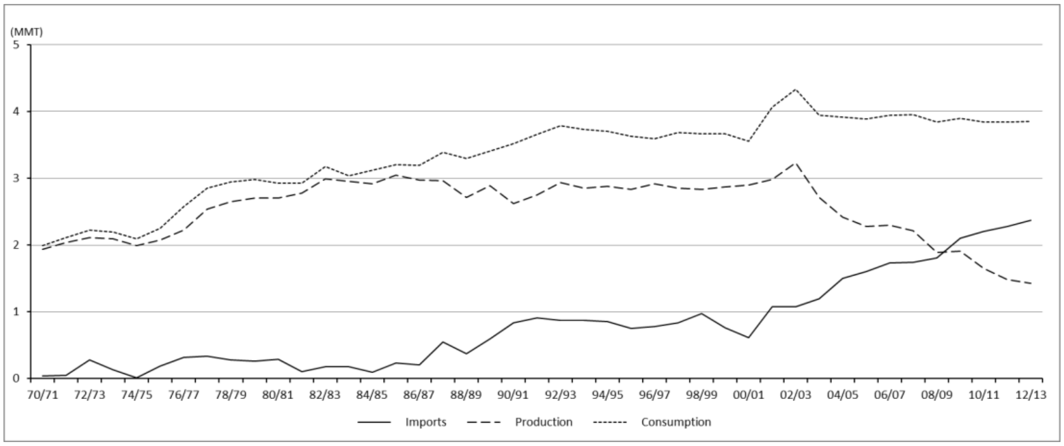
Since the early 2000s, a relatively high international price for soyoil compared to that of palm oil has been a primary factor behind the shift in consumption and, therefore, the decline in soyoil and soybean imports since 2002/03. Soybean imports dropped almost in half between 2002/03 and 2011/12 from 5.1 mmt to 2.76 mmt (Figure 15).

Japanese Soymeal

About 80 ~ 90% of the soybean meal produced and imported by Japan is used for feed production with the remainder used for soybean products like tofu (Hayashi 2012). After a cow infected with Bovine spongiform encephalopathy (BSE), commonly known as mad cow disease, was discovered in Japan in 2001, the demand for soymeal as protein supplement in animal feed rations replaced protein from animal origins leading to an increase in soymeal consumption in 2001/02 and 2002/03 (Hamamoto 2003).

After that time, reflecting stagnant demand for feed from the livestock sector, total soymeal consumption stabilized until 2011/12. However, total soymeal production had been on a downward trend due to the downturn in the amount of crushing soybeans. Therefore, soymeal imports have increased due to decreases in soymeal production. The amount of imported soymeal increased by 111% in 2011/12 compared to 2001/02 and domestic soymeal production decreased from 2.98 mmt in 2001/02 to 1.48 mmt in 2011/12 (Figure 16).

Figure 16. Japanese Soymeal Production, Consumption, and Imports, 1970/71-2012/13

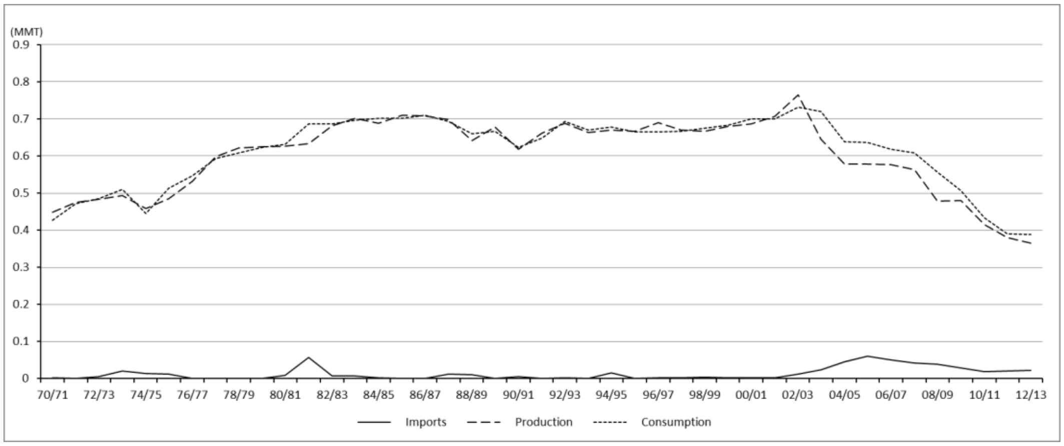


Source: USDA/FAS, 2013

Japanese Soyoil

Japanese soyoil consumption and production increased until the early 1980s and then remained stable for two decades. High tariffs on imported soyoil assured little competition for the domestic crushing industry from imports. Since 2002/03, however, both the consumption and production of soyoil have been declining consistently as consumers switched to other oil sources due to growing concerns about trans-fat in Japan and a relatively high price of soyoil compared to other oil like palm oil. As Japanese soyoil production has dropped, imports of rapeseed oil and palm oil have increased (Wixom and Hayashi 2011). Because soyoil production has declined more rapidly than consumption, soyoil imports have increased over the last decade. Japanese soyoil consumption declined by 46.9% from 2002/03 to 2012/13 while domestic soyoil production decreased from 765,000 mt in 2002/03 to 380,000 mt in 2011/12 (Figure 17).

Figure 17. Japanese Soyoil Production, Consumption, and Imports, 1970/71-2012/13



Source: USDA/FAS, 2013

Japanese Soybean Policies

Until 1960, Japan maintained a 10% tariff rate on imported soybeans after which the tariff was steadily reduced until it was completely eliminated in 1972. There are currently no tariffs on soybean or soymeal imports. Soybean oil is a different story. Over the years, Japan has maintained a soyoil tariff that has effectively protected the Japanese crushing industry from competition with imports.

Because the relatively low price of imported soybeans for food uses has had a tendency to depress the price of domestically produced soybeans over the years, the Japanese government has implemented programs designed to support domestic production. Beginning in 1961, soybean producers received a deficiency payment in which the government paid the difference between the market and target prices to farmers when market prices fell below a fixed target level, regardless of any quality differential in the price of the soybeans (Hamamoto, Dyck, and Stout 2002).

In 2000, the deficiency payment program was replaced by a Soybean Subsidy Program that the government paid soybean farmers the difference between the market price and a production cost estimate (Hamamoto, Dyck, and Stout 2002). Under this subsidy program, the government pays a fixed subsidy to farmers when the sum of the producer price and the fixed subsidy does not reach the production cost set by the government each year (Hamamoto 2003). Meanwhile, if the sum of the producer price and the fixed subsidy exceeds the production cost, the farmers are paid only the difference between the production cost and the producer price, instead of full amount of the fixed subsidy (Hamamoto 2003). In the case of the producer price exceeding the production cost, farmers would not benefit from the subsidy.

In addition to the subsidy for soybeans, the Japanese government also implemented an income stabilization policy in 2000. This program compensates participating farmers with 80% of the difference between the current year market price and the average of the market prices of the previous 3 years (Hamamoto, Dyck, and Stout 2002). Another major policy that supports domestic soybean production is rice diversion subsidies which are paid per hectare of soybeans planted on paddies that have been diverted away from rice production (Hamamoto, Dyck, and Stout 2002).

Because the overall Japanese domestic agricultural production declined in recent years, Japanese government launched the Farm Income Support Payment program in 2011 designed to increase domestic production of major grains including soybeans. Under this program, farmers who plant soybeans on rice paddies receive a fixed subsidy.

Farmers who cultivate soybeans in upland field receive the difference between a nationwide standard production cost and the nationwide standard farm price.

Factors influencing Competitiveness in Japanese Soybean Industry

As mentioned above, for the last decade, soyoil consumption has declined mainly due to changes in consumer preference for rapeseed oil and palm oil rather than soyoil. Japanese consumers have become more concerned about food safety and are demanding non-biotech soybeans for food purposes.

An important competitive change for the Japanese crushing industry has been the reduction of the historically high protection against soyoil imports in the form of high import tariffs. Currently, Japan's tariff on imported soyoil is applied on a specific rate basis and the rate is 10.9 yen/kg that is as high as or higher than for other similar vegetable oils (e.g. palm oil 3.5 yen/kg; sunflower oil 8.5 yen/kg; rapeseed oil 10.9 yen/kg). Under WTO rules, the high Japanese tariffs on imports of soyoil will need to be reduced which will likely create a competitive disadvantage for Japanese soybean crushing industry.

The EU Soybean Industry

In the early 1900s, soybean imports from East Asia rapidly increased in Europe. At that time, England was the leading soybean importer in Europe. European soybean imports declined sharply during World War I. In the post-war years, European imports of soybeans and soyoil began to recover rapidly (Shurtleff and Aoyagi 2007a). After the late 1920s, Europe began to import more soybeans and extract the soyoil domestically, which dampened European imports of soyoil (Shurtleff and Aoyagi 2007a). Soybean imports fell to almost zero during World War II because of naval warfare over trade routes and Japanese invasions of Manchuria and China (Shurtleff and Aoyagi 2007a).

After the war, imports of soybeans recovered dramatically from 0.11 mmt in 1945 to 2.8 mmt in 1960. However, the U.S. rather than East Asia became the major source of the imports (Shurtleff and Aoyagi 2007a). In the Dillon round of GATT negotiations during the early 1960s, the European Economic Community (EEC) negotiated zero duties on imports of soybeans (Bertheau and Davison 2011). Between 1960/61 and 1979/80, European soybean imports grew from 2 mmt to 16.3 mmt. The major soybean importers were West Germany, Netherlands, Spain and Italy (Shurtleff and Aoyagi 2007a).

During the 1990s, soybeans and soymeal imports gradually increased while soyoil imports sharply decreased. Before mid-1990s, the United States had been a major supplier of soybeans to Europe, accounting for 45% of EU imports (Hasha 2002). However, consumer rejection of biotech soybeans in Europe reduced the U.S. share of EU soybean imports to 22 % in 2007 (van Gelder, Kammeraat, and Kroes 2008). In contrast, European imports of soybean from Brazil that grows both biotech and non-biotech have been rapidly increasing. Since the mid-2000s, Brazil has accounted for more than 50% of the soybeans imported by the EU while the U.S. has accounted for less than 20% (European Commission 2013).

Given its small soybean production compared to its high demand for feed use, the EU is the world's second largest importer of soybeans and the largest importer of soymeal. Although Brazil is still the EU's leading soybean supplier, the market share of Brazil in EU soybean imports has decreased while soybean imports from Paraguay and Canada have increased substantially over the last two years. Total imports of soybeans by the EU have decreased over the last decade due to reduced demand for soymeal in animal feed (Krautgartner et al. 2012). The Netherlands, Spain, and Germany account for 60% of total EU soybean imports. Argentina and Brazil are major soymeal exporter to the EU that account for more than 95% of the soymeal imported from these two countries.

EU Soybean Supply and Demand

Although the EU is the second largest soybean consumer in the world, soybean production is small in the EU. The production of soybeans is at a competitive disadvantage in Europe due to adverse climate and soil conditions. Moreover, closely substitutable commodities, such as rapeseed, sunflower seed, and cottonseed, are more suited to the climatic and soil conditions in Europe.

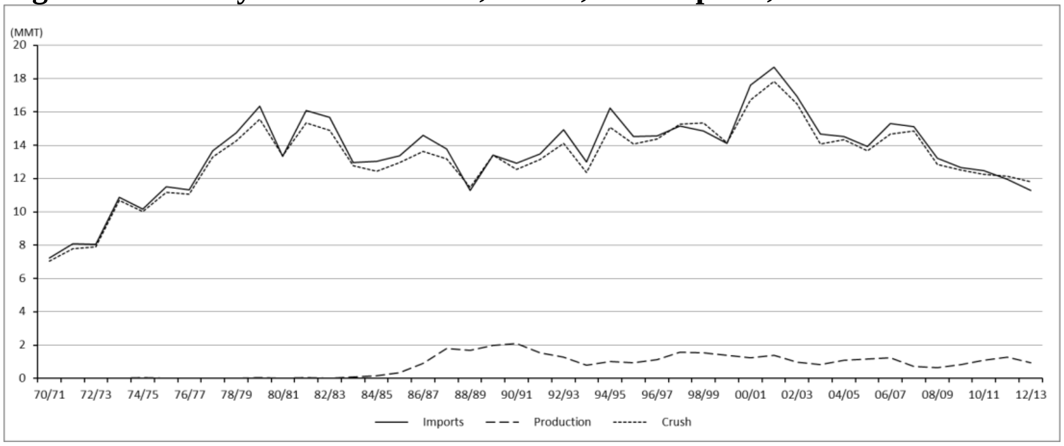
Soybean production in Europe began in 1933 in countries along the Danube, including Romania, Bulgaria, Hungary, and Austria (Shurtleff and Aoyagi 2007a). Total production in these countries reached 125,000 mt in 1941 before World War II forced a dramatic decline in production (Shurtleff and Aoyagi 2007a). By the early 1950s, small amounts of soybeans were produced in Eastern European countries such as Romania.

However, there was still no noteworthy production of soybeans in Western European countries.

In 1973, a shortage of soybeans in the U.S. impacted soybean imports by Western European countries which motivated some European countries such as Spain and France to attempt to reduce their dependence on imported soymeal by encouraging the production of soybeans (Shurtleff and Aoyagi 2007a). Domestic soybean production in Europe, however, still only contributed about 5% of total soybean crush at the time. In the 1980s, European countries began subsidizing the production of rapeseed and sunflower seed in an effort to reduce their dependence on imports. Consequently, production of other oilseeds increased while the volume of soybeans crushed declined.

During the 1990s, European soybean crush demand and soybean imports both gradually increased by almost 30% (Figure 18). However, the area planted to soybean in Europe did not expand given its relatively low price compared to other oilseeds like rapeseed. During that period, the share of soybeans in total European oilseed production was less than 10% (Borremans 1998).

Figure 18. EU Soybean Production, Crush, and Imports, 1970/71-2012/1



Source: USDA/FAS, 2013

In the early 2000s, the EU soybean production was concentrated in Italy, France, Austria, and Spain. European soybean crushing increased in the early 2000s due to the prohibition against the production and use of meat and bone meal in the EU and improved crushing margins for soybeans (Talks 2003). However, by 2005/06, the EU soybean crushing was on the decline due to high crushing costs and relatively high soybean prices (Talks 2004). When Romania joined the EU in 2006/07, soybean production increased slightly. However, production declined again in 2007/08 mainly due to the prohibition against the production of biotech soybeans in Romania (Bendz 2007). In the late 2000s, the annual EU-27 soybean production in EU-27 was no more than 600,000 mt to 850,000 mt, which is only 3% of total EU-27 oilseed production. More than 50% of EU-27 soybeans are produced in Italy.

The decline in the EU soybean imports over the last decade is due mainly to a decline in the demand for feed including soymeal and growing substitution of rapeseed meal for soymeal in livestock rations. A decreasing crush margins for soybeans is also one of crucial reasons for the decline of soybean imports (Bendz 2005). Over the last decade, the EU countries have tended to increase their imports of soymeal and soyoil rather than soybeans. After 2010/11, there was growth in the acreage planted to soybeans in major European soybean producing countries such as Italy and France leading to a slight increase in the EU-27 soybean production. The almost continuous decline in soybean crush demand in the EU-27 is primarily the result of a decline in the demand for soymeal in animal feed rations and a decline in soyoil demand with greater competition from sunflower oil, palm oil, and other close substitutes (Krautgartner et al. 2012). Major crushers in the EU-27 include Germany, Spain, Italy, and Benelux countries (Krautgartner et al. 2012). Germany and Spain together account more than 40% of the total EU-27 soybean crush.

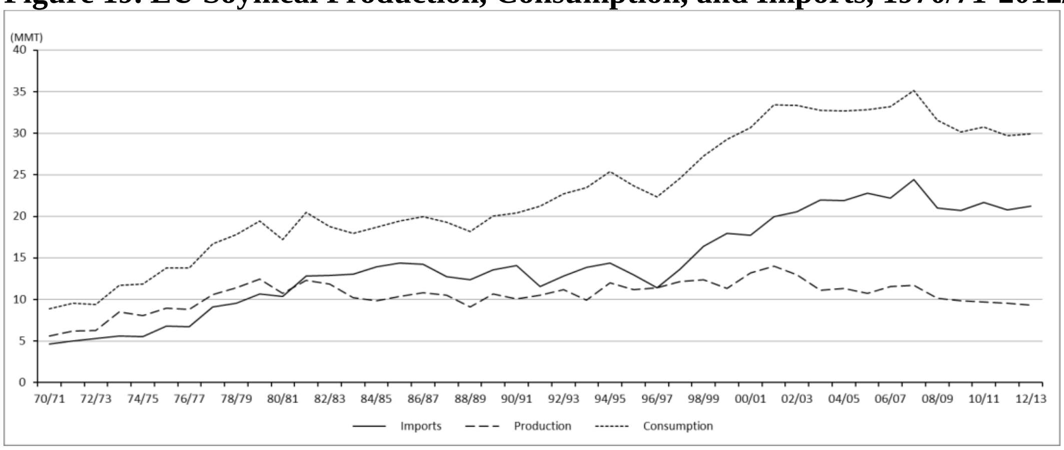
EU Soymeal

Because the EU is one of the largest livestock and poultry producers in the world, the EU is also the world's largest importer of soymeal. During the 1990s, soymeal was relatively cheaper than feed grains making soymeal a cheap protein supplement for balanced feed rations in the region. However, after the early 2000s, soymeal production declined mainly due to a decreased crush margins for soybeans (Talks 2004).

A rise in the EU demand for soymeal in the early 2000 was the result of the BSE scare in 2000 and the subsequent ban by the EU on the use of meat and bone meal in animal feeds the next year. The EU-27 demand for soymeal peaked in 2007/08 due to high grain prices leading to a similar spike in soybean imports that year (Lieberz 2008).

However, after that time, the demand of soymeal for animal feed use declined in most member states (Krautgartner et al. 2010). Soymeal consumption in the EU-27 was 35 mmt in 2007/08 and only 30 mmt in 2011/12 (Figure 19). Major consumers of soymeal in the EU-27 are Germany, Spain, and France. Total soymeal consumption of these countries accounts for more than 40 % of total EU-27 soymeal consumption (Krautgartner et al. 2011).

Figure 19. EU Soymeal Production, Consumption, and Imports, 1970/71-2012/13

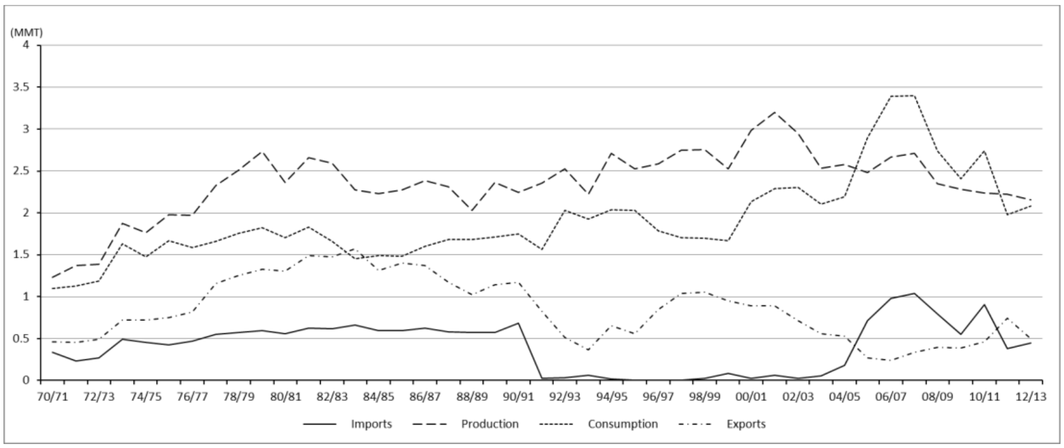


Source: USDA/FAS, 2013

EU Soyoil

Before the mid-2000s, the EU-27 had been net exporter of soyoil. During 1900s, soyoil imports in the EU were almost zero due to the growth of domestic soyoil production (Figure 20). The production of soyoil gradually increased until the early 2000s and then declined once again due to lower crush margins and high soybean prices. In the late 2000s, the EU-27 became a net importer of soyoil although soyoil exports again exceeded soyoil imports in 2011/12. Brazil and Argentina are the main exporters of soyoil to the EU-27. EU-27 soyoil imports increased in the mid-2000s because of increased demand for biodiesel especially in Germany, Spain, Italy, and Portugal (Bendz 2006).

Figure 20. EU Soyoil Production, Consumption, Exports and Imports, 1970/71-2012/13



Source: USDA/FAS, 2013

EU-27 traceability and labeling legislation came into force in 2003 making it mandatory to label soyoil produced from biotech soybeans (Bendz 2005). Consumption of soyoil in the EU had gradually increased and reached to 3.4 mmt in 2007/08 (Figure 20). Since that time, however, the EU-27 demand for soyoil has decreased, both for food use and for biodiesel use. Crushing plants specifically for soybeans in EU-27 countries have been replaced by multi-seed crushing plants (Bendz 2007). The food industry in the EU-27 tends to avoid using oil products which are labeled biotech (Krautgartner et al. 2010). Italy, Romania, and France are the largest producers of soyoil, accounting for almost 80 % of total soyoil production in the EU (Krautgartner et al. 2012). In 2012/13, EU-27 soyoil consumption was 2.1 mmt and soyoil production was 2.2 mmt (Figure 20).

EU Soybean Policies

Because soybean production is relatively small in the EU-27, few government policies have been implemented to support its growth. Soybeans and soymeal have been imported into the EU with zero tariffs since the 1960s. The Common Agricultural Policy (CAP), initiated in 1962, aimed to enhance agricultural productivity in the EU and insure a stable food supply. However, EU agricultural policies primarily motivated growth in the production of other oilseeds such as rapeseed and sunflower seed rather than soybeans. Under the CAP reforms implemented in1993/94, the EU began to replace its price support policy with direct payments based on historical yields. Moreover, the 1992 Blair House agreement in response to an EU-US dispute on EU oilseed supports set a maximum of 5.482 million ha of EU oilseed area that were eligible for oilseed payments (Dufey, Baldock, and Farmer 2006; European Commission 2011). In addition, under the Agenda 2000 reforms, compensatory payments for oilseeds were gradually replaced by direct payments.

Following the 2003 CAP reform, the EU introduced the Single Farm Payment (SFP) program. Decoupling the SFP from production and the unfavorable production conditions for soybeans in much of Europe lead to a decline in the production of soybeans. Moreover, a 10% set-aside rule for production area reduced the area planted to soybeans. In 2008, the EU-27 passed a biofuels directive that requires use of renewable fuels up to 10% of total EU transport fuels by 2020. However, rapeseed oil is the main feedstock used to produce biodiesel in EU. Consequently, soybean production has benefited little from that policy. The cultivation of biotech soybeans has been prohibited in the EU-27. Several EU-27 regulations and directives relate to biotechnology and food safety. In 2004, the EU-27 implemented a regulation requiring traceability systems and the labeling of biotech commodities and products produced from biotech commodities. Currently, the EU-27 has zero-tolerance policy on imports of unauthorized biotech soybeans. Therefore, if small amounts of unauthorized biotech soybeans are found in shipments of approved soybeans then the EU-27 could ban its import. In 2011, the EU-27 relaxed its zero-tolerance policy only for imports of animal feed by allowing the presence of EU unapproved biotech commodities in a batch of non-biotech or EU approved biotech commodities up to 0.1%.

Factors influencing Competitiveness in EU Soybean Industry

For the EU, it is difficult to substitute soybean imports with domestically produced soybeans due to unfavorable conditions to grow a large volume of soybeans. In recent years, soybean consumption and, therefore, imports have declined as result of three major factors (1) high soybean price, (2) decline in demand for soyoil as consumers substitute away from soyoil towards rapeseed and other vegetable oils, and (3) reduced feed demand. Although some of EU soybean imports have been replaced by alternative oilseeds such as rapeseed and sunflower seed, soymeal is one of the most important feedstuffs for the EU feed industry given its high protein profile, for which very limited substitutes are available (Aramyan, van Wagenberg, Backus 2009).

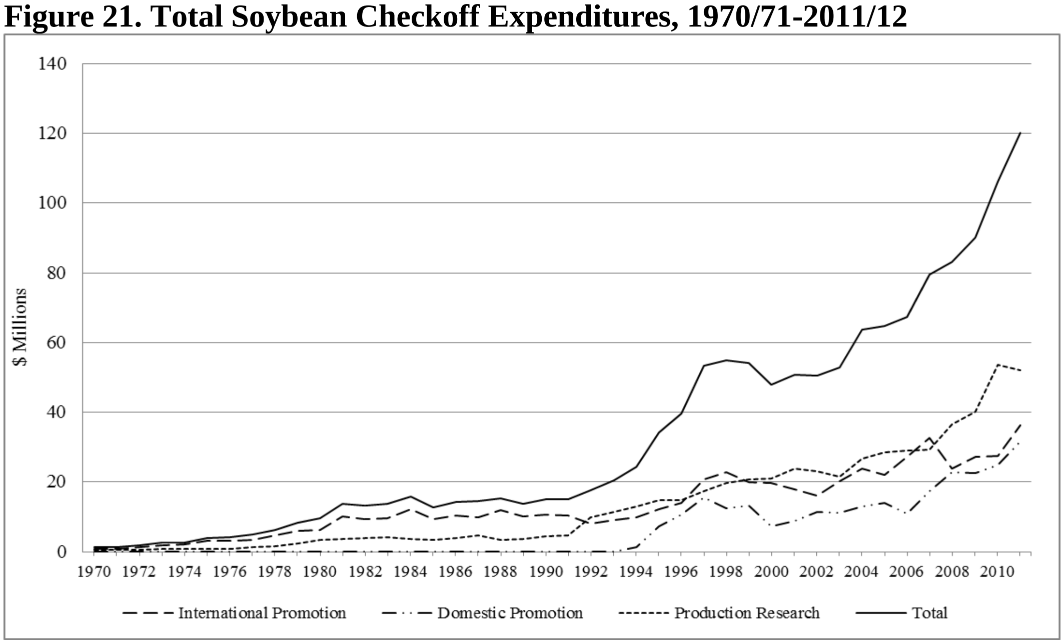
Soymeal is used primarily as a livestock feed supplement in the EU-27. Soyoil is used mostly for margarine production, and cooking and salad oils. Some soyoil is also used as a biofuel feedstock. With the introduction of the biotech product labeling requirements for soymeal and soyoil, the EU import demand for soybeans and soybean products has declined. Furthermore, there have been changes in the sources of EU-27 imports of soybeans and soymeal. Soybean imports from the United States have declined while imports of biotech-free soybeans from Brazil, Paraguay, and Canada have increased. EU-27 imports of Argentine soymeal have declined in favor of biotech-free soymeal from Brazil.

Historical Soybean Checkoff Expenditures

Since 1970/71, U.S. soybean farmers spent a total of over $1,380 million in checkoff funds on both supply-oriented and demand-oriented programs to enhance the probability and their competitiveness. Of that total, 40.5% have been invested in international market, 40.9% in production research and 18.6% in domestic market. Before the national soybean checkoff program became effective in 1991, annual soybean checkoff expenditure was less than $20 million (Figure 21). Between 1970/71 and 1991/92, about 70% of the total checkoff expenditure was invested in the international market and the rest of the total checkoff expenditure was invested in production research (Figure 22). Over the same period, the soybean checkoff funds were rarely invested in domestic demand promotion activities.

With the implementation of the national soybean checkoff program, annual soybean checkoff expenditure grew rapidly to almost $40 million by 1996/1997, $51 million by 2001/02, $67 million by 2006/07 and $120 million by 2011/12 (Figure 21). Over time, a larger share of checkoff funds was allocated to domestic promotion to expand domestic use of soybeans, soymeal and soyoil (Figure 22). The shift in the allocation away from international market promotion towards domestic promotion caused a decline in the international market promotion share from 69.5% in 1991/92 to 30.2% in 2011/12. Since 2000/01, production research has been the largest part of the overall soybean checkoff expenditure.

Figure 21. Total Soybean Checkoff Expenditures, 1970/71-2011/12



Source: author's analysis of USB's expenditure record

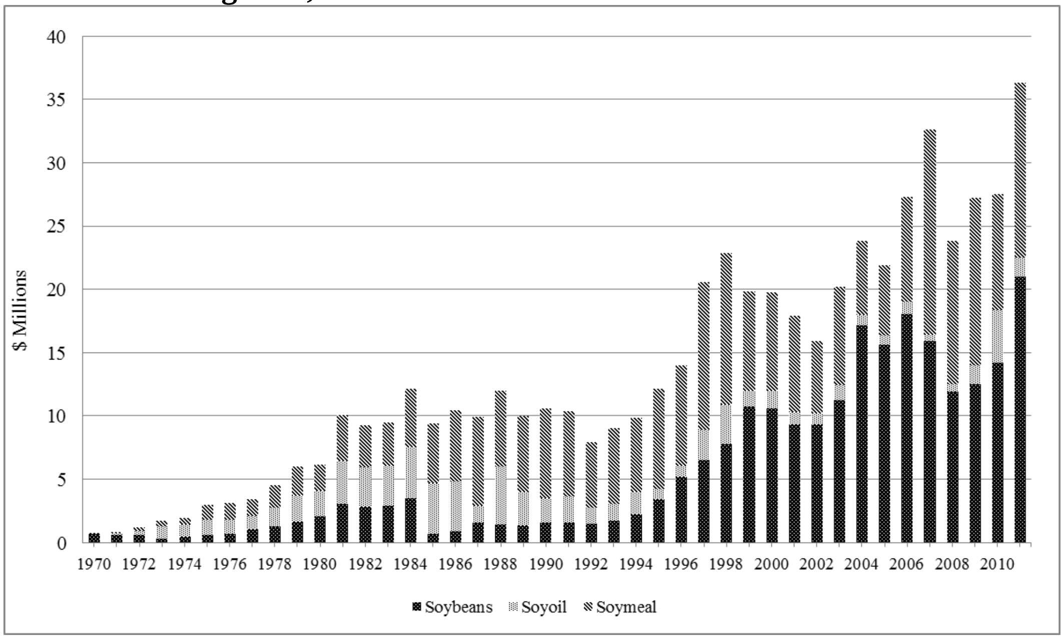
Figure 22. Share of Soybean Checkoff Expenditures Allocated to International Market Promotion, Domestic Market Promotion, and Production Research, 1970/71-2011/12

Source: author's analysis of USB's expenditure record

International Market Promotion Expenditure

Between 1970/71 and 2011/12, $559 million were invested in international market promotion to boost exports of U.S. soybeans and soybean products. Over the same period, checkoff funds invested for foreign market development increased steadily from $0.7 million in 1970/71 to $36 million in 2011/12 (Figure 23). In 1970/71, soybeans accounted for the largest share of international market promotion with $699 thousand. However, after the mid-1970s, soybean products share increased until late 1980s. By 1985/86, soyoil accounted for 42.3% and soymeal accounted for 50.2% of international market promotion with soybeans only 8% (Figure 24).

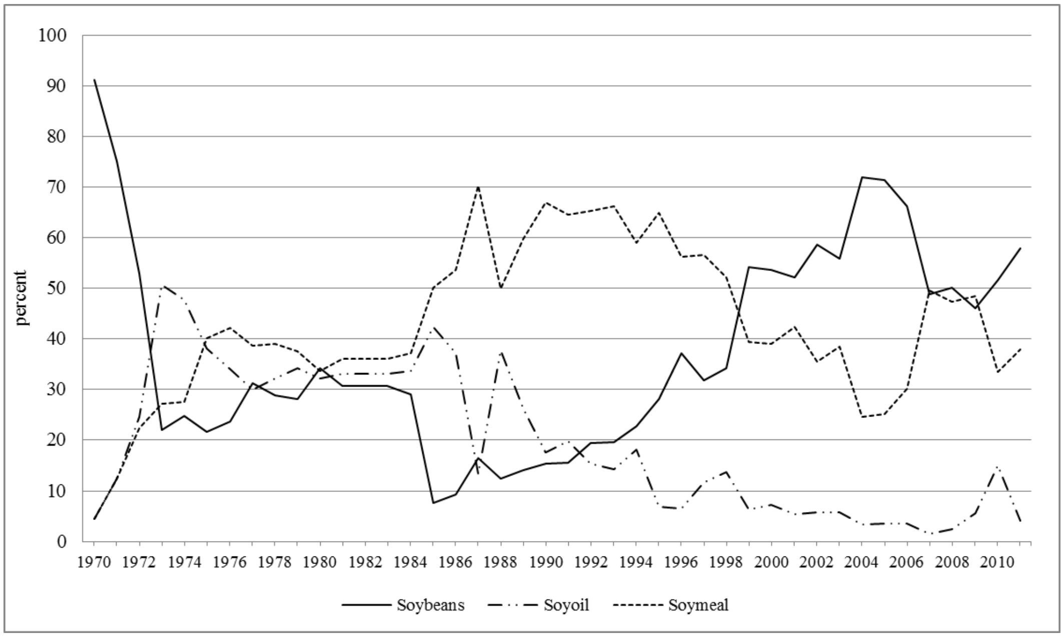
Figure 23. Soybean Checkoff Expenditures on International Market Promotion Programs, 1970/71-2011/12



Source: author's analysis of USB's expenditure record

After the implementation of the national soybean checkoff program, the strategy of the international market development reemphasized soybeans rather than soybean products. By 2011/12, the soybean share has risen to 58% of international promotion expenditure (Figure 24). From $699 thousand in 1970/71, checkoff funds for soybeans increased to $21 million in 2011/12 (Figure 23). The expenditure for soyoil reached a high of $4.5 million in 1988/89 but declined to $0.5 million in 2007/08. With an emphasis on development for new uses of soyoil, checkoff expenditure increased to $1.5 million in 2011/12. Between 1970/71 and 2011/12, checkoff funds for soymeal grew from $33 thousand to $13.8 million.

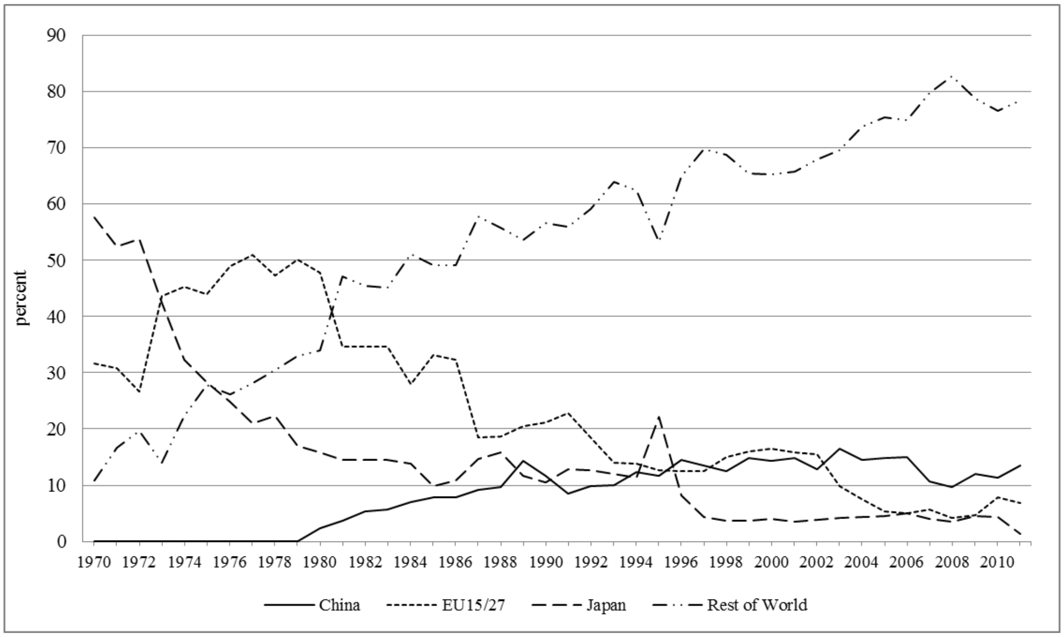
Figure 24. Commodity Shares of International Market Promotion Expenditures, 1970/71-2011/12



Source: author's analysis of USB's expenditure record

In the early 1970s, Japan accounted for the largest share of international market promotion, approximately 50% to 60% (Figure 25). Japan share of international market promotion expenditure has substantially diminished between mid-1970s and mid-1980s mainly because the emphasis in promotion activities began to switch from soybeans to soybean products (Figure 24). The share of expenditure in the European Community was the largest in 1977/78 with 51%, however, it also decreased to 6.8% in 2011/12 (Figure 25).

Figure 25. Regional Shares of International Market Promotion Expenditures, 1970/71-2011/12



Source: author's analysis of USB's expenditure record

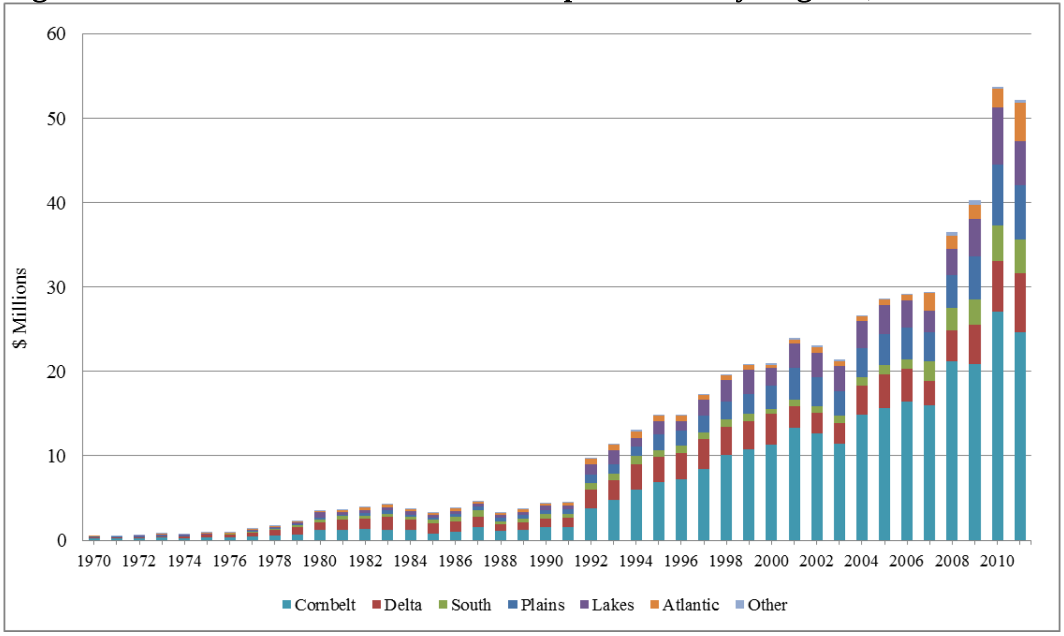
In 1970/71, Japan and the European Community accounted for almost 90% of all international market promotion expenditure, however, the European Community and Japan share declined to 8.1% in 2011/12 (Figure 25). In contrast, since 1980/81, the international market promotion expanded into China and the share of expenditure increased to 13.5% in 2011/12. The share of expenditure for rest of world increased dramatically from 10.8% in 1970/71 to 78.4% in 2011/12 due to the growing emphasis on new and emerging markets.

Soybean Production Research Expenditure

Between 1970/71 and 2011/12, $565 million were invested in production research to enhance soybean yield and to reduce production cost (Figure 26). In 1970/71, soybean farmers invested $0.5 million in domestic production research activities and production research expenditure has grown to $52.2 million by 2011/12 (Figure 26). By 1970/71, about 46.9% of total checkoff research funds went to Cornbelt region, 19.8% to Plains regions, 17.2% to Delta region, 8.4% to Atlantic region, 7.8% to Lakes region and little or no expenditure to South and Other regions. By 2011/12, about 47.3% of total checkoff research funds went to Cornbelt region, 13.4% to Delta regions, 12.4% to Plains region, 10.0% to Lakes region, 8.7% to Atlantic region, and 7.5% to South region (Figure 26).

During the period of 1970/71 through 2011/12, annual expenditures on production research in Cornbelt region have increased a hundredfold from $243 thousand to $24.7 million and annual expenditures on production research in Delta region have increased almost 78 times from $89 thousand to $7.0 million (Figure 26). Over that period, annual expenditures on production research in Plains region increased more than sixtyfold from $103 thousand in 1970/71 to $6.5 million in 2011/12 and annual expenditures on production research in Lakes region increased from $40 thousand in 1970/71 to $5.2 million in 2011/12. Over the same period, annual expenditures on production research in Atlantic region increased from $43 thousand to $4.5 million and annual expenditures on production research in South region increased from almost zero to $3.9 million.

Figure 26. Total Production Research Expenditures by Regions, 1970/71-2011/12

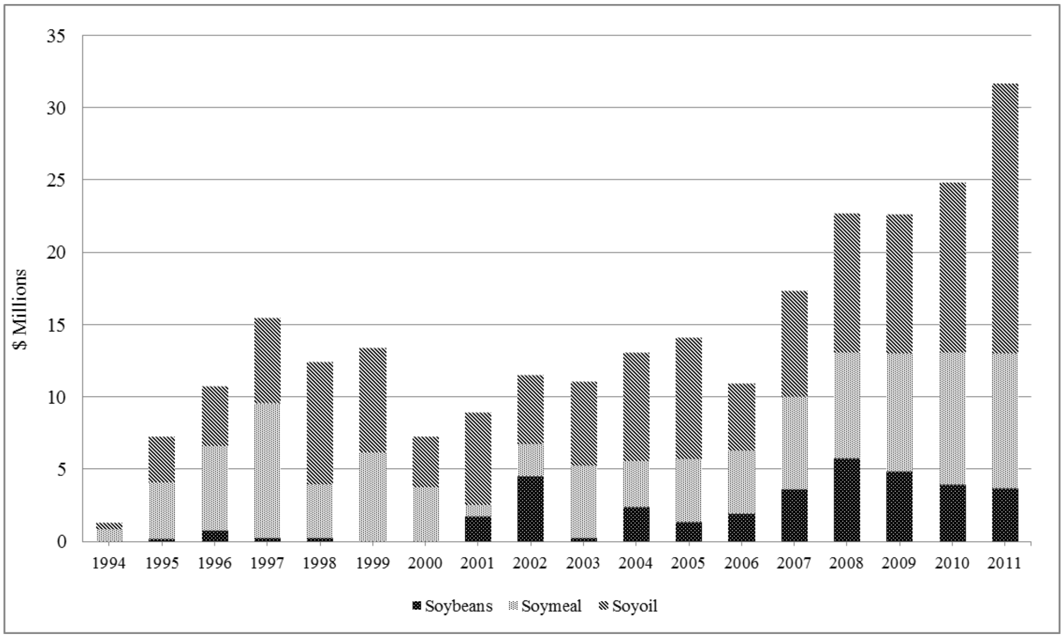


Source: author's analysis of USB's expenditure record

Domestic Promotion Program Expenditure

Between 1994/95 and 2011/12, $257 million were invested in domestic promotion programs to enhance domestic uses of soybeans and soybean products. Over the same period, checkoff funds invested for domestic promotion increased from $1.3 million in 1994/95 to $31.7 million in 2011/12 (Figure 27). In the 1990s, most domestic expenditure funds were invested for promotion demand of soymeal and soyoil. There was little investment for soybean promotion. However, after 2000/01, soybean promotion share increased until late 2000s. By 2011/12, soyoil accounted for 59% and soymeal accounted for 29.4% of domestic promotion with soybeans only 11.6% (Figure 27).

Figure 27. National Level Expenditures on Domestic Promotion Programs, 1994/95-2011/12



Source: author's analysis of USB's expenditure record

From $406 thousand in 1994/95, checkoff funds for soyoil increased to $18.7 million in 2011/12 (Figure 27). Between 1994/95 and 1997/98, checkoff funds for soymeal grew from $865 thousand to $9.3 million but declined until the early-2000s. With an emphasis on development for new uses of soymeal, checkoff expenditure increased from $754 thousand in 2001/02 to $9.3 million in 2011/12. The expenditure for soybeans reached a high of $5.7 million in 2008/2009 but declined to $3.7 million in 2011/12.

CHAPTER III

CONCEPTUAL ANALYSIS

The primary objective of most commodity checkoff programs is to foster the growth and profitability of the production of that commodity. Individual producers contributing to the program expect that the benefits of downstream checkoff activities will transmit upstream to them such that they are individually better off than they would have been without the checkoff program. The producer benefits of most federally mandated checkoff programs have been analyzed, some on multiple occasions as required by the 1996 Farm Bill. In conducting those analyses, however, many researchers often make simplifying assumptions about the nature of the upstream transmission of the benefits of checkoff programs that could affect the measured returns to producers.

After considering the various simplifying assumptions made in the analyses of the benefits of various checkoff programs, this chapter then provides a graphical analysis of the upstream transmission of the benefits of the U.S. soybean checkoff program to soybean producers in which the simplifying assumptions made by others are relaxed. The chapter then proposes a model to measure the effects of the simplifying assumptions on the upstream transmission of the benefits of the soybean checkoff program.

Simplifying Assumptions Often Made in the Analyses of Checkoff Programs

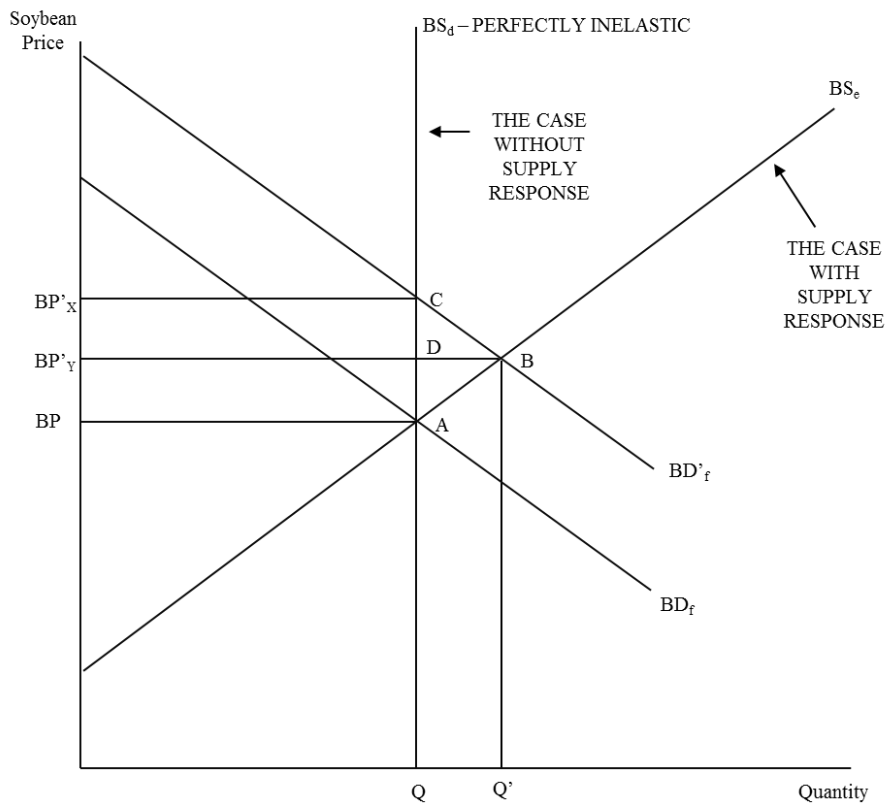
Among the most common simplifying assumptions made in analyses of commodity checkoff programs include: (1) no supply response (inelastic supply), (2) no price effects (elastic supply), (3) no government intervention in the related commodity markets (free markets), (4) no free riders, (5) no domestic supply chain effects, (6) no global supply chain effects, (7) no checkoff investments in production research (only in demand promotion), and (8) no promotion programs at multiple levels of the supply chain (promotion occurs at only the retail level of the market).

Common Simplifying Assumption #1: No supply response

In some analyses of commodity checkoff programs, such as Goddard and Conboy (1993) who analyzed the effects of generic promotion of U.S. beef exports to Japan using a meat demand system, supply is assumed to be perfectly inelastic. Under this assumption, a checkoff-promotion-induced change in demand can lead only to a price effect. That is, there is no supply response and, therefore, no quantity impact of the promotion. Figure 28 illustrates the implications of a checkoff promotion for producer benefits in the case of soybeans under the assumption of a perfectly inelastic supply curve.

Before any checkoff investment to promote the demand for soybeans is made, the market is in initial equilibrium at point A where supply equals demand, the soybean price is BP, and the quantity of soybeans produced and demanded is Q. The soybean supply curve initially is assumed to be perfectly inelastic (BS_d in Figure 28). The investment of checkoff funds to promote soybean demand shifts the demand curve from BD_f to BD'_f and raises the soybean price to BP'_X which has no effect on soybean sales given the inelasticity of the supply curve. Producer surplus increases by the area $BPACBP'_X$. If the supply curve is assumed to be more price elastic (such as BSe in Figure 28), the same promotion-induced-increase in soybean demand from BD_f to BD'_f drives price to only BP'_Y while increasing soybean sales to Q' and adding the area $BPABBP'_Y$ to producer surplus.

Figure 28. The Effects of Assuming No Supply Response (inelastic supply)



In general, with the more inelastic demand such as a demand for agricultural commodity, the gain in producer surplus with a sloped supply curve is less than the gain in the case of a perfectly inelastic supply curve. The difference in the producer surplus between the two scenarios is the area of the rectangle $BP'_Y DCBP'_X$ minus the area of the triangle ABD.

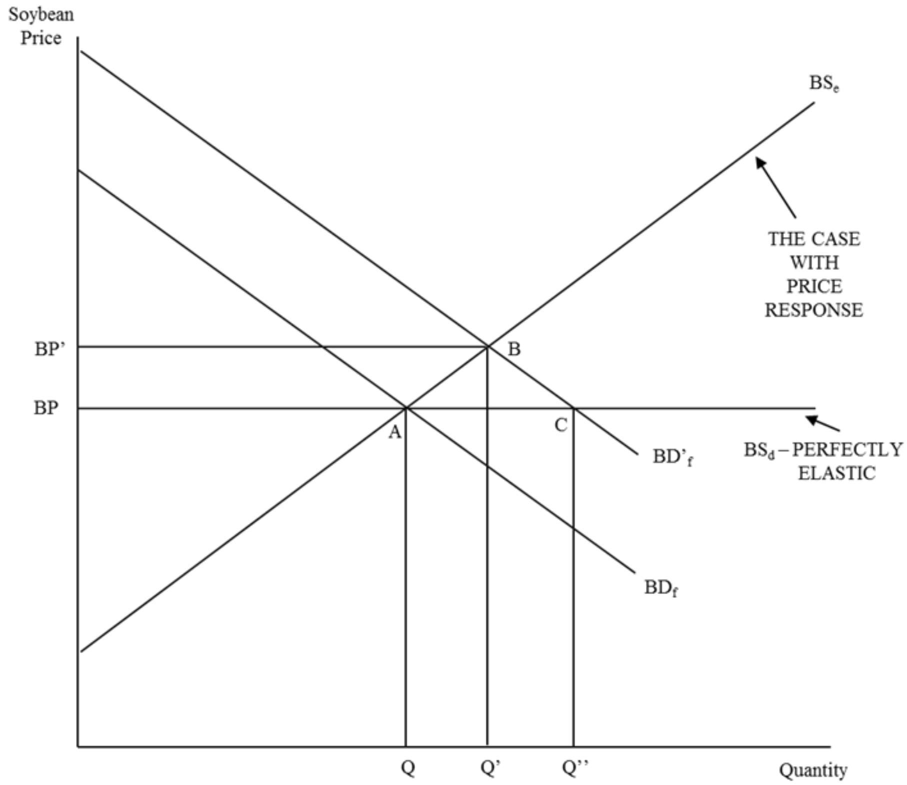
The inelastic supply curve may be considered to be the short-run supply curve while the more elastic supply curve may be considered to be the long-run supply curve. Studies of the effects of checkoff-funded demand promotion expenditures for commodities like beef often assume (correctly) that supply is inelastic in the short run and proceed with the promotion impact analysis but then ignore the longer run consequences of promotion on beef price and sales (i.e., supply response is ignored). Checkoff promotion over time may have market effects that carryover into the long run when production can respond to the price effects of the promotion. Sustained promotion over time compounds the long-run effects. As a consequence, assuming a perfectly price-inelastic supply curve can lead to erroneous conclusions about the producer benefits of demand enhancement through checkoff promotion.

Common Simplifying Assumption #2: No price response (perfectly elastic supply)

Rather than assuming no supply response, some commodity checkoff studies assume just the opposite, an infinite supply response with a perfectly elastic supply curve. Studies that adopt a single equation approach often assume supply is perfectly elastic (e.g., Armah and Epperson 1997; Schmit and Kaiser 1998; Capps and Williams 2008; Rusmevichientong and Kaiser 2009; and Williams, Capps, and Dang 2010). The advantage of this approach is that the researcher avoids the problem of a promotion-induced price change and the complication of having to account for the simultaneity in supply response, cross-commodity effects, and supply chain impacts. The justification is often that the measured quantity effects of the promotion are likely to be too small to have any measureable effect on market price.

Figure 29 illustrates the implications of a checkoff promotion for producer benefits in the case of soybeans under the assumption of a perfectly elastic supply curve (BS_d) which does not allow for a price response to a promotion-induced shift in the demand curve. Before promotion, the initial equilibrium is at again point A with price BP and sales of Q. Suppose checkoff expenditures are invested to promote demand which shifts the demand curve from BD_f to BD'_f. With a perfectly elastic supply curve, price is unaffected but sales increase from Q to Q''. With a more inelastic supply curve (BS_e), the same promotion-induced demand shift generates a new equilibrium at point B where the supply curve intersects the higher demand curve (BD'_f). Soybean sales increase from Q to only Q' rather than to Q" and soybean price rises from BP to BP'.

Figure 29. The Effects of Assuming No Price Response (elastic supply)



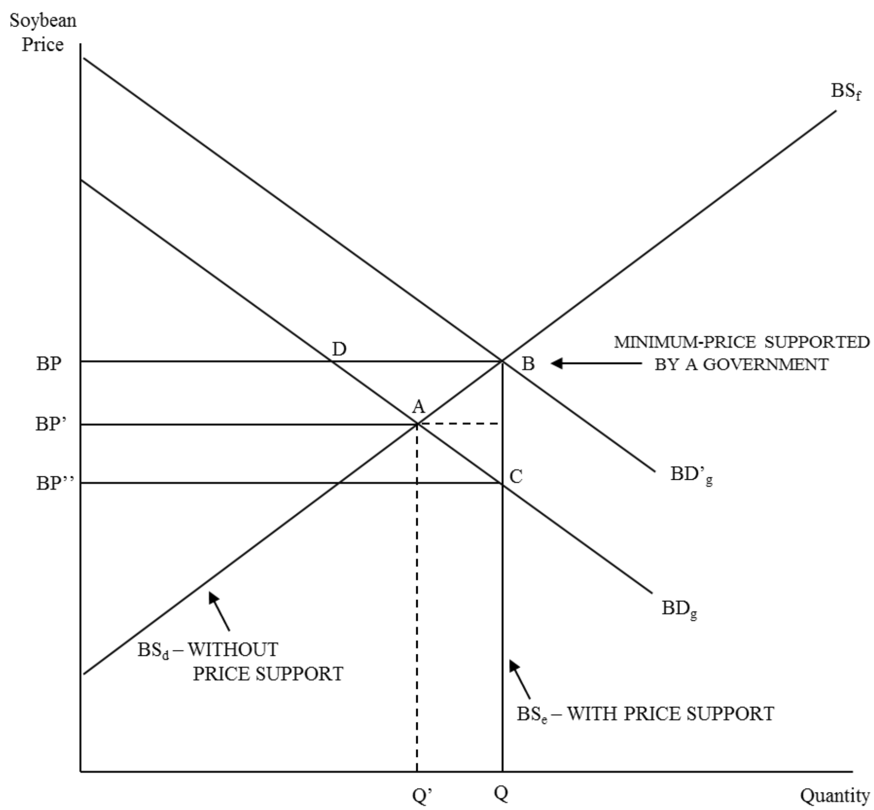
The implications of relaxing the assumption of a perfectly elastic supply curve are clear – price increases and the sales increase is less than with a perfectly elastic supply curve. The implications for the measurement of producer benefits are also clear. With a less than perfectly elastic supply curve, a checkoff-induced demand increase generates additional producer surplus of BPABBP'. In contrast, with a perfectly elastic supply curve, such a demand increase has no effect on producer surplus. Consequently, assuming no price response basically assumes that there is no benefit to producers from promotion and, thus, could lead to a serious underestimate of the benefit of checkoff promotion to producers if the supply curve is, in fact, less than perfectly elastic.

Common Simplifying Assumption #3: No government intervention (free markets)

Government interventions have played a major role in many countries with various objectives such as increasing domestic supplies at reasonable prices, supporting farm revenues and income, the protection of domestic production from import competition, and the stimulation of exports. Many analyses of checkoff programs ignore the fact that farm price levels are supported or otherwise distorted by government policies. However, the transmission of the benefits of checkoff expenditures up the supply chain to producers can depend critically on the nature of government intervention in the agricultural sector. For the cotton checkoff program, for example, Williams et al. (2011) found that the U.S. taxpayer was the primary beneficiary of the program in many years. Despite substantial investments by cotton producers in the retail promotion of cotton products over the years, they found that the deficiency payment, counter-cyclical, and marketing loan programs in place over those years meant that the higher cotton prices generated by the cotton checkoff expenditures lead to farm program cost savings rather than increases in cotton producer revenues. Trade policies and domestic policies in other countries can also distort market signals along the global supply chain (Williams and Thompson 1984).

Figure 30 illustrates the importance of government intervention in the transmission of benefits to producers from commodity checkoff programs. Assume in Figure 30 that the farm price is supported by a non-recourse loan program or a counter-cyclical payment, price-loss coverage, a marketing loan, or similar program. Under any of those programs, production will be at Q which is in excess of the equilibrium production level of Q'. The market price will be at BP above the equilibrium price of BP' for a non-recourse loan program or at BP'' below the equilibrium price for the other types of government intervention. With a non-recourse loan program, the government essentially purchases the quantity DB off the market to keep the price supported at BP. With the other government programs, the government pays the farmer the difference between the announced price support (BP) and the market price (BP'').

Figure 30. The Effects of Assuming No Government Intervention to Support Farm Price and Revenue



If checkoff expenditures then shift out the demand curve to BDg', the market surplus for the government to purchase disappears under the non-recourse loan program.

Under the other programs, the market price rises to the support price level eliminating any government payments to farmers. In either case, neither the production nor the per unit revenue earned by the farmer changes so none of the benefit of the checkoff program accrues to producers. Instead, the checkoff program reduces government costs so that the taxpayer is the beneficiary of the checkoff program. Obviously, ignoring the effects of government intervention in the market in these cases could lead to the erroneous conclusion of a positive benefit to producers of the area BP'ABBP when, in fact, taxpayers realize all the benefits and none transmit up the supply chain to producers.

Common Simplifying Assumption #4: No Free Riders

Another common implicit if not explicit assumption in the analysis of checkoff programs is that there are no free riders. This assumption is sometimes implicitly made, for example, in using a single demand function to estimate the relationship between demand and checkoff expenditures when imports are an important source of supply in the market. More sophisticated empirical approaches to the analysis checkoff programs, however, also suffer from a similar problem. For example, a number of researchers, including Kinnucan and Cai (2011) and Beach et al. (2002), have examined the effects of checkoff-financed export promotion using a domestic sector model and an export demand equation to close the model. Export demand models have long been known to seriously underestimate the price elasticity of export demand (Orcutt, 1950; Gardiner and Dixit, 1987; and Reimer, Zheng, and Gehlhar, 2012). To the extent that such models also underestimate the supply response of foreign export competitors to the price changes generated by domestic demand promotion, the effects of free riders in international markets are also underestimated.

Figure 31. The Effects of Free-riders

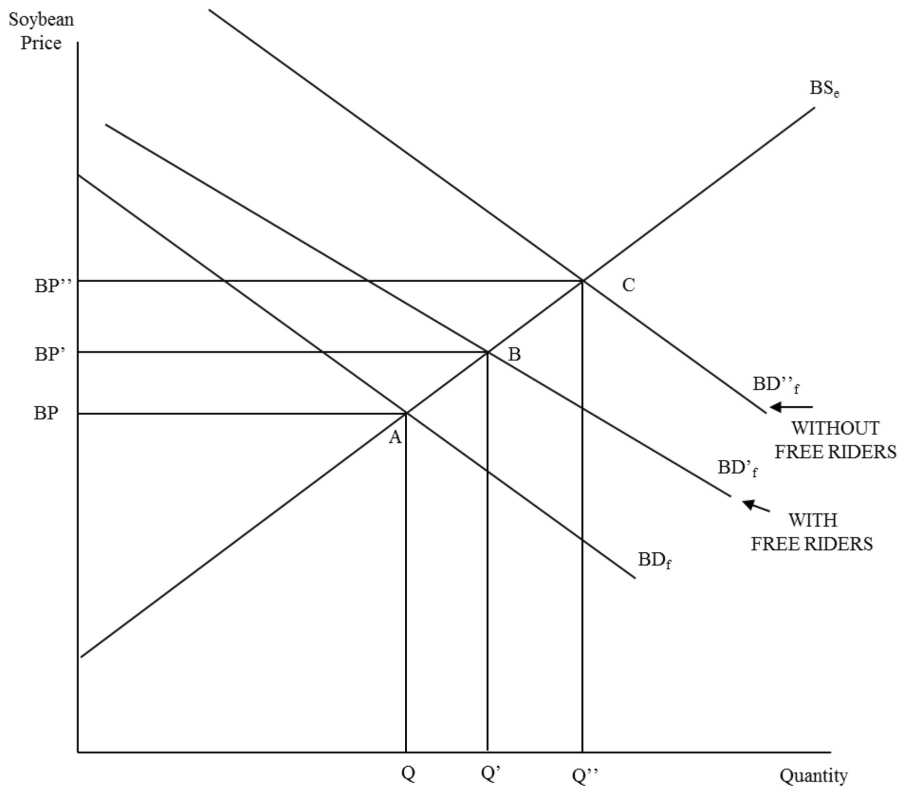


Figure 31 illustrates the free rider problem for the U.S. as a soybean exporting country and the impact of ignoring or underestimating the free rider effects. Before promotion, the initial equilibrium is at again point A with price BP and sales of Q. If the export competition facing the U.S. from Brazil and Argentina is ignored, then any promotion induced increase in world demand for soybeans would have no effect on soybean exports from Brazil and Argentina. Without free riders, the promotion shifts the demand curve from BD_f to BD''_f. Soybean sales increase from Q to Q'' and soybean price rises from BP to BP''. With free riders, the promotion shifts the demand curve from BD_f to BD'_f. Soybean sales increase from Q to only Q' rather than to Q" and soybean price rises from BP to BP'. The increase in U.S. soybean sales in this case would likely be less than in the case of no free rider response. Thus, both the value and volume of U.S. soybean exports would be lower than in the case of no free rider response and likely result in lower gains to U.S. producers than in the case of no free rider response.

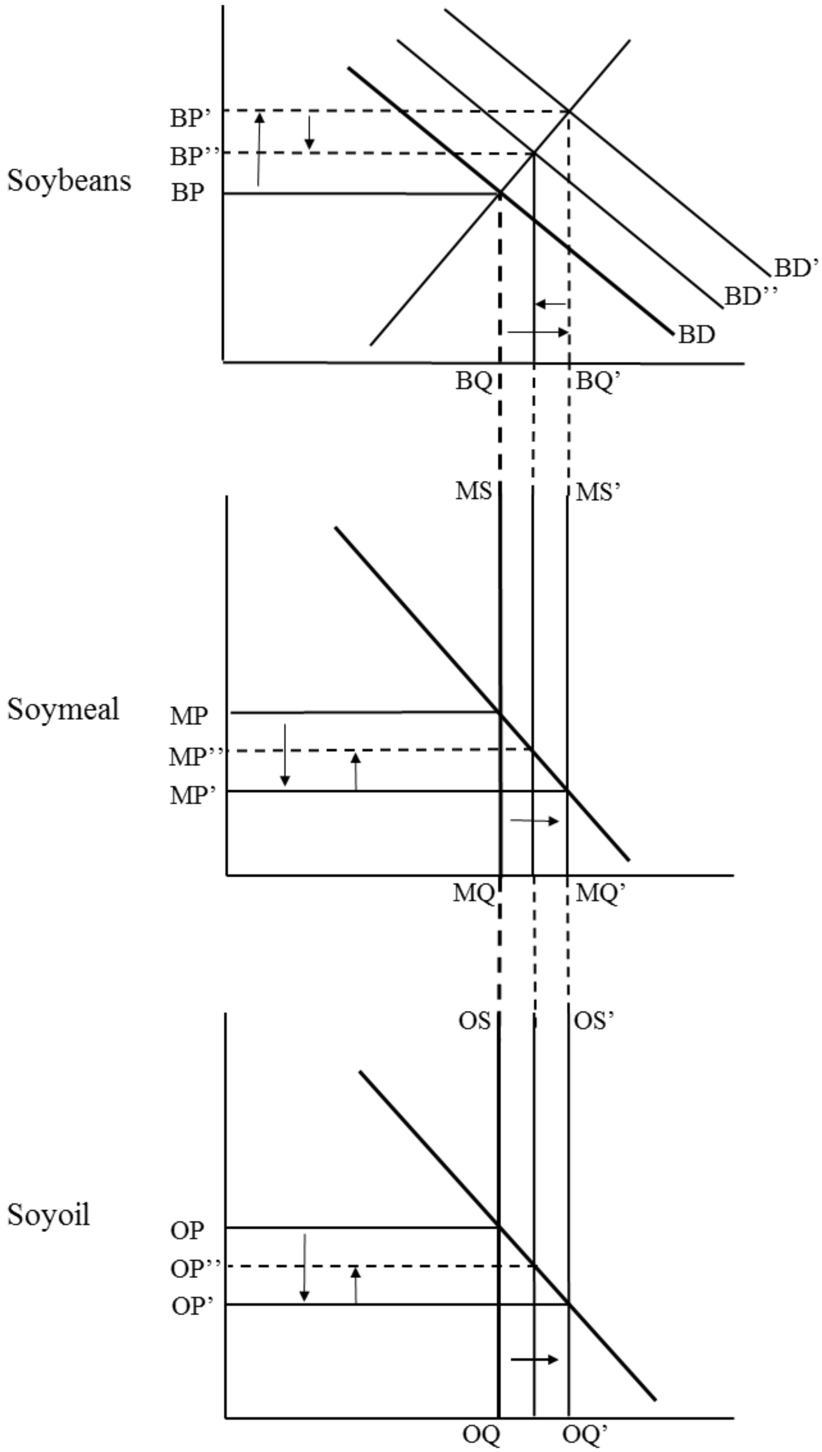
Common Simplifying Assumption #5: No Domestic Supply Chain Effects

Some analyses of checkoff programs ignore the fact that many commodities promoted with checkoff funds are components of often lengthy domestic supply chains. Consequently, their analyses ignore the potentially important checkoff-promotion-induced simultaneous interactions among different levels of the supply chain on the transmission of benefits to producers. The case of soybeans and its joint products, soymeal and soyoil, provides a clear example of the domestic supply chain problem.

Figure 32 represents the U.S. soybean and product chain in which the top set of supply and demand curves represent the soybean market, the middle set represents the soybean meal market, and the bottom set represents the soybean oil market. Note in the top graph that the equilibrium quantity of soybeans processed (BQ) at the equilibrium market price (BP) results in a supply of soybean meal and a supply of soybean oil represented by the vertical lines marked MS and OS, respectively in the bottom two graphs of Figure 32. The vertical nature of the MS and OS curves in Figure 32 reflects the fact that when soybeans are processed, a fixed amount of meal and oil are produced and that the quantity of meal and oil supplied to the market cannot change as their prices change unless the volume of soybeans processed changes first.

Now, if domestic soybean use is promoted leading to a rightward shift in the demand for soybeans from BD to BD' in the top graph of Figure 32, the consequence is not only an initial increase of soybean price to BP' and an increase in soybean crush to BQ' but also an increase in the supply of soymeal to MS' in the middle graph of Figure 32 and of soyoil to OS' in the lower graph of Figure 32. The result is lower prices in the markets for both joint products (MP' in the soymeal market and OP' in the soybean oil market). The lower prices for the soybean products reduces the profitability of processing soybeans (i.e., soybean crush margin declines) which shifts the soybean demand curve back somewhat to the left in the top graph of Figure 32. The process of simultaneous interactions between the soybean level of the supply chain and the soybean product levels of the supply chain continues until an equilibrium is reached. The equilibrium will occur at a soybean demand curve somewhere like BD" between BD and BD'. Thus, ignoring the supply chain effects leads to an overestimate of the price, quantity, and soybean producer surplus effects of the demand promotion.

Figure 32. The Effects of Domestic Supply Chain Interactions



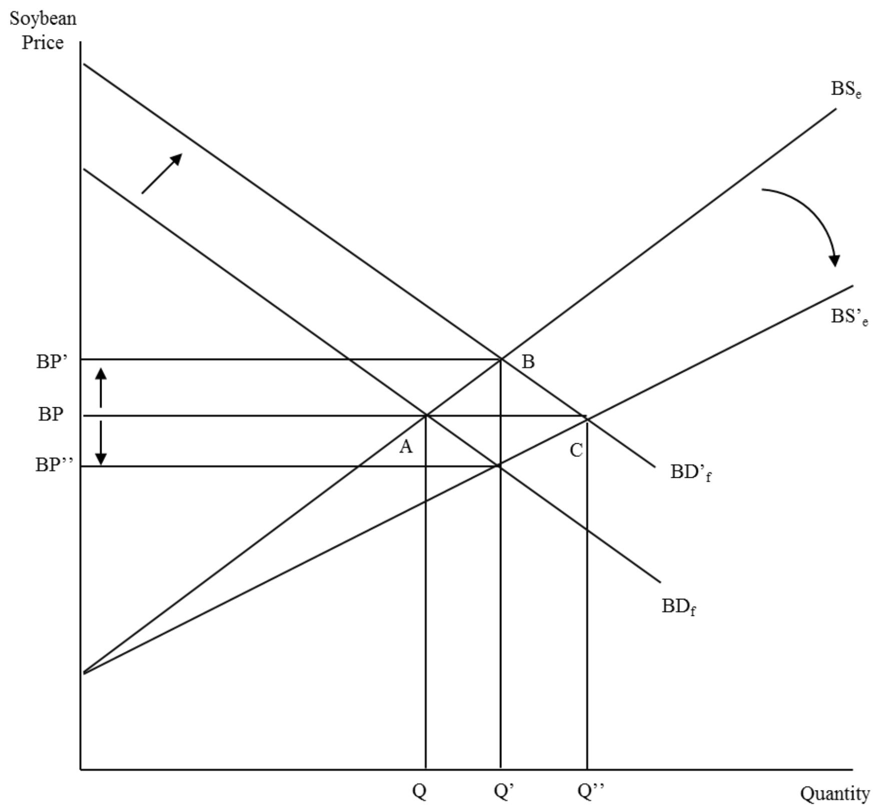
Common Simplifying Assumption #6: No Global Supply Chain Effects

Just as there are domestic supply chain effects from promoting commodities with checkoff funds, there are also global supply chain effects as well. The same shift of the demand curve in Figure 32 from promotion can have effects across the entire global soybean and products supply chain as the demand shift affects prices and trade of soybeans, meal, and oil. Failure to account for those effects can also seriously bias the calculation of producer benefits from checkoff promotion.

Common Simplifying Assumption #7: Checkoff Investments are Made only in Demand Promotion (No Checkoff Investments in Production Research)

The analyses of many checkoff programs for beef, dairy products, eggs, mangos, and a number of others analyze only the promotion effects of checkoff programs and ignore the fact that those programs simultaneously invest in production research with the objective of boosting producer profits through technological advances that reduce their production costs and/or boost their yields.

Figure 33. Market Effects of Simultaneous Checkoff Investments in Demand Promotion and Production Research



From a market perspective, if such research-induced technological advances are adopted by a majority of producers, the effect is an increase in the market supply of the commodity. While analyses of the separate effects of checkoff investments in research and in demand promotion may be instructive, such analyses ignore the tendency for the two types of investments to push market price in opposite directions when applied at the same time as illustrated in Figure 33. Before promotion, the initial equilibrium is at again point A with price BP and sales of Q. On its own, checkoff-funded demand promotion would tend to shift demand to BD'_f and increase price to BP' from BP in Figure 33. On the other hand, checkoff-funded research, on its own, would tend to shift out supply to BS'_e and reduce price to BP''. Funded at the same time, however, the price increasing effects of demand promotion are muted by the price-reducing effects of supply enhancement from research investments. The net effects on price could be higher, lower, or just about the same as the initial price (BP) depending on the relative shifts of the demand and supply curves as result of checkoff activities. While the two types of investments work together to generate more production and sales (from Q to Q'' in Figure 33), they work against each other in their effects on price. Clearly, ignoring the effects of checkoff investments in production research could lead to a serious overestimation of the benefits of a checkoff program to producers. Williams, Shumway and Love (2002) warned about this problem. More recently, Williams, Capps, and Lee (2014) have demonstrated that the investment strategy of the United Soybean Board over the years of increasing the share of checkoff funds invested in production research while reducing the share invested in demand promotion (domestic and foreign) has slowly erased the positive price effects reported for the program in earlier years.

Common Simplifying Assumption #8: Promotion Occurs Only at the Retail Level of the Supply Chain (No Promotion Programs at Multiple Levels of the Supply Chain)

The soybean checkoff program invests not only in the promotion of soybeans but also in the promotion of soybean oil and soybean meal, joint products of the processing of soybeans. In fact, the demand for soybeans is derived from the demand for its joint products. Some analyses of checkoff programs ignore the fact that many commodities promoted with checkoff funds occurs at multiple levels of the supply chains.

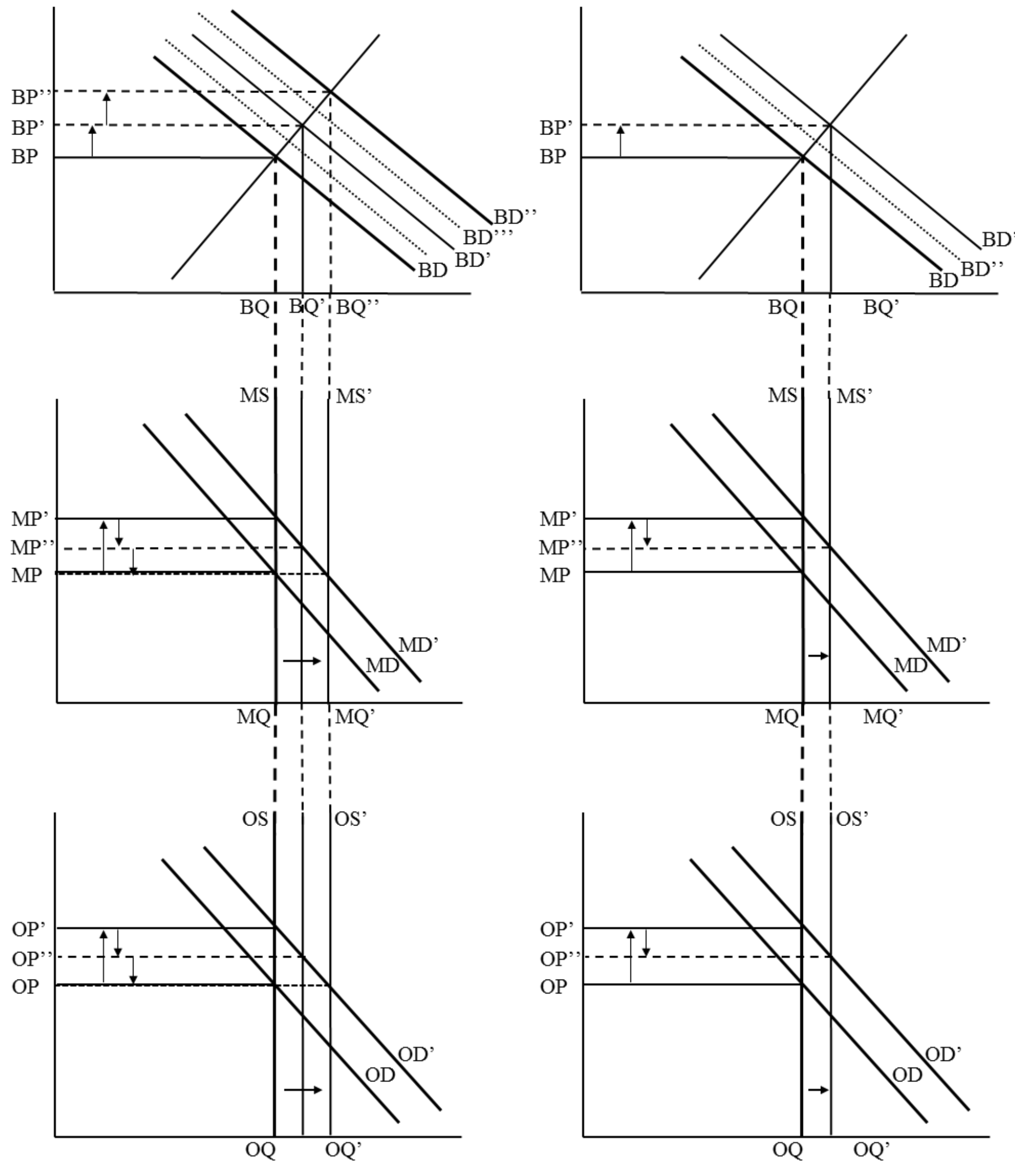
Consequently, their analyses ignore the potentially important checkoff-promotion-induced simultaneous interactions among different levels of the supply chain on the transmission of benefits to producers.

For example, if the demand for soybeans and its joint products are promoted, the consequence is higher soybean price, lower soymeal and soyoil prices but more quantity of soybeans produced and consumed as shown in the column of graphs on the left side of Figure 34. In those graphs, the top set of supply and demand curves represent the soybean market, the middle set represents the soybean meal market, and the bottom set represents the soybean oil market. Note in the top graph that the quantity of soybeans processed (BQ) at the market price (BP) results in a supply of soybean meal and a supply of soybean oil represented by the vertical lines marked MS and OS, respectively. The vertical nature of the MS and OS curves in Figure 34 reflects the fact that when soybeans are processed, a fixed amount of meal and oil are produced and that the quantity of meal and oil supplied to the market cannot change as their prices change unless the volume of soybeans processed changes first.

If the demand for soymeal and soyoil are promoted with checkoff funds, the result is a rightward shift of the soymeal and soyoil demand curves from MD to MD' and from OD to OD', respectively. As a result, prices of soymeal and soyoil increase from MP to MP' and from OP to OP' in the top left graph of Figure 34. The higher prices of joint products results in a rightward shift in the demand for soybeans from BD to BD' in the top left graph of Figure 34. At the same time, the increased volume of soybeans processed increases the supply of soymeal from MS to MS' and of soyoil from

SO to SO'. The result is lower prices in the markets for both joint products. The lower prices for the soybean products reduces the profitability of processing soybeans (i.e., soybean crush margin declines) which shifts the soybean demand curve back somewhat to the left in the top graph of Figure 34. If the demand for soybeans is promoted sametime with checkoff funds, the result is a rightward shift of the soybean demand curve to BD'' in the top left graph of Figure 34. As a result, the price of soybeans increases from BP' to BP''. The process of simultaneous interactions between the soybean level of the supply chain and the soybean product levels of the supply chain continues until an equilibrium is reached. The equilibrium will occur at a soybean demand curve somewhere between BD' and BD''. The equilibrium price will occur at somewhere between BP' and BP''.

Figure 34. Market Effects of Promotion Occurs Only at the Retail Level of the Supply Chain



Rather than promoting soybeans and soybean products in the multilevel markets, the checkoff promotion could focus on promoting the demand for the joint products. In the right hand column of graphs in Figure 34, which also represents the markets for soybeans and its joint products, the demand for both joint products are assumed to be promoted rather than soybeans. The resulting increased demand for soymeal and soyoil are represented by shifts of the soymeal and soyoil demand curves from MD to MD' and in the middle and bottom graphs of the right hand column of graphs in Figure 34. The result is an initial increase in prices of soymeal and soyoil to MP' and OP'. Higher prices increase the crush margin for soybean processors and leads to an increase in the demand for soybeans for processing (a shift of the soybean demand curve from BD to BD' in the top right panel of Figure 34). The increase in processing, however, increases the supply of both soybean meal and soybean oil to SM' and SO', respectively, in the right hand column of graphs in Figure 34. The increase in the soymeal and soyoil supply moderates the initial joint prices increase to some extent resulting in a somewhat lower prices like MP'' and OP''. The lower prices for the soybean products shifts the soybean demand curve back somewhat like BD" between BD and BD' to the right in the top graph of Figure 34. The equilibrium soybean price will occur at somewhere like between BP and BP'. Thus, ignoring the promotion programs at multiple levels of the supply chain effects leads to an overestimate of the price, quantity, and soybean producer surplus effects of the demand promotion.

The Conceptual Model of World Soybean and Product Markets

An analysis of the simultaneous effects of the soybean checkoff investments in U.S. soybean production research and in the promotion of the domestic and foreign demands for soybeans and soybean products requires an empirical model that accounts for the way in which U.S. and world soybean and soybean product markets function.

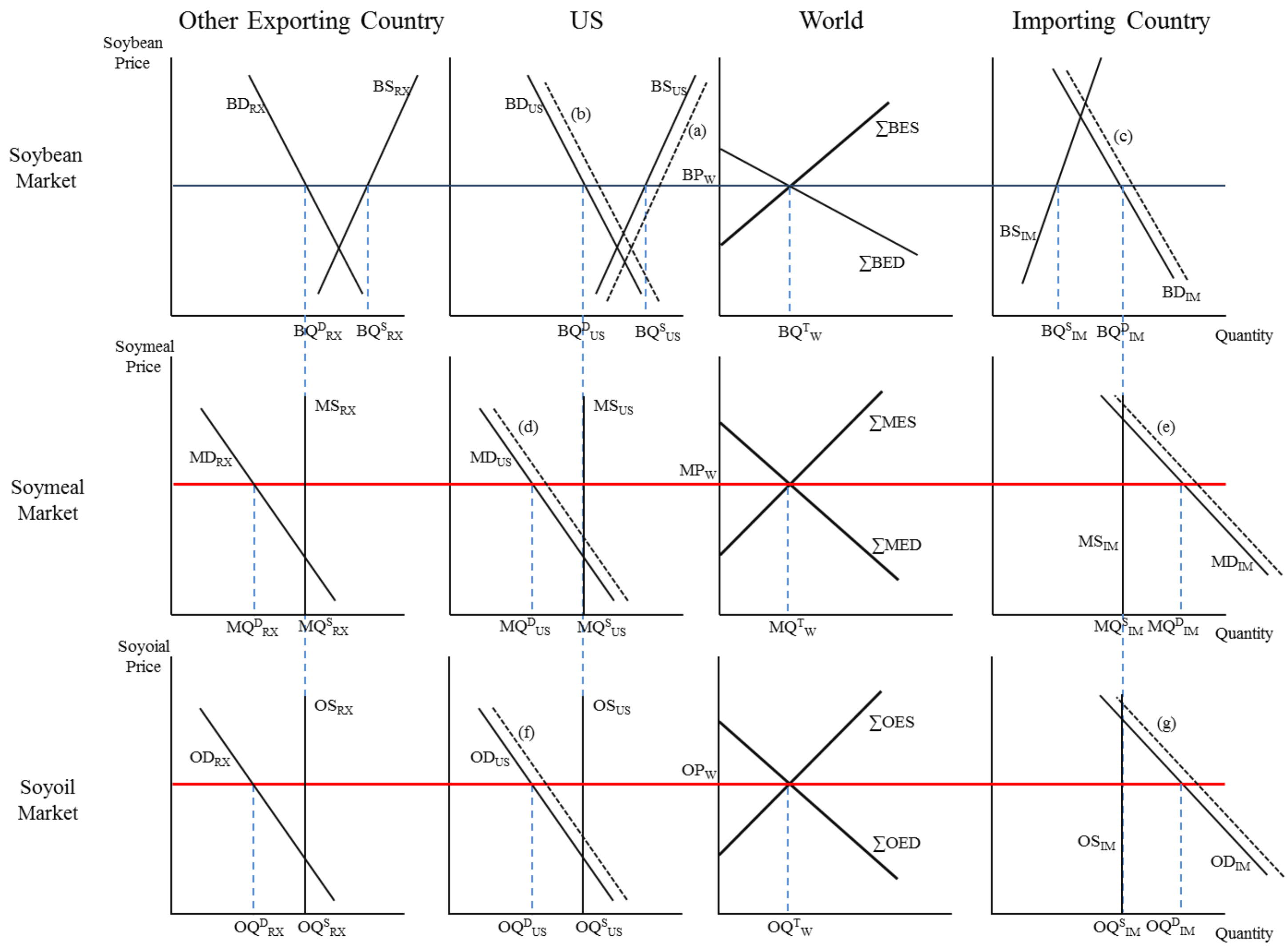
Once that model is developed, it can be used to analyze the implications of the many simplifying assumptions made in the analyses of checkoff programs for the transmission of benefits to producers.

The conceptual model of world soybean markets to be used in the analysis in later chapters is based on the work by Williams (1985) and updated versions of that model (Williams 1999; Williams, Shumway, and Love 2002; Williams, Capps, and Bessler 2009; Williams et al. 1998; and Williams, Capps, and Lee, 2014). The world soybean and products market model developed to be used in this analysis will include three soybean and soybean product exporting regions (U.S., Brazil, and Argentina) and four soybean and soybean product importing regions (China, Japan, EU, and a rest-of-the-world region). The soybean, soymeal and soyoil markets in the model are linked within each region and between regions. The model allows for the simultaneous determination of the supplies, demands, prices, and trade of soybeans, soymeal, and soyoil in all regions. For each region, soybean, soymeal and soyoil sectors contain behavioral relationships specifying the manner in supply and demand responds to changes in key variables including the prices of soybeans and soybean products, prices of competing commodities, technology, weather, income, livestock production, government policy, etc. as appropriate. Soybean checkoff expenditures impact the appropriate supply and demand functions in the model.

Figure 35 provides a conceptual representation of the world soybean market. For graphical simplicity, the model considers only two exporting regions, the U.S. and other exporting countries (RX), and an importing country region (IM). Also, exchange rates, transportation costs, and government interventions are ignored for analytical simplicity. Finally, we assume perfectly competitive markets.

The top row of graphs in Figure 35 represents soybean markets while the middle row represents soymeal markets and the bottom row represents soyoil markets. The supply of soybeans in each country (BS_{US}, BS_{RX}, and BS_{IM} for the U.S., other exporting countries, and importing countries, respectively) is upward sloping, indicating that a higher soybean price leads to an increase in the quantity of soybeans supplied to the market over time. Soybeans are mainly processed by the soybean crushing industry to produce soymeal and soyoil. Small amounts of soybeans are also demanded for feed, food, and inventory purposes. The crush demand for soybeans in each country (BD_{US}, BD_{RX}, and BD_{IM} for the U.S., other exporting countries, and importing countries) is downward sloping implying that a higher soybean price reduces the quantity of soybeans demanded for processing. The crush demand for soybeans also is affected by other variables such as the prices of soybean products and processing capacity in the corresponding country. Soybean excess supply (BES) and soybean excess demand (BED) are calculated as the difference between domestic soybean supply and demand schedules in the respective regions.

Figure 35. The Graphical Representation of the World Soybean Market



The horizontal summation of the excess supplies of soybeans by exporting countries is the world soybean excess supply (ΣBES). The horizontal summation of the excess demands for soybeans by importing countries is the world soybean excess demand (ΣBED). The equilibrium world soybean price (BP_W) and equilibrium volume of trade (BQ^T_W) are determined at the intersection of ΣBES and ΣBED. Given the price of soybeans, the volume of soybean crushed in the U.S. is BQ^D_{US} is crushed, and exports are the difference between U.S. soybean production and consumption ($BQ^S_{US} – BQ^D_{US}$). In importing countries, BQ^S_{IM} is volume of soybeans produced in those countries, BQ^D_{IM} is the volume consumed, and imports are the difference between consumption and production ($BQ^D_{IM} – BQ^S_{IM}$).

In all countries, soybeans are crushed to produce soyoil and soymeal. Extraction rates may vary across countries depending upon the oil and protein content of the soybeans and crushing technology. In each importing and exporting country/region in the model, once the crush volume of soybeans is determined, the volume of soymeal and soyoil produced is proportionally fixed. The vertical nature of the soybean meal and oil supply curves in Figure 35 is a graphical device to indicate that the quantity of soybean products supplied can only change in any country or region when the soybean price increases if soybean crushers first respond to the change in the soybean price by demanding more soybeans to produce additional soybean products. When that occurs, the vertical soybean meal and oil curves then shift to reflect the effects of the soybean price change on soybean crush and, therefore, the volume produced of soymeal and soyoil.

In soymeal and soyoil exporting countries/regions, the differences between the domestic supplies and demands for each soybean product are their excess supplies (MES and OES). Excess demands for soybean products in importing countries/regions are the differences between their respective domestic demands and supplies (MED and OED). Given the derived demand nature of soybeans, the crush demand for soybeans in each country/region shifts left or right depending on changes in the prices of the soymeal and soyoil joint products. Higher world soymeal or soyoil prices, for example, enhance the profitability of crushing soybeans and, thus, increase the domestic crush demand for soybeans.

In the world soymeal market, the horizontal summation of soymeal excess supplies from exporting countries is the world soymeal excess supply curve (ΣMES in Figure 35). The horizontal summation of the excess demands for soymeal by importing countries is the world soymeal excess demand curve (ΣMED). The equilibrium world soymeal price (MP_W) and the equilibrium volume of soymeal traded ($MQ^T{}_{WD}$) are determined at the intersection of ΣMES and ΣMED. Given the equilibrium price of soymeal (MP_W), $MQ^D{}_{US}$ of soymeal is consumed domestically in the U.S., $MQ^S{}_{US}$ is volume of soymeal produced in the U.S., and the difference ($MQ^D{}_{IM} – MQ^D{}_{US}$) is the volume of U.S. soymeal exported. For importing countries, $MQ^S{}_{IM}$ is the volume of soymeal produced domestically, ($MQ^D{}_{IM}$) is the volume of soymeal consumed in those countries, and the difference ($MQ^D{}_{IM} – MQ^S{}_{IM}$) is volume of soymeal imported by those countries.

The same derivation also applies to the U.S., importing and other exporting country soyoil markets. The horizontal summation of soyoil excess supplies from all exporting countries is the world soyoil excess supply curve (ΣOES) in Figure 34. The horizontal summation of excess soyoil demands by importing countries is the world soyoil excess demand curve (ΣOED). The equilibrium world soyoil price (OP_W) and the equilibrium world volume of soyoil traded (OQ^T_W) are determined at the intersection of ΣOES and ΣOED. Given OP_W, OQ^D_{US} is volume of soyoil consumed in the U.S., OQ^S_{US} is the volume produced in the U.S., and difference ($OQ^S_{US} – OQ^D_{US}$) is volume of U.S. soyoil exported. For importing countries, OQ^S_{IM} is the volume of soyoil produced domestically, (OQ^D_{IM}) is the volume of soyoil consumed in those countries, and the difference ($OQ^D_{IM} – OQ^S_{IM}$) is volume of soyoil imported by those countries.

Graphical Analysis of Checkoff Expenditure Effects

Soybean checkoff expenditures are made to: (1) enhance U.S. soybean production through investments in production research, (2) promote domestic U.S. demands for soybeans, soybean meal, and soybean oil, and (3) promote foreign demands for soybeans, soymeal, and soyoil. As depicted in Figure 35, production research investments of soybean checkoff funds are intended to expand the U.S. area under soybean production as well as to boost soybean productivity leading to a rightward shift of the U.S. soybean supply curve (shift (a) shown in Figure 35). Domestic promotion of soybeans, soymeal, and soyoil intend to shift out the U.S. demands for the three commodities (shifts (b), (d), and (f) shown in Figure 35). The international marketing investments of soybean checkoff funds are intended toshift out the demand for all three products in importing countries (shifts (c), (e), and (g) in Figure 35). The net effect of all shifts (a) through (g) in Figure 35 on U.S. and world markets is graphically intractable and depends critically on various factors, including the price elasticities of supply and demand in importing and exporting countries, the size of the respective checkoff investments (and, thus, the shifts of the corresponding curves), and the responsiveness of supply and demand in the U.S. and importing countries to checkoff investments (i.e., the relative checkoff investment elasticities).

To provide some insights into the likely market effects of the various types of checkoff investments, this section graphically analyzes the effects of each independently of the others. The analysis of the simultaneous effects of all checkoff investments at all levels of the market requires an empirical analysis. Following this discuss, a conceptual model capable of analyzing those simultaneous effects is proposed.

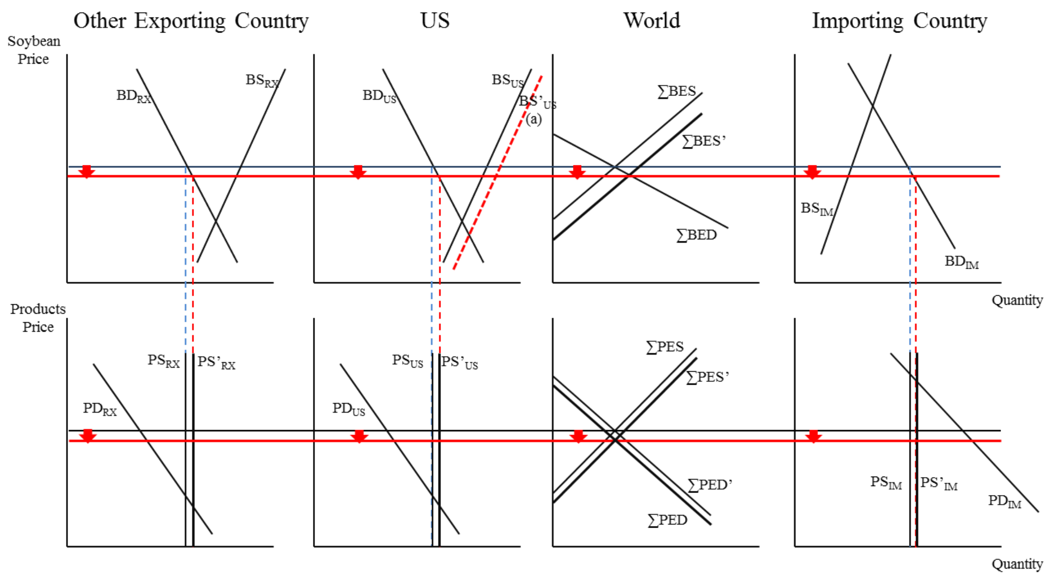
Soybean Checkoff Expenditures in Soybean Markets

The market effects of soybean checkoff expenditures are complicated since investments are made to enhance soybean production as well as to promote both domestic and foreign soybean demand. Figure 36 shows illustrates the effects of checkoff investments only in soybean production research. Figure 36 as well as subsequent figures in this chapter represent "soybean products" rather than soymeal and soyoil separately when distinguishing between the effects on the two joint product markets is not of interest.

Soybean Checkoff Investments in U.S. Soybean Production Research

A checkoff investment in production research leads to either cost-reducing or yield enhancing effects on soybean production shown as a shift to the right and/or down of the U.S. soybean supply curve (BS_{US}) and, therefore, of the U.S. excess supply of soybeans which shifts the world excess supply of soybeans (ΣBES in Figure 36) to the right. As a consequence, the world price of soybeans declines and the world trade in soybeans increases. The lower world soybean price results in an increase in the quantity of soybeans crushed and, therefore, in the supply of soybean products in all countries.

Figure 36. Checkoff Expenditure Invested in Production Research

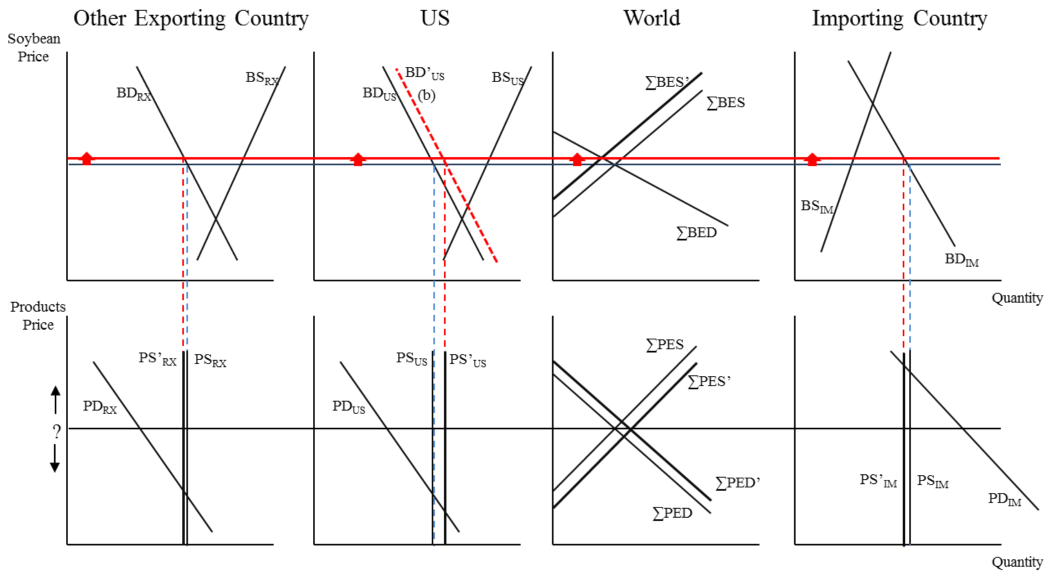


The subsequent increase in the domestic production of soybean products in all countries results in an increase in the U.S. excess supply of soybean products by the U.S. and other exporting countries and a decline in the excess demand for soybean products by importing countries. The consequence is an unambiguous decline in the prices of soybean products and an ambiguous change in the world volume of soybean product trade. The soybean product price decline reduces the crush margin in all countries and shifts crush demand curves to the left in all countries somewhat, moderating the soybean price decline to some extent (not shown in Figure 36). Thus, while soybean-checkoff-funded soybean production research is expected to increase U.S. soybean exports at a lower price, the prices of soybean products also decline and soymeal consumption increases in all countries with an indeterminate effect of soybean product exports.

Soybean Checkoff Investments in the Promotion of U.S. Soybean Demand

Soybean checkoff expenditures to boost domestic soybean demand shifts the domestic demand for soybean curve (BD_{US} in Figure 37) to the right (shift (b) in Figure 37). Consequently, the world excess supply of soybeans (ΣBES) declines which pressures the world price of soybeans upward. The higher soybean price squeezes the crush margin in importing countries resulting in a decline in the crush volume in those countries while the crush volume in the U.S. increases.

Figure 37. Checkoff Expenditure Invested in U.S. Soybean Demand Promotion

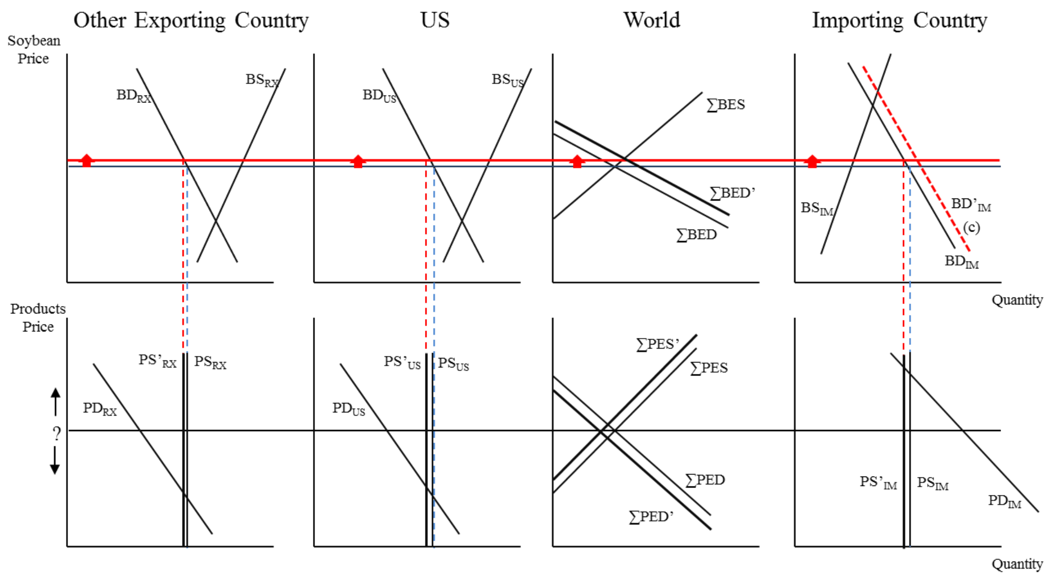


The changes in soybean crush volume will affect the production and prices of soybean products in each country. In the U.S., the increase in soybean crush increases soybean product supply and U.S. excess supplies of soybean products. Just the opposite happens in importing countries with a decline in the volume of soybeans crush and, therefore, a decline in the domestic production of soybean products and increase in the excess demand for soybean products. Consequently, exports of soybean products unambiguously increase but the effect on the price of soybean products is indeterminate. Thus, the domestic promotion of U.S. soybean demand increases the soybean price, expands the domestic use of soybeans, and substitutes increased exports of soybean products for the reduced exports of soybeans.

Soybean Checkoff Investments in the Foreign Demand for Soybeans

Soybean checkoff investments in promoting the foreign demand for soybeans has the opposite effects on U.S. domestic soybean demand and exports and U.S. soybean product exports from that of the promotion of the domestic demand for soybeans. The foreign promotion of soybean demand shifts the foreign demand for soybeans (BD_{IM} in Figure 38) to the right (shift (c) in Figure 38). The result is an increase in world soybean excess demand (ΣBED to ΣBED') which results in higher world price of soybeans.

Figure 38. Checkoff Expenditure Invested in Promoting Foreign Soybean Demand



The higher world soybean price results in the shortfall in soybean crush demand in each country. Consequently, the U.S. crush volume of soybean declines while the demand for soybeans in an importing country increases. The result is an increase in productions of soybean products in an importing country and a simultaneous decline in soybean product production in the U.S. Thus, U.S. soybean product export supplies decline at the same time that the soybean product import demand in an importing country declines. The result is an unambiguous decline in world soybean product trade and an indeterminate effect on the price of soybean products. So the promotion of the demand for soybeans in an importing country tends to trade off increased U.S. soybean exports for reduced U.S. soybean product exports.

Soybean Checkoff Expenditure Investment in Soybean Product Markets

Soybean checkoff expenditure to promote U.S. soybean products demand shifts the soybean products demand curve (PD_{US} in Figure 39) to the right (shift (d) in Figure 39) which reduces U.S. soybean products exports and pressures the soybean products price upwards. The leftward shift of excess supply of soybean products export country leads to a higher world soybean products price. The higher soybean products price increases the crush margin in all countries resulting in a rightward shift of the soybean demand curve in all countries. The soybean price increases with an indeterminate effect on U.S. soybean exports. At the same time, as the soybean crush demand increases in each country, the production of soymeal in all countries increases as well. The result is a smaller increase in the soybean products price and domestic consumption and a smaller decline in soymeal exports than originally shown.

The analysis of soybean checkoff expenditures to promote the foreign demand for soybean products is similar to that of the promotion of domestic demand except that the result is a decrease in domestic consumption of soymeal and an increase in U.S. exports of soymeal (shift (e) in Figure 40).

Figure 39. Soybean Checkoff Expenditures to Promote U.S. Soybean Products Demand

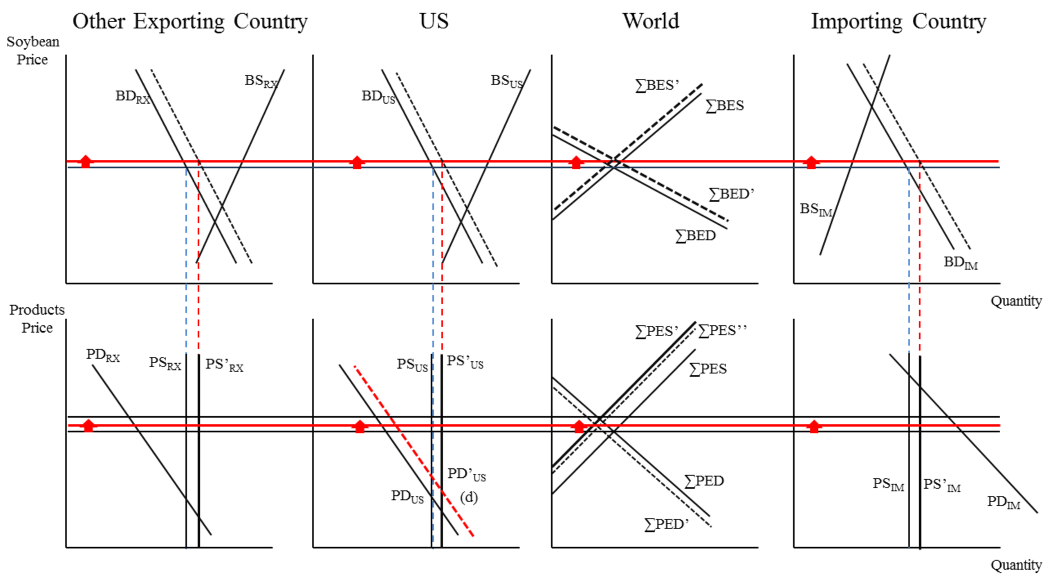
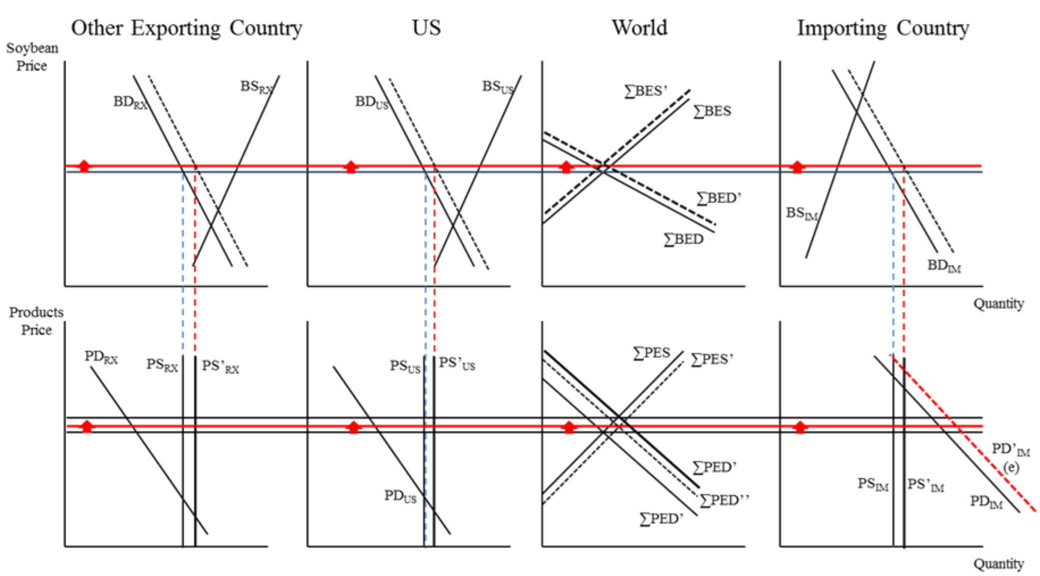


Figure 40. Soybean Checkoff Expenditures to Promote Foreign Soybean Products Demand



CHAPTER IV

MODEL PARAMETER ESTIMATION, DATA, AND VALIDATION

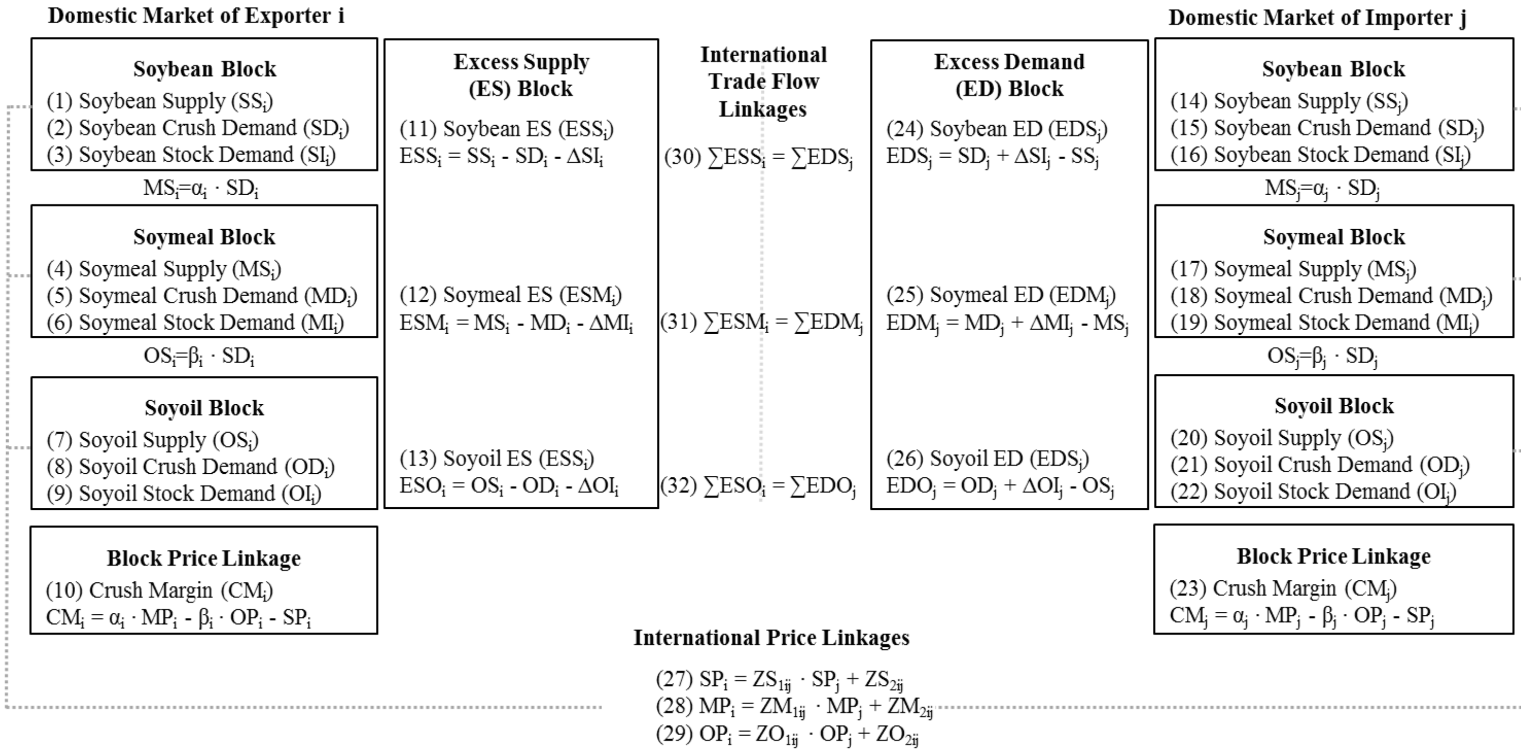
To measure the returns to soybean checkoff program investments in research and demand promotion and to analyze the effects of the simplifying assumption used in other checkoff analyses on the transmission of benefits to producers, the first step is to isolate the effects of those investments in domestic and foreign soybean and soybean product markets from those of other events that may have affected those same markets over the years. For this purpose, a world model of soybeans and soybean product trade which includes soybean checkoff research, domestic promotion, and foreign demand promotion stock variables as explanatory variables is first constructed. The world soybean and soybean products model developed is presented and the econometric estimates of the model parameters are discussed, the data used are described, and the model is validated through simulation analysis. In the next chapter, the results of simulating the model over the 1980/81-2012/13 period under alternative assumptions regarding soybean checkoff research and domestic and international market promotion investments are reported. The results used to analyze the implications of those assumptions for the calculation of the transmission of the benefits to producers.

The Structural Model of World Soybean and Products Markets

The analysis of the transmission of returns to producers from the soybean checkoff program and the impacts of alternative assumptions on those returns in this study utilizes a 194-equation, annual econometric, non-spatial, price equilibrium simulation model of world soybean and soybean product markets. The model develop and presented here is based on the world soybean and products model known as SOYMOD developed by Williams (1981) and used over the years to analyze various issues related to world soybean and products markets (see, for example, Williams and Thompson 1984, Williams 1985, Williams 1994, Williams 1999, Williams Shumway, and Love 2002, and Williams, Capps, and Bessler 2009, and Williams, Capps, and Lee 2014 for more details on SOYMOD). Because it has its roots in the early work of Houck, Ryan, and Subotnik (1972), SOYMOD is similar in form and specification to the world oilseed models utilized by FAPRI/CARD (2014), Meilke and Griffith (1983), and Meilke, Wensley, and Cluff (2001).

The model developed in this study allows for the simultaneous determination of the supplies, demands, prices, and trade of soybeans, soymeal, and soyoil in seven major world trading regions: (1) the United States, (2) Brazil, (3) Argentina, (4) the European Union, (5) Japan, (6) China, and (7) a Rest-of-the-World region which accounts for the effects of primarily smaller, new demand growth areas in world soybean markets. The domestic market of each region in the model is divided into four simultaneous blocks of equations: (1) a soybean block, (2) a soybean meal block, (3) a soybean oil block, and (4) an excess supply or excess demand block (Figure 41).

Figure 41. Structure of World Soybean and Soybean Products Model



Note: i = any exporter i=1, ... , n; and j = any importer j=1, ... , k. Also, Δ should be read "change in."
The ZS, ZM and ZO include all multiplicative (e.g. exchange rates and ad valorem subsidies) and additive (transportation costs, specific tariffs, etc.) measures that come between prices of country i and j.
α and β are meal and oil extraction rates; SP, MP, and OP are soybean, soyoil, soymeal prices.

Source: Williams, Capps, and Bessler 2009

For each region, the first three blocks contain behavioral relationships specifying the manner in which soybean supply (acreage planted, acreage harvested, soybean yields, and production), soybean domestic demand (crush and stocks), and the supply, consumption, and stocks of soybean meal and soybean oil behave in response to changes in variables like prices of soybeans and products, prices of various competing commodities, technology, income, livestock production and prices, government policy, etc. as appropriate.

For the U.S., the soybean block contains regional rather than national acreage planted, acreage harvested, yield, and production equations (equation (1) in Figure 41) for seven U.S. production regions (Atlantic, Cornbelt, Delta, Lakes, Plains, South, and Other) to represent the soybean supply relationship and account for interregional competition within the United States:

(1) $AS_{kt} = AS_{kt}(SP^e, RS_{kt}, \alpha_{kt}),$

(2) $HS_{kt} = HS_{kt}(AS_{kt}),$

(3) $YS_{kt} = YS_{kt}(RS_{kt}, \Theta_{kt}),$

(4) $SS_{kt} = YS_{kt} \bullet HS_{kt}$

where k = U.S. production region 1, ..., 7; t = time period; AS = soybean acreage planted; HS = soybean acreage harvested; YS= soybean yield; SS = soybean production; RS = soybean research stock variable; α and θ are appropriate shift variables and SP^e = expected real soybean farm price defined for each region as:

(5) $SP^e = MAX(SP_{t-1}, LS_t) \bullet D5901 + MAX(SP_{t-1}, 0.85 \bullet TS_t + 0.15 \bullet MAX(SP_{t-1}, LS_t)) \bullet D0212$

where SP = the real farm soybean price; LS = the real soybean loan rate; TS = real soybean target price; D5901 = indicator variable which equals 1 for 1959/60 through 2001/02 and 0 otherwise; and D0212 = indicator variable which equals 1 for 2002/03 through 2012/13 and 0 otherwise.

For other countries and regions in the model where soybean production is important (Brazil, Argentina, and China), the soybean block contains one national harvested acreage equation and a corresponding soybean production identity:

(6) $HS_{it} = HS_{it}(SP_e, \alpha_{it}),$

(7) $SS_{it} = YS_{it} \bullet HS_{it}$

where i = non-U.S. soybean producing country (Brazil, Argentina, China); t = time, and PS_e = expected real soybean price defined for each country as the lagged soybean price. The specification of the domestic demand functions (D) in the soybean, soybean meal, and soybean oil blocks of each country in the model (corresponding to equations (2), (5), and (8) for the United States and equations (15), (18), and (21) for importing regions in Figure 41) include promotion stock variables, referred to as “goodwill” variables (G), to capture the effects of soybean check-off funded promotion activities in each region where such activities have been conducted:

(8) $D_{ist} = D_{ist}(P_{ist}, G_{ist}, ß_{ist})$

where i = only the U.S. and importing countries (Japan, the EU-27, China, and the Rest-of-the-world; s = commodity (soybeans, soybean meal, and soybean oil); t = time period; P = domestic market price; G_{is} = promotion stock variables, and β represents appropriate shift variables.

Simultaneous interaction of soybean and soybean product markets within each region in SOYMOD is insured through the endogenous soybean crush margin (equations (10) and (23) in Figure 41) which is the own price variable in the crush demand equations ((2) and (15) in Figure 41). The fourth block in each domestic market (equations (11)-(13) and (24)-(26) in Figure 41) of the model includes net excess supply relationships for exporting regions and net excess demand relationships for importing regions specified as the residual differences between their respective domestic supply and demand schedules.

The soybean and soybean product markets of the trading countries in the model are linked through international price and trade flow relationships. The prices of soybeans, soymeal, and soyoil in exporting and importing regions are linked through price transmission equations (equations (27)-(29) in Figure 42) following Bredahl, Meyers, and Collins (1979) which account for the effects of exchange rates as well as tariffs, export subsidies, border taxes, transportation costs, etc. and other factors (the Zij) that drive a wedge between prices in each world region. International market clearing conditions (equations (30)-(32) in Figure 41) require equality of the world excess supply and demand for soybeans, soymeal, and soyoil in each time period.

The U.S. portion of the model includes seven production regions and the full model includes seven world trading countries/regions. The U.S. component of the model also includes a sub-model of the U.S. corn market which features regional acreage and production as well as national consumption (feed, food, other), inventory, price, and net export demand relationships and operates at both the farm and wholesale levels. The U.S. corn market relationships are included in SOYMOD given the importance of corn as a substitute in regional soybean production and as a complement in national livestock feed demand.

Model Parameter Estimation

The model parameters are estimated using the Ordinary Least Squares (OLS) estimator using annual data for 1960/61 through 2012/13 where data are available for that full period. A longer time period is used for some equations where data are available, such as the regional U.S. acreage planted, acreage harvested, and yield equations. Normalization by an exogenous price index maintains linear homogeneity in prices. Two or three-stage least squares procedures sometimes are used in the estimation of simultaneous systems. In this case, however, the large size of the model and associated endogenous and exogenous variables and the limited number of annual observations for a number of equations resulted in a greater number of predetermined variables than observations. Given that the efficiency gained in parameter estimation with the use of 2SLS and 3SLS is actually consistent with a large number of data points, OLS is the estimator of choice in this analysis. Because the time period of the data available across equations is highly non-uniform, a system estimator like 3SLS could not be used to estimate the behavioral equation parameters in the model.

The following discussion describes equations and estimation results with parameters estimates and various regression statistics, including standard errors, Durbin-h and Durbin Watson statistics, and the corrected R^2 for the equations in each country/region in the model. Variable definitions are in the Appendix A.

U.S. Sub Model

The soybean supply component of the U.S. sub-model consists of behavioral equations for acreage planted, acreage harvested, and yield in seven U.S. production regions (Cornbelt, Delta, South, Plains, Lakes, Atlantic and Other). The model also includes identities explaining production, and expected prices in each of the seven regions (Table 1).

Table 1. The U.S. Soybean Supply Component of the World Soybean Model

Regional and Total U.S. Acreage Planted

(1) ASOYSAC = -425.3898 + 796.9325*ASOYPCC/UFPI67(-1) − 471.8455*ACORPPC/UFPI67(-1) − 752.3993*AOATPPC/UFPI67(-1) +
(416.87) (92.40) (199.64) (336.47)
0.7125*ASOYSAC(-1) − 620.6839*D1011 + 1035.851*D82 + 310.320*DASOYSA +
(0.04) (136.13) (194.59) (126.58)
$\sum_{n=1}^{12} ASOYSACn$*LOG(ASOYRESDF/UFPI67)
Adj. R^2=0.9411 Dh=0.2191 ASOYSACn=1.3566, 2.4871, 3.3914, 4.0697, 4.5219, 4.7480, 4.7480, 4.5219, 4.0697, 3.3914, 2.4871, 1.3566 (t-values=1.4829) for n=lag period

(2) CSOYSAC = -3819.739 + 1374.160*CSOYPCC/UFPI67(-1) − 2644.954*CCORPPC/UFPI67(-1) + 0.7185*CSOYSAC(-1) − 1062.961*D03T05
(1759.81) (358.29) (785.08) (0.05) (529.12)
− 5055.051*DRGHT07 + 3939.797*D73 + 2056.838*D7879 + $\sum_{n=1}^{2} CSOYSACn$*LOG(CSOYRESDF/UFPI67)
(885.23) (877.52) (674.63)
Adj. R^2=0.9894 Dh=0.2328 CSOYSACn=439.482, 439.482 (t-values=1.4829) for n=lag period

(3) DSOYSAC = -1701.628 + 829.9335*DSOYPCC/UFPI67(-1) − 267.8094*DCORPPC/UFPI67(-1) − 236.1900*DWHEPPC/UFPI67(-1)
(1048.42) (207.29) (104.15) (292.06)
+ 0.7720*DSOYSAC(-1) + 1455.756*D49T82 − 687.27*DRGHT07 + 1061.104*D9308 − 1487.107*D01 +
(0.04) (307.35) (430.44) (302.45) (436.94)
+ $\sum_{n=1}^{4} DSOYSACn$*LOG(DSOYRESDF/UFPI67)
Adj. R^2=0.9746 Dh=0.0041 DSOYSACn=34.7887, 52.1831, 52.1831, 34.7887 (t-values=1.4829) for n=lag period

(4) LSOYSAC = -553.4381 + 783.7250*LSOYPCC/UFPI67(-1) − 1248.894*LCORPPC/UFPI67(-1) − 1018.265* LBARPPC/UFPI67(-1)
(707.36) (166.30) (526.14) (426.74)
+ 0.8471*LSOYSAC(-1) + 113.7729*DFB96 − 590.3213*DLBW − 1417.723*DRGHT07
(0.07) (191.12) (148.27) (389.78)
+ $\sum_{n=1}^{12} LSOYSACn$*LOG(LSOYRESDF/UFPI67)
Adj. R^2=0.9840 Dh=-0.0665 LSOYSACn=6.2245, 11.4115, 15.5612, 18.6734, 20.7482, 21.7856, 21.7856, 20.7482, 18.6734, 15.5612, 11.4115, 6.2245 (t-values=1.4829) for n=lag period

Table 1 Continued.

(5) OSOYSAC = -89.6529 + 94.9415*OSOYPCC/UFPI67(-1) − 104.8972*OCORPPC/UFPI67(-1) + 0.7702*OSOYSAC(-1) + 81.0652*DOSOYSA1
(37.71) (17.96) (39.62) (0.05) (18.45)
− 58.2743*DOSOYSA2 + $\sum_{n=1}^{29} OSOYSACn$*LOG(OSOYRESDF/UFPI67)
(13.17)
Adj. R^2=0.9890 DW=2.1468 Dh=-0.4462 OSOYSACn=0.0992, 0.1945, 0.2770, 0.3557, 0.4275, 0.4925, 0.5506, 0.6019, 0.6464, 0.6840, 0.7148, 0.7388, 0.7559, 0.7661, 0.7695, 0.7661, 0.7559, 0.7388, 0.7148, 0.6840, 0.6464, 0.6019, 0.5506, 0.4925, 0.4275, 0.3557, 0.2770, 0.1945, 0.0992 (t-values=1.4829) for n=lag period

(6) PSOYSAC = -1367.743 + 507.6680*PSOYPCC/UFPI67(-1) − 521.6744*PCORPPC/UFPI67(-1) − 894.0700*OWHEPPC/UFPI67(-1)
(832.40) (189.78) (580.01) (403.66)
+ 0.8485*PSOYSAC(-1) + 930.9177*DFB96 + 1088.262*D60T64 − 306.4439*D71T79 − 746.2320*DPSOYSA1
(0.03) (169.99) (369.33) (185.63) (149.22)
− 3099.740*DPSOYSA2 − 1561.810*DPSOYSA3 + $\sum_{n=1}^{10} PSOYSACn$*LOG(PSOYRESDF/UFPI67)
(264.79) (218.91)
Adj. R^2=0.9959 DW=1.9022 Dh=0.3662 PSOYSACn=12.7067, 22.8720, 30.4960, 35.5787, 38.1201, 38.1201, 35.5787, 30.4960, 22.8720, 12.7067 (t-values=1.4829) for n=lag period

(7) SSOYSAC = -2260.208 + 1603.485*SSOYPCC/UFPI67(-1) − 1492.635*SCORPPC/UFPI67(-1) + 0.6505*SSOYSAC(-1) + 1631.154*D62T82
(345.44) (161.64) (339.49) (0.04) (227.96)
− 708.7166*D1011+ 861.8043*D78T84 − 458.3851*D6465 + + $\sum_{n=1}^{12} SSOYSACn$*LOG(SSOYRESDF/UFPI67)
(203.22) (219.20) (223.20)
Adj. R^2=0.9860 DW=2.2964 Dh=-1.1022 SSOYSACn=3.5309, 6.4734, 8.8274, 10.5928, 11.76982, 12.3583, 12.3583, 11.7698, 10.5928, 8.8274, 6.4734, 3.5309 (t-values=1.4829) for n=lag period

Regional and Total U.S. Acreage Harvested

(8) ASOYSHC = -5823.78 + 0.9986*ASOYSAC + 2.8620*TIME
(872.4) (0.01) (0.44) Adj. R^2=0.9960 DW=1.9084

(9) CSOYSHC = -117.442 + 0.9945*CSOYSAC
(114.50) (0.004) Adj. R^2=0.9992 DW=2.1294

Table 1 Continued.

(10) DSOYSHC = -22.6499 + 0.9753*DSOYSAC
(50.40) (0.01) Adj. R^2=0.9977 DW=2.0655

(11) LSOYSHC = -18.4087 + 0.9870*LSOYSAC
(22.78) (0.003) Adj. R^2=0.9995 DW=1.5767

(12) OSOYSHC = -3.8308 + 0.9881*OSOYSAC − 22.8495*D60T64
(1.30) (0.002) (2.33) Adj. R^2=0.9997 DW=2.0802

(13) PSOYSHC = -28.5613 + 0.9835*PSOYSAC
(19.98) (0.002) Adj. R^2=0.9997 DW=1.8874

(14) SSOYSHC = -107.024 + 0.9698*SSOYSAC
(30.40) (0.01) Adj. R^2=0.9980 DW=1.6011

Regional Soybean Yields

(15) ASOYSYC = 4.7275 − 0.0568*LA_NINA − 1.3991*EL_NINO + 3.6799*D88T12 + $\sum_{n=1}^{2} ASOYSYCn$*LOG(ASOYRESDF/UFPI67)
(4.13) (0.85) (0.84) (1.29)
Adj. R^2=0.6059 DW=2.1706 ASOYSYCn=0.8830, 0.8830 (t-values=1.4829) for n=lag period

(16) CSOYSYC = 8.4462 − 2.5615*LA_NINA + 0.5193*EL_NINO + 4.4863*D75T02 + 3.4821*D92T02 + 12.6560*D04T12 + 4.3935*DCOYSYC
(2.81) (0.60) (0.57) (0.89) (0.95) (1.55) (1.00)
+ $\sum_{n=1}^{2} CSOYSYCn$*LOG(CSOYRESDF/UFPI67)
Adj. R^2=0.9299 DW=2.1378 CSOYSYCn=0.8817, 0.8817 (t-values=1.4829) for n=lag period

(17) DSOYSYC = 14.0867 − 0.4133*LA_NINA − 0.4822*EL_NINO + 11.4088*D02T12 + $\sum_{n=1}^{5} DSOYSYCn$*LOG(DSOYRESDF/UFPI67)
(2.30) (0.88) (0.88) (1.23)
Adj. R^2=0.7577 DW=1.8646 DSOYSYCn=0.1265, 0.2023, 0.2276, 0.2023, 0.1265 (t-values=1.4829) for n=lag period

Table 1 Continued.

(18) LSOYSYC = -5.7083 − 1.1449*LA_NINA + 0.9331*EL_NINO + $\sum_{n=1}^{8} LSOYSYCn$*LOG(LSOYRESDF/UFPI67)
(2.69) (1.08) (1.03)
Adj. R^2=0.7927 DW=1.7371 LSOYSYCn=0.2258, 0.3951, 0.5080, 0.5645, 0.5645, 0.5080, 0.3951, 0.2258
(t-values=1.4829) for n=lag period

(19) OSOYSYC = 28.2843 − 1.1205*LA_NINA − 2.2830 *EL_NINO + 7.6005*D03T12+ $\sum_{n=1}^{17} OSOYSYCn$*LOG(LSOYRESDF/UFPI67)
(1.29) (1.12) (1.10) (1.50)
Adj. R^2=0.7329 DW=2.1140 OSOYSYCn=0.0139, 0.0261, 0.0367, 0.0456, 0.0530, 0.0587, 0.0628, 0.0652, 0.0660,
0.0652, 0.0628, 0.0587, 0.0530, 0.0456, 0.0367, 0.0261, 0.0139
(t-values=1.4829) for n=lag period

(20) PSOYSYC = -2.1790 − 2.0285*LA_NINA + 1.0856 *EL_NINO + $\sum_{n=1}^{2} PSOYSYCn$*LOG(PSOYRESDF/UFPI67)
(2.02) (0.99) (0.99)
Adj. R^2=0.8099 DW=1.8225 PSOYSYCn=2.0922, 2.0922 (t-values=1.4829) for n=lag period

(21) SSOYSYC = 23.1708 − 0.7777*LA_NINA + 0.2240*EL_NINO + 7.8780*D02T12 + $\sum_{n=1}^{5} SSOYSYCn$*LOG(SSOYRESDF/UFPI67)
(1.11) (1.06) (1.06) (1.45)
Adj. R^2=0.5728 DW=1.8044 SSOYSYCn=0.0478, 0.0764, 0.0860, 0.0764, 0.0478 (t-values=1.4829)
for n=lag period

Regional and Total U.S. Production

(22) ASOYSPC=ASOYSYC*ASOYSHC
(23) CSOYSPC=CSOYSYC*CSOYSHC
(24) DSOYSPC=DSOYSYC*DSOYSHC
(25) LSOYSPC=LSOYSYC*LSOYSHC
(26) OSOYSPC=OSOYSYC*OSOYSHC
(27) PSOYSPC=PSOYSYC*PSOYSHC
(28) SSOYSPC=SSOYSYC*SSOYSHC
(29) USOYSPC=(CSOYSPC+LSOYSPC+PSOYSPC+ASOYSPC+SSOYSPC+DSOYSPC+OSOYSPC)/1000

Regional Market Price (Farm Level)
(30) ASOYPFC = -0.0369 + 1.0092*USOYPFC − 0.7978*D08
(0.07) (0.01) (0.20) Adj. R^2=0.9946 DW=2.2691

Table 1 Continued.

(31) CSOYPFC = -0.0639 + 1.0167*USOYPFC + 0.5774*D76
(0.02) (0.003) (0.07) Adj. R^2=0.9993 DW=1.3665

(32) DSOYPFC = 0.1756 + 0.9766*USOYPFC − 1.3083*D07
(0.07) (0.01) (0.21) Adj. R^2=0.9934 DW=1.5733

(33) LSOYPFC = 0.0093 + 0.9803*USOYPFC + 1.0047*D76
(0.04) (0.01) (0.12) Adj. R^2=0.9978 DW=1.5705

(34) OSOYPFC = -0.1394 + 1.0144*USOYPFC
(0.08) (0.01) Adj. R^2=0.9921 DW=2.3219

(35) PSOYPFC = -0.0945 + 0.9798*USOYPFC + 0.8864*D76
(0.03) (0.004) (0.08) Adj. R^2=0.9990 DW=2.3987

(36) SSOYPFC = -0.0481 + 1.0091*USOYPFC
(0.05) (0.01) Adj. R^2=0.9969 DW=2.3005

Regional Expected Farm Price

(37) ASOYPCC=MAX(LAG(ASOYPFC),ASOYPLC)*D5901+MAX(LAG(ASOYPFC),0.85*USOYPTC +0.15*MAX(LAG(ASOYPFC),ASOYPLC))*D0212
(38) CSOYPCC=MAX(LAG(CSOYPFC),CSOYPLC)*D5901+MAX(LAG(CSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(CSOYPFC),CSOYPLC))*D0212
(39) DSOYPCC=MAX(LAG(DSOYPFC),DSOYPLC)*D5901+MAX(LAG(DSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(DSOYPFC),DSOYPLC))*D0212
(40) LSOYPCC=MAX(LAG(LSOYPFC),LSOYPLC)*D5901+MAX(LAG(LSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(LSOYPFC),LSOYPLC))*D0212
(41) OSOYPCC=MAX(LAG(OSOYPFC),OSOYPLC)*D5901+MAX(LAG(OSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(OSOYPFC),OSOYPLC))*D0212
(42) PSOYPCC=MAX(LAG(PSOYPFC),PSOYPLC)*D5901+MAX(LAG(PSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(PSOYPFC),PSOYPLC))*D0212
(43) SSOYPCC=MAX(LAG(SSOYPFC),SSOYPLC)*D5901+MAX(LAG(SSOYPFC),0.85*USOYPTC +0.15*MAX(LAG(SSOYPFC),SSOYPLC))*D0212

The estimated parameters for the area planted equations in all seven regions are significant with correct signs, no serial correlation, and high adjusted R-squares (equations (1)-(7) in Table 1). In all seven regions, soybean acreage planted is significantly influenced by the expected soybean farm price. The estimated short-run and long-run own-price elasticities across regions are within the inelastic range, ranging from a low of 0.111 for the Cornbelt region to a high of 0.783 for the South region (Table 2).

Table 2. Estimated U.S. Soybean Acreage and Yield Elasticities[a]

U.S. Production Region	U.S. Planted Acreage				U.S. Yield	
	Soybean Farm Price		Research Stock		Research Stock	
	Short Run	Long Run	Short Run	Long Run	Short Run	Long Run
Atlantic	0.5607***	1.9503***	0.0034*	0.0119*	0.0198***	0.0688***
Corn Belt	0.1106***	0.3928***	0.0080***	0.0284***	0.0132***	0.0471***
Delta	0.2681***	1.1758***	0.0055**	0.0240**	0.0076***	0.0334***
Lakes	0.2512***	1.6425***	0.0042**	0.0275**	0.0154***	0.1007***
Other	0.5120***	2.2282***	0.0107***	0.0465***	0.0057***	0.0246***
Plains	0.1406**	0.9280**	0.0075***	0.0494***	0.0141***	0.0930***
South	0.7827***	2.2394***	0.0083***	0.0224***	0.0043***	0.0123***

[a] Elasticities evaluated at the means of the data based on the coefficients used in the simulation model. *** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.

This range of elasticities makes intuitive sense because producers in the Cornbelt region participate extensively in government programs which considerably reduces their responsive to movements in the market prices of soybeans and other crops. At the same time, corn is the only real substitute in production for soybeans in that region. On the other hand, producers in the South plant a much larger range of crops and tend to move more quickly out of the production of one crop and into the production of another given changes in relative prices. In the regional soybean area planted equations, prices of substitute crops include corn price in the Cornbelt, corn and wheat prices in the Delta, corn price in the South region, corn and wheat prices in the Plains region, corn and barley prices in the Lakes region, corn and oats prices in the Atlantic region, and corn price in the Other region are found to be statistically significant.

Soybean checkoff research stock variables (RS_k) are also arguments of the regional soybean planted equations (equations (1)-(7) in Table 1). The RS_k are formulated based on two main results from previous research on the returns to research: (1) research benefits are not immediate so that a lag exists from the time the expenditures are made and possible real time adoption of results in the field and (2) research results from many years ago may still yield benefits for a number of years into the future. Consequently, the RS_k are formed as weighted averages of historical soybean checkoff expenditures on production research at the national and state level measured in constant dollars to account for the time lag in the impact of research expenditure. In general, for any U.S. region k:

$$(9) \quad RS_k = \sum_{r=i}^{s} \lambda_r IS^*_{t-r}, \quad \sum_{r=i}^{s} \lambda_r = 1$$

where $IS_t^* = IS_t/p_t$ is the constant-dollar research investment in year t, IS_t is the nominal-dollar research investment in year t, p_t is the corresponding research price index, λ_r is the weight on the constant dollar research expenditures lagged r years, i is the number of years before the first impact, and s is the lag length over which research investments are expected to impact farm decisions. The RSk are proxies for the quantity of effective research in each region (k).

Because research expenditures tend to reduce production costs and/or increase yields, two sets of research stock variables are developed – one set for use in the regional acreage equations (equations (1)-(7) in Table 1) and the second for use in the regional yield equations (equations (15)-(21) in Table 1). Cost-reducing production research expenditures affect soybean production by shifting the acreage planted function to the right while yield-enhancing production research expenditures affect soybean production by shifting the yield function to the right.

To determine which of several alternative weighting schemes and lag structures on production research investment is preferred for purposes of defining the acreage and yield research stock variables, a series of model specifications were tested, balancing fit and forecasts (or parsimony) in possible models. The Akaike Information Criterion (AIC) was used as the model selection metric. The model specification that minimized the AIC criterion for both regional acreage and yield was a second-degree polynomial distributed lag model with both head and tail restrictions and a delay of one period between actual expenditures of (real) check-off production research dollars and new technology adoption and use in the field across all seven U.S. soybean production regions. The optimal lag length, however, differed substantially by production region for both acreage and yield functions.

For regional soybean acreage, the longest lag length was determined for the Other region at 29 periods followed by the Atlantic, Lakes and South regions at 12 periods, the Plains region at 10 periods, the Delta region at four periods, and the Cornbelt region at two periods. Besides the real regional research expenditures and the expected regional real soybean farm prices as defined in equation (5), other explanatory variables in the seven regional acreage equations (the α_{kt} in equation (1) above) included the expected real prices of competing crops in each region as appropriate, and soybean acreage in the previous year. Equations (37)-(43) in Table 1 are the expected regional soybean farm prices equations. Crop year data over the time period 1959/60 to 2012/13 were used.

For regional soybean yields, the longest optimal lag length was determined for the Other region at 17 periods followed by the Lakes region at 8 periods, the Delta and South region at 5 periods, and the Atlantic, Cornbelt, and Plains regions at two periods. Besides the real regional research expenditures, other explanatory factors of the regional yield equations (the Θ_{kt} in equation (3) above) included weather effects (El Niño and La Niña).

The estimated elasticities of regional soybean acreage and yields with respect to the regional soybean research stock variables are provided in Table 2. With few exceptions, the research stock elasticities are statistically significant at the 1% level. The short-run and long-run research stock elasticities of regional soybean planted acreage are all quite small ranging from 0.0034 in the Atlantic region to 0.0107 in the Other region (short-run) and from 0.0119 in the Atlantic region to 0.0494 in the Plains region (long-run). The short-run and long-run research stock elasticities of regional soybean yields are somewhat higher ranging from 0.0043 in the South region to 0.0198 in the Atlantic region (short-run) and from 0.0123 in the South to 0.1007 in the Lakes region (long-run).

The soybean acreage harvested is determined in the model by soybean acreage planted (equations (8)-(14) in Table 1). The regional harvested acreage estimation results indicate that, on average, about 98.5% of planted acres are harvested. Soybean production in each region is defined in the model as acreage harvested times yield (equations (22)-(28) in Table 1). Total U.S. soybean production (USOYSPC) is the sum of soybean production in all of the regions (equations (29) in Table 1). Also, regional soybean farm prices are linked in the model to the national soybean farm price (USOYPFC) (equations (30)-(36) in Table 1). A coefficient of the national soybean farm price in each of the equation is close to one implies that in the long-run regional soybean farm prices and the national soybean farm price were nearly equal.

Soybean crush demand (USOYDCC) is significantly influenced by the crush margin (USOYGCC), soybean processing capacity (UOISCPC), the availability of soybeans for processing (as measured by the sum of beginning soybean stocks ($USOYHTC_{-1}$) and soybean production (USOYSPC)), and soybean checkoff expenditures represented by the stock of soybean checkoff expenditures to promote U.S. soybean demand (equation (1) in Table 3). The promotion stock variables used as a regressor in this equation and those used in the soybean demand equations in importing countries as well as in the soymeal and soyoil demand equations in the U.S. and in importing countries were constructed following Williams (1999), Williams, Shumway, and Love (2002), Williams, Capps, and Bessler (2009), and Williams, Capps, and Lee

(2014) as weighted averages of the respective inflation- and exchange-rate-adjusted expenditures on promotion activities in each region.

To capture diminishing marginal returns to domestic and foreign checkoff promotion expenditures, a square root transformation each was used for each promotion stock variable. In most evaluations of the effectiveness of promotion campaigns, a logarithmic transformation of promotion expenditures is used to capture diminishing marginal returns. However, because of the presence of zero promotion expenditures for some commodities in some years in some regions, a square root transformation was used in this study following the work of Williams, Capps, and Bessler (2009), Williams, Capps, and Lee (2014), and others.

To account for the time lag in the impact of the promotion investments on the soybean, soybean meal, and soybean oil demands in each region, Williams (1999) and Williams, Shumway, and Love (2002) used a second order polynomial inverse lag (PIL) formulation based on Mitchell and Speaker (1986). The Almon polynomial distributed lag (PDL) is an alternative lag formulation commonly used in the analysis of advertising effectiveness (see, for example, Williams, Capps, and Bessler (2009) and Williams, Capps, and Lee (2014)). Other lag models have been employed in the literature on checkoff promotion programs, including moving averages and unrestricted lags of varying lengths.

Table 3. The U.S. Soybean Demand Component of the World Soybean Model

Soybean Demand, and Market Clearing Condition

(1) USOYDCC = 96.6819 + 34.12*USOYGCC/UWPI67R + 0.1729*UOISCPC + 0.3167*(LAG(USOYHTC)+USOYSPC)
(23.8) (15.1) (0.04) (0.03)
+ 4.9496*LAG(SQRT(USOYEXP)) + 154.3876*D88T07 + 63.5100*D97T01 + 57.2607*D7071 + 88.5448*D0812
(0.8) (13.3) (18.1) (25.2) (28.4)
Adj. R2=0.9939 DW=2.2944

(2) USOYHEC = -96.2691 − 77.6716*USOYPFC/UFPI67 + 69.1946*UCORPPC/UFPI67 + 0.1150*USOYSPC − 0.3409*USOYHGC
(63.00) (16.92) (35.26) (0.01) (0.12)
+ 0.3508*LAG(USOYHEC) + 171.1127*D60T94 + 149.5038*DSUSOYP + 219.9866*D0506
(0.05) (21.63) (25.40) (32.11) Adj. R2=0.9040 Dh=0.0375

(3) USOYPWC = 0.1440 + 1.0223*USOYPFC + 1.102*D7287 + 1.2137*D10
(0.08) (0.01) (0.17) (0.26) Adj. R2=0.9922 DW=2.0800

(4) USOYGCC=USOMQ*USOMPWC/1000+USOOQ*USOOPWC/100−USOYPFC

(5) USOYHEC=USOYHTC−USOYHGC

(6) USOYHTC=LAG(USOYHTC)+USOYSPC+USOYMMC-USOYDCC−USOYMEC−USOYDZC

Soybean Meal Supply, Demand, and Market Clearing Condition

(7) USOMSPC=USOMQ*USOYDCC

(8) UHPMDDC = -821.1583 − 31.3650*UHIPMPWC/UWPI67R + 9.7083*UYDA/UCPI67 + 3.2031*UCORDFC
(758.4) (4.3) (0.53) (0.2)
+ 72.0192*LAG(SQRT(USOMEXP)) + 972.0786*D75T84 + 938.2113*D88T91 − 1069.300*D97T10 + 2230.950*DUHPMDD
(13.3) (223.1) (351.0) (345.4) (302.3)
Adj. R2=0.9949 DW=1.5994

Table 3 Continued.

(9) UCOMDPC = 0.0398 − 0.0547*(USOMDPC+UPEMDPC)*UCOMPWC/(USOMDPC*USOMPWC+UPEMDPC*UPEMPWC)
(0.01) (0.02)
+ 0.7572*(.8103*UCOMSPC)/(USOMSPC+.8103*UCOMSPC+1.124*UPEMSPC) + 0.3706*LAG(UCOMDPC)
(0.08) (0.07)
+ 0.0049*D67T93 − 0.0332*D6080
(0.002) (0.01) Adj. R2=0.9791 Dh=-0.2065

(10) USOMDPC=1−UCOMDPC−UPEMDPC

(11) UHPMDDC=USOMDDC/USOMDPC

(12) USOMPWC=(UHPMPWC−UCOMDPC*UCOMPWC−UPEMDPC*UPEMPWC)/USOMDPC

(13) USOMHEC = 231.0272 − 0.7531*USOMPWC/UWPI67R + 0.3298*LAG(USOMHEC) + 292.9165*LAG(EMBARGO) − 81.4235*D60T70
(98.91) (0.24) (0.07) (39.25) (17.43)
+ 236.3429*D82 − 53.7256*D91T04 + 112.1968*DUSOMH
(38.87) (14.10) (17.43) Adj. R2=0.8362 Dh=-0.1440

(14) USOMDDC=LAG(USOMHEC)+USOMMMC+USOMSPC-USOMDZC-USOMHEC-USOMMEC

Soybean Oil Supply, Demand, and Market Clearing Condition

(15) USOOSPC=USOOQ*USOYDCC

(16) UOLODDC = 1390.356 − 48.7039*UOLOPWC/UWPI67R + 20.9764*ULAOPWC/UWPI67R + 10.0755*UYDA/UCPI67
(364.3) (10.6) (6.90) (0.3)
+ 31.4586*LAG(SQRT(USOOEXP)) − 2554.645*DUECRIS + 554.1306*D69T82 + 1053.619*D89T95 − 1124.589*D12
(8.09) (238.5) (140.2) (201.0) (401.3)
Adj. R2=0.9943 DW=2.1965

(17) UCOODPC = 0.0205 − 0.0179* (USOODPC+UPEODPC)*UCOOPWC/(USOODPC*USOOPWC+UPEODPC*UPEOPWC)
(0.01) (0.01)
+ 0.1625*UCOOSPC/(USOOSPC+UPEOSPC) + 0.7362*LAG(UCOODPC) + 0.0238*D6004 − 0.0260*D66
(0.05) (0.07) (0.01) (0.01)
Adj. R2=0.9828 Dh=-0.3389

Table 3 Continued.

(18) $\text{USOODPC}=1-\text{UCOODPC}-\text{UPEODPC}$

(19) $\text{USOODDC}=\text{UOLODDC}*\text{USOODPC}$

(20) $\text{UOLOPWC}=\text{UCOODPC}*\text{UCOOPWC}+\text{UPEODPC}*\text{UPEOPWC}+\text{USOOPWC}*\text{USOODPC}$

(21)
$$\underset{(436.7)}{\text{USOOHEC} = 509.4553} - \underset{(19.57)}{45.1976}*\text{USOOPWC/UWPI67R} + \underset{(0.02)}{0.1095}*\text{USOOSPC} - \underset{(0.51)}{1.0236}*\text{USOOMGC} + \underset{(2.20)}{2.111}*\text{USOOHGC}$$
$$+ \underset{(0.10)}{0.4566}*\text{LAG(USOOHEC)} - \underset{(0.10)}{0.3354}*\text{LAG2(USOOHEC)} - \underset{(184.6)}{740.836}*\text{D96T98} - \underset{(195.2)}{799.82}*\text{D01T03} - \underset{(229.2)}{803.7}*\text{D0412}$$

Adj. R2=0.8705 Dh=0.6821

(22) $\text{USOOMEC}=\text{USOOMTC}-2.20462*\text{USOOMGC}$

(23) $\text{USOOHEC}=\text{USOOHTC}-\text{USOOHGC}$

(24) $\text{USOOHTC}=\text{LAG(USOOHTC)}+\text{USOOSPC}+\text{USOOMMC}-\text{USOODZC}-\text{USOOMTC}-\text{UOLODDC}*\text{USOODPC}$

The lag formulation and lag length used for each demand equation for each commodity (soybeans, soymeal, and soyoil) in each relevant region of the model (U.S., EU15/27, Japan, China, and the Rest-of-the-World) were selected using the process described earlier for production research expenditures. Although the PIL does not require specifying the lag length, it is conceptually an infinite lag. Thus, the use of the PIL lag formulation imposes the assumption on the model that advertising expenditures in one period have infinitely long impacts over time on consumption. Consequently, in testing for lag length, the PIL model was not included leaving the PDL formulation, moving averages, and simple lags of varying lengths as the potential lag formulations to be considered.

The search for the pattern and time period over which soybean checkoff promotion expenditures influence soybean and soybean product demand in each region in the model involved a series of nested OLS regressions. For each lag formulation considered, lags of up to 10 years were considered and for the PDL up to fourth degree polynomials with alternative choices of head and tail restrictions. Based on a composite set of criteria, including the Akaike Information Criterion (AIC), the Schwarz statistic, and heuristic measures[1] (i.e., the number of significant parameters and the number of expected signs on own-price demand response), a second order PDL of one lag with head and tail restrictions was selected for U.S. soybeans, soymeal, and soyoil demand functions.

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[1] The heuristic aspect of the composite criteria may be viewed as *ad hoc* but is equivalent to restricting the class of models to be only those consistent with underlying theory. This procedure is commonly encountered in the literature, especially in analyses where equilibrium displacement models are used and only parameter values consistent with theory are utilized.

For foreign market demands, simple, one-year lags of the square root transformation of the respective demand promotion expenditure variables were selected using the same criteria. Before being transformed in this way, however, the demand promotion expenditure variables for the U.S. and foreign markets were first deflated by the wholesale price index in the respective regions. The foreign demand promotion expenditure variables were converted from U.S. dollars to foreign currency using the respective exchange rates.

The crush margin (USOYGCC) used in the U.S soybean demand equation is defined in the model as the soymeal extraction rate (USOMQ) multiplied by soymeal wholesale price plus the soyoil extraction rate (USOOQ) multiplied by soyoil wholesale price minus the soybean farm price (equation (4) in Table 3). Dummy variables (D88T07, D97T01, D7071, and D0812) are also added to capture the unobservable effects (equation (1) in Table 3).

As expected, the results show that crush margin is statistically significant at the 5% level and the promotion stock is statistically significant at the 1% level implying that a higher crush margin and a larger amount of the demand promotion expenditures increase soybean crush demand (equation (1) in Table 3). The estimated elasticity of soybean crush demand with respect to gross soybean crush margin is 0.014, indicating that soybean crush demand is not highly responsive to crush margin. The estimated elasticity of soybean crush demand with respect to promotion stock of soybean checkoff expenditures for soybeans is 0.023 (Table 4). Soybean processing capacity and the availability of soybeans for processing are also statistically significant at the 1% level implying that larger facilities and more available resources increase soybean crush demand (equation (1) in Table 3). Those variables in equation (1) in Table 3 account for 99.4% of the variation in the U.S soybean demand equation. The value of Durbin-Watson is 2.2944, approximately equal to 2, indicating no serial correlation.

Soybean private ending stocks (USOYHEC) are an identity in the model calculated as total ending stocks (USOYHTC) minus government ending stocks (USOYHGC) (equation (5) in Table 3). Note that private ending stocks of soybeans also were estimated to be a function of the soybean farm price, the expected farm price of corn, soybean production, beginning private stocks of soybeans and government soybean ending stocks (equation (2) in Table 3). Dummy variables (D60T94, DSUSOYP, and D0506) are also added to capture the unobservable effects. In simulation, this equation was re-normalized on the soybean price. A higher soybean price was found to significantly reduce private ending stocks of soybeans while a higher corn price was found to significantly increase those stocks. The soybean production, beginning private stocks of soybeans, and government soybean ending stocks are statistically significant at the 1% level. A larger soybean production and larger beginning private stocks of soybeans were found to reduce private ending stocks of soybeans while a larger government soybean ending stocks were found to increase those stocks. Those variables in equation (2) in Table 3 account for 90.4% of the variation in the soybean private ending stocks equation. The value of Durbin-h is 0.0375, approximately equal to 0, indicating no serial correlation.

The national wholesale price of soybeans (USOYPWC) is estimated in the model as a function of the national farm price of soybeans (equation (3) in Table 3). Dummy variables for year 1972, 1987 and 2010 are also added to capture the unobservable effect. The coefficient of the national farm price of soybeans is statistically significant at the 1% level. On average, the wholesale price was found to 2.23% higher than the national soybean farm price.

Total soybean ending stocks (USOYHTC) are calculated in the model as the sum of the total beginning stocks of soybeans, soybean production, and soybean imports minus the sum of soybean crush, soybean exports and seed, feed, and other use of soybeans (equation (6) in Table 3). This is the market clearing identity in the U.S. soybean model.

Table 4. Estimated Domestic Price and Promotion Stock Elasticities of U.S. and Foreign Demand[a]

	Domestic Price (S)			Promotion Stock		
	Soybeans[b]	Soymeal[c]	Soyoil[c]	Soybeans	Soymeal	Soyoil
U.S.	0.014**	-0.095***	-0.035***	0.023***	0.032***	0.035***
EU	0.055***	-0.128***	-0.085***	0.027*	0.030*	0.035**
Japan	0.012*	-0.133***	-0.031	0.035*	0.044**	0.047***
China	0.059*	-0.120*	-0.027***	0.044***	0.041*	0.029**
ROW	-1.00	-0.80	-0.80	0.048*	0.048*	0.049*

[a] All elasticities evaluated at the mean of the data. *** = significant at the 1% level, ** = significant at the 5% level, * = significant at the 10% level.
[b] Elasticities of domestic demand with to respect to the gross soybean crushing margin for the U.S., EU-15/27, Japan, and China and elasticity of import demand with respect to soybean price for the Rest of the World (ROW).
[c] Direct price elasticities of domestic demand for U.S., EU-15/27, Japan and China and direct import demand elasticity for ROW. In the U.S., the domestic demand is for high protein meal including soymeal.

Soymeal production (USOMSPC) is defined in the model to equal the soymeal extraction rate times soybeans crushed (equation (7) in Table 3). To analyze soymeal demand, the demand for high protein meal is first estimated as a function of a high protein meal price, personal disposable income, feed demand for corn, and the stock of soybean checkoff expenditures for the promotion of soymeal demand (equation (8) in Table 3). Dummy variables (D88T91, D97T10, and DUHPMDD) are also added to capture the unobservable effect. A higher high protein meal price significantly decreases a high protein meal use while a higher personal disposable income, greater feed demand for corn and stock of soybean checkoff expenditures for soymeal significantly increases a high protein meal use. The estimated elasticity of high protein meal demand with respect to the high protein meal price is -0.095 and the estimated elasticity of high protein meal demand with respect to the stock of soybean checkoff expenditures for soymeal promotion is 0.032 (Table 4). Those variables in equation (8) in Table 3 account for 99.5% of the variation in the demand equation for high protein meal. The value of Durbin-Watson is 1.5994, approximately close to 2, indicating no serial correlation. This equation is re-normalized on the high protein meal price for the simulations conducted in the next chapter.

High protein meal use (UHPMDDC) includes both cottonseed meal and peanut meal as close substitutes for soymeal. Therefore, to determine the demand for soymeal in the model, the cottonseed meal share of U.S. high protein meal use (UCOMDPC) is first estimated as a function of the wholesale price of cottonseed meal relative to the wholesale prices of soymeal and peanut meal weighted by consumption shares, the soybean protein equivalent of high protein meal production, defined as sum of the soybean protein equivalents of cottonseed meal, soymeal, and peanut meal, and the cottonseed meal share of a high protein meal use lagged one period (equation (9) in Table 3). Dummy variables (D67T93 and D6080) are also added to capture the unobservable effect. All variables but D67T93are statistically significant at the 1% level indicating that a higher wholesale price of cottonseed meal decreases the cottonseed meal share of U.S. high protein meal use and a larger high protein meal production increases the share. Then, the soymeal share of U.S. high protein meal use is calculated to be one minus the endogenous cottonseed meal share of high protein meal use and the exogenous (and very small) peanut meal share of high protein meal use (equation (10) in Table 3). High protein meal use is calculated in the model as soymeal consumption divided by the soymeal share of high protein meal use (equation (11) in Table 3). The wholesale price of soymeal (USOMPWC) is calculated in the model as the wholesale price of high protein meal minus the weighted average of the wholesale prices of cottonseed meal and peanut meal (equation (12) in Table 3)

The ending stocks of soymeal (USOMHEC) also were estimated to be a function of wholesale real price of soymeal, beginning stocks of soymeal and dummy variable for U.S. embargo of U.S. soybean and product exports in 1972 (equation (13) in Table 3). Dummy variables (D60T70, D82, D91T04 and DUSOMH) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. A higher soymeal price was found to significantly reduce ending stocks of soymeal while a larger beginning stocks of soymeal was found to significantly increase those stocks. The U.S. embargo of U.S. soybean and product exports were found to increase stocks of soymeal in 1972. Those variables in equation (13) in Table 3 account for 83.6% of the variation in the soymeal ending stocks equation. The value of Durbin-h is 0.1440, approximately equal to 0, indicating no serial correlation.

The consumption of soymeal (USOMDDC) is determined in the market clearing condition for the soymeal market as the sum of beginning soymeal stocks, soymeal imports, and soymeal production minus soymeal exports, soymeal ending stocks, and other use of soymeal. U.S. exports of soymeal are explained later in the global soymeal market clearing condition (equation (14) in Table 3).

Soyoil production (USOOSPC) is determined in the model as the soyoil extraction rate times the volume of soybeans crushed (soybean crush demand) (equation (15) in Table 3).

To analyze U.S. soyoil demand, U.S. oleic/linoleic oil use (UOLODDC) first is estimated as a function of a weighted average price of oleic/linoleic oils (soyoil, cottonseed oil, and peanut oil), a weighted average price of lauric oils (coconut oil and palm kernel oil), U.S. personal disposable income, and the stock of soybean checkoff expenditures for U.S. domestic soyoil promotion (equation (16) in Table 3). A dummy variable, DUECRIS, capture the effect of recent U.S. recession during 2008-2010. Dummy variables (D69T82, D89T95, and D12) are also added to capture the unobservable effects. All estimated coefficients are statistically significant ($p<0.01$) and their signs and magnitudes are all consistent with a priori expectations. An increase in the weighted average oleic/linoleic oil price decreases oleic/linoleic oil use while a higher personal disposable income and larger stock of soybean checkoff expenditures for soyoil increase the U.S. consumption of oleic/linoleic oils. The result also found that the recent U.S. recession during 2008-2010 decreased oleic/linoleic oil use. The estimated elasticity of oleic/linoleic oil demand with respect to the weighted average price of oleic/linoleic oils is -0.095 (Table 4). The estimated elasticity of oleic/linoleic oil demand with respect to the stock of soybean checkoff expenditures for soyoil promotion is 0.035 (Table 4). Those variables in equation (16) in Table 3 account for 99.4% of the variation in the U.S. oleic/linoleic oil use equation. The value of Durbin-Watson is 2.1965, approximately equal to 2, indicating no serial correlation.

. After estimating the total demand for oleic linoleic oils, the cottonseed oil share of that demand (UCOODPC) is then estimated as a function of the wholesale price of cottonseed oil relative to the wholesale prices of soyoil and peanut oil weighted by their consumption shares, the cottonseed oil production relative to the production of peanut oil and soyoil, and the cottonseed oil share of oleic/linoleic oil use in the previous period (equation (17) in Table 3). Dummy variables (D6004 and D66) are also added to capture the unobservable effects. The wholesale price of cottonseed oil was significant at 10% and negative sign indicates that a higher wholesale price of cottonseed oil reduces the cottonseed oil share of oleic/linoleic oil use. The cottonseed oil production and the cottonseed oil share in the previous period were significant at 1% and positive signs indicate that a larger production and a higher level of the cottonseed oil share in the previous period increase the cottonseed oil share of oleic/linoleic oil use. Those variables in equation (17) in Table 3 account for 98.3% of the variation in the cottonseed oil share equation. The value of Durbin-h is -0.3389, approximately close to 0, indicating no serial correlation.

The soyoil share of oleic/linoleic oil use (USOODPC) is then calculated in the model as equal to one minus the endogenous cottonseed oil share and the exogenous (and very small) peanut oil share of oleic/linoleic oil use (equation (18) in Table 3). Then U.S. soyoil use (USOODDC) is calculated in the model as the total oleic/linoleic oil use times the soyoil share of oleic/linoleic oil use (equation (19) in Table 3). The wholesale price of oleic/linoleic oil (UOLOPWC) is calculated in the model as the weighted average of the wholesale prices of soyoil, cottonseed oil, and peanut oil (equation (20) in Table 3).

The private ending stocks of soyoil (USOOHEC) also were estimated to be a function of wholesale real price of soyoil, government PL480 exports of soyoil, government stocks of soyoil, beginning stocks of soyoil, and beginning stocks of soyoil lagged one year (equation (21) in Table 3). Dummy variables (D96T98, D01T03, and D0412) are also added to capture the unobservable effects. Private ending stocks of soyoil are found to be significantly ($p<0.05$) and negatively influenced by the changes in the wholesale price of soyoil as well as by government PL480 exports of soyoil. However, government stocks of soyoil are found to be insignificant at the 0.1% level. Changes in soyoil production on the other hand significantly ($p<0.01$) but positive impact changes in private soyoil ending stocks. Those variables in equation (21) in Table 3 account for 87.1% of the variation in the private soyoil ending stocks equation. The value of Durbin-h is 0.6821. Note that this equation is re-normalized on price for the simulations conducted in the next chapter.

Commercial exports of soyoil (USOOMEC) are calculated as the difference between total U.S. oil exports and exogenous government (PL480) exports of soyoil adjusted from thousands of tons to millions of pounds to be consistent with the other soyoil export data (equation (22) in Table 3). Total U.S. soyoil exports are explained later in the global soyoil market clearing condition.

Private stock of soyoil (USOOHEC) are explained in the mode as the difference between total soyoil stock and government stocks of soyoil (equation (23) in Table 3). In turn, total soyoil stocks (USOOHTC) are explained as the difference between the U.S. supply of soyoil (the sum of U.S. beginning stocks of soyoil, U.S. soyoil production, and exogenous imports minus the U.S. demand for soyoil (the sum of domestic soyoil consumption (USOODDC=USOLODDC*USOODPC), U.S. total soyoil exports, and an exogenous other uses of soyoil (equation (24) in Table 3).

In the major production regions, soybeans compete with corn. Therefore, the model also includes U.S. corn sector. Equations for regional and total corn acreage planted, regional and total corn acreage harvested, regional market price, corn demand were estimated similar to soybean sector.

The corn supply component of the U.S. sub-model consists of behavioral equations for acreage planted, acreage harvested, and yield in eight U.S. production regions (Cornbelt, Delta, South, Plains, Lakes, Atlantic ,Other and Residual). The model also includes identities explaining production, and expected prices in each of the eight regions (Table 5).

The estimated parameters for the area planted equations in all eight regions are significant with correct signs, no serial correlation, and high adjusted R-squares (equations (1)-(8) in Table 5). In all eight regions, corn acreage planted is significantly influenced by the expected corn farm price. In the regional corn area planted equations, the statistically significant prices of substitute crops include soybean price in the Cornbelt region, soybean and rice prices in the Delta region, soybean price in the South region, soybean price in the Plains region, soybean and barley prices in the Lakes region, soybean and oats prices in the Atlantic region, soybeans and wheat prices in the Other region and soybeans and wheat prices in the Residual region. The indicator variable (DPIK) for the 1982 U.S. payment-in-kind (PIK) program is included in all regional corn area planted equations but the equation for the Delta region, the variable is found to be significantly ($p<0.01$) and negatively influenced by the changes in the corn area planted in each region. In equations for corn area planted in the Atlantic region and the Plains region, indicate variable (NORFLEC) for percent of acres required in the normal flex program under the 1990 farm bill is included. The variable is found to be significantly (at least $p<0.1$) and negatively influenced by the changes in the corn area planted in each region. The indicator variable (UCORARP) for the corn acreage reduction program requirement is included in all regional corn area planted equations but equations for the Other and the Residual regions, the variable is found to be significantly and negatively influenced by the changes in the corn area planted in each region. Time trend and dummy variables are also added in the equation for each region to capture the unobservable effects.

The corn acreage harvested is determined in the model by corn acreage planted (equations (10)-(17) in Table 5). The regional harvested acreage estimation results indicate that, overall, more than 90% of planted acres are harvested. However, only 77.4% of planted acres are harvested in the Other region (equations (14) in Table 5) and only 64.9% of planted acres are harvested in the Residual region (equations (17) in Table 5). Both regions plant corn in relatively small acres compared to acres of corn planted in other regions. The estimated parameters for the corn acreage harvested equations in all eight regions are significant with correct signs, no serial correlation, and high adjusted R-squares.

Corn production in each region is defined in the model as acreage harvested times yield (equations (19)-(26) in Table 5). Total U.S. corn production (UCORSPC) is the sum of corn production in all of the regions (equations (27) in Table 5). Also, regional corn farm prices are linked in the model to the national corn farm price (UCORPFC) (equations (28)-(35) in Table 5). A coefficient of the national corn farm price in each of the equation is close to one implies that in the long-run regional corn farm prices and the national corn farm price were nearly equal.

The expected corn farm price, PC^e, defined for each region as:

$$(10)\ PC^e = MAX(PC_{t-1}, LC_t \bullet (1- RC_t)) \bullet D5973 + MAX(PC_{t-1}, TC_t \bullet (1- RC_t)) \bullet D7490 + MAX(PC_{t-1}, TC_t \bullet (1- RC_t - NF_t) + LC_t \bullet NF_t) \bullet D9195 + MAX(PC_{t-1}, LC_t) \bullet D9601 + MAX(PS_{t-1}, 0.85 \bullet TC_t + 0.15 \bullet MAX(PS_{t-1}, LS_t)) \bullet D0212$$

where LC = the corn average loan rate; TC = corn target price; RC = corn acreage reduction program requirement rate; NF = percent of acres required in the normal flex program; D5973 = indicator variable which equals 1 for 1959/60 through 1973/74 and 0 otherwise; D7490 = indicator variable which equals 1 for 1974/75 through 1990/91 and 0 otherwise; D9195 = indicator variable which equals 1 for 1991/92 through 1995/96 and 0 otherwise; D9601 = indicator variable which equals 1 for 1996/97 through 2001/02 and 0 otherwise; and D0212 = indicator variable which equals 1 for 2002/03 through 2012/13 and 0 otherwise. Equations (36)-(43) in Table 5 are the expected regional corn farm prices equations. The national corn farm price (UCORPPC) is the weighted average of corn farm price in all of the regions (equations (44) in Table 5).

Total corn demand includes both feed use and food use. Therefore, both uses are estimated separately. Corn demand for feed use (UCORDFC) is first estimated as a function of the wholesale price of corn, farm price of hogs, and grain consuming animal units (equation (45) in Table 5). Dummy variables (D60T72 and D09T12) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. As expected, the results show that a higher wholesale price of corn reduces corn demand for feed use while a higher farm price of hogs and a larger number of grain consuming animal units increase corn demand for feed use. Those variables in equation (45) in Table 5 account for 93.7% of the variation in the corn demand for feed use equation. The value of Durbin-Watson is 2.0271, approximately equal to 2, indicating no serial correlation.

Table 5. The U.S. Corn Component of the World Soybean Model

Regional and Total U.S. Acreage Planted

(1) ACORSAC = -557.5309 + 1031.606*ACORPPC/LAG(UFPI67) − 253.019*ASOYPCC/LAG(UFPI67) − 1190.33*AOATPPC/LAG(UFPI67)
(277.6) (220.4) (116.9) (366.0)
+ 0.9260*LAG(ACORSAC) − 698.484*DPIK − 6.4886*UCORARP − 13.5029*NORFLEX − 631.839*DACORS1
(0.05) (213.6) (3.73) (6.77) (124.5)
+ 377.6361* DACORS2
(138.80) Adj. R^2=0.9289 Dh=0.2444

(2) CCORSAC = 25912.89 + 6544.666*CCORPPC/LAG(UFPI67) − 2022.57*CSOYPCC/LAG(UFPI67) + 0.2608*LAG(CCORSAC)
(2987.13) (1455.74) (711.3) (0.07)
− 187.646*UCORARP − 12405.1*DPIK − 10168.2*D61 + 2939.353*D77T84 − 2764.46*DCCORS
(24.86) (1445.0) (1344.2) (628.0) (556.5)
Adj. R^2=0.8318 Dh=0.6557

(3) DCORSAC = 385.5977 + 455.7042*DCORPPC/LAG(UFPI67) − 194.721*DSOYPCC/LAG(UFPI67) − 48.7536*DRICPPC/LAG(UFPI67)
(161.6) (134.3) (74.25) (25.85)
+ 0.7455*LAG(DCORSAC) − 6.3385*UCORARP + 1410.126*D07 + 463.196*DDCORSA
(0.04) (2.4945) (139.4) (52.45) Adj. R^2=0.9420 Dh=-0.1698

(4) LCORSAC = 7396.440 + 4441.309*LCORPPC/LAG(UFPI67) − 710.603*LSOYPCC/LAG(UFPI67) − 2049.011*LBARPPC/LAG(UFPI67)
(1226.85) (814.47) (310.14) (705.43)
+ 0.3956*LAG(LCORSAC) − 109.823*UCORARP − 4584.758*DPIK − 2948.36*D6061 + 1695.28*D77T85 + 894.263*DLCORS
(0.07) (13.16) (615.18) (460.01) (268.28) (352.34)
Adj. R^2=0.8890 Dh=-0.4382

(5) OCORSAC = 291.3514 + 627.5862*OCORPPC/LAG(UFPI67) − 101.4770*OSOYPCC/LAG(UFPI67) − 153.761*OWHEPPC/LAG(UFPI67)
(154.1) (95.31) (44.29) (52.06)
+ 0.8007*LAG(OCORSAC) − 341.068*DPIK − 195.052*D60T70 + 222.6691*D77T81 + 246.5734*D8497
(0.05) (85.41) (44.15) (48.09) (56.82)
Adj. R^2=0.9650 Dh=1.0178

(6) PCORSAC = -171042 + 4835.942*PCORPPC/LAG(UFPI67) − 854.577*PSOYPCC/LAG(UFPI67) + 0.5710*LAG(PCORSAC) − 4642.32*DPIK
(31982.6) (1176.2) (396.9) (0.08) (860.7)
− 50.2303*UCORARP − 62.0088*NORFLEX + 88.1054*TIME − 1481.28*D85T87 − 2264.58*DPCORS
(22.24) (27.51) (16.40) (546.6) (537.4)
Adj. R^2=0.9413 Dh=-0.1370

Table 5 Continued.

(7) SCORSAC = 706.5924 + 2054.194*SCORPPC/LAG(UFPI67) − 490.5360*SSOYPCC/LAG(UFPI67) + 0.6898*LAG(SCORSAC)
(367.14) (355.13) (172.80) (0.04)
− 1058.528*DPIK − 15.1979*UCORARP − 827.6628*DSCORS1 + 1107.025*DSCORS2
(328.34) (5.48) (201.85) (200.60) Adj. R^2=0.9047 Dh=-0.6499

(8) TCORSAC = -17454 + 710.3939*TCORPPC/LAG(UFPI67) − 127.5255*OSOYPCC/LAG(UFPI67) − 329.2298*OWHEPPC/LAG(UFPI67)
(4334.1) (142.66) (61.89) (68.60)
+ 0.9185*LAG(TCORSAC) − 497.8490*DPIK + 8.9044*TIME − 287.5030*D01T06 − 313.9572*DSTCORS
(0.06) (109.10) (2.21) (54.11) (48.14)
Adj. R^2=0.9729 Dh=0.2641

(9) UCORSAC=(ACORSAC+CCORSAC+DCORSAC+LCORSAC+OCORSAC+PCORSAC+SCORSAC+TCORSAC)/1000

Regional and Total U.S. Acreage Harvested

(10) ACORSHC = -154.1743 + 0.8895*ACORSAC + 110.0273*D03T12
(53.95) (0.02) (30.95) Adj. R^2=0.9867 DW=1.7547

(11) CCORSHC = -44111.1 + 0.9520*CCORSAC + 22.3608*TIME
(6573.5) (0.02) (3.44) Adj. R^2=0.9885 DW=1.8338

(12) DCORSHC = -3220.83 + 0.9771*DCORSAC + 1.5898*TIME
(589.0) (0.008) (0.30) Adj. R^2=0.9970 DW=1.8007

(13) LCORSHC = -55827.5 + 0.9152*LCORSAC + 27.6145*TIME
(8113.3) (0.04) (4.24) Adj. R^2=0.9636 DW=1.8513

(14) OCORSHC = -5343.14 + 0.7739*OCORSAC + 2.4595*TIME + 223.4563*D6061
(1550.5) (0.03) (0.78) (64.85) Adj. R^2=0.9367 DW=1.6207

(15) PCORSHC = -50268.2 + 0.9776*PCORSAC + 554.2467*D81T00 + 24.4498*TIME
(21206.7) (0.05) (170.42) (11.02) Adj. R^2=0.9834 DW=1.7174

(16) SCORSHC = -10100.7 + 0.9280*SCORSAC + 4.9344*TIME − 1638.570*D77 − 533.4324*D9811
(2118.4) (0.02) (1.04) (92.54) (63.73) Adj. R^2=0.9908 DW=1.9735

(17) TCORSHC = -335.0729 + 0.6487*TCORSAC + 214.8242*D81T00
(40.64) (0.02) (21.49) Adj. R^2=0.9691 DW=1.8500

Table 5 Continued.

(18) UCORSHC=(ACORSHC+CCORSHC+DCORSHC+LCORSHC+OCORSHC+PCORSHC+SCORSHC+TCORSHC)/1000

Regional and U.S. Production

(19) ACORSPC=ACORSYC*ACORSHC
(20) CCORSPC=CCORSYC*CCORSHC
(21) DCORSPC=DCORSYC*DCORSHC
(22) LCORSPC=LCORSYC*LCORSHC
(23) OCORSPC=OCORSYC*OCORSHC
(24) PCORSPC=PCORSYC*PCORSHC
(25) SCORSPC=SCORSYC*SCORSHC
(26) TCORSPC=TCORSYC*TCORSHC
(27) UCORSPC=(ACORSPC+CCORSPC+DCORSPC+LCORSPC+OCORSPC+PCORSPC+SCORSPC+TCORSPC)/1000

Regional Market Price (Farm Level)

(28) ACORPFC = 0.0667 + 1.0639*UCORPFC + 0.2361*D96T98
(0.04) (0.02) (0.08) Adj. R^2=0.9887 DW=1.9383

(29) CCORPFC = -0.0318 + 1.0167*UCORPFC − 0.0211*D80T85
(0.01) (0.003) (0.01) Adj. R^2=0.9998 DW=1.8609

(30) DCORPFC = 0.2031 + 0.9872*UCORPFC + 0.8111*D85 − 0.6626*D0710
(0.06) (0.02) (0.18) (0.14) Adj. R^2=0.9775 DW=1.8939

(31) LCORPFC = -0.0427 + 0.9862*UCORPFC − 0.112*D80 − 0.1034*D96T98
(0.01) (0.01) (0.05) (0.03) Adj. R^2=0.9985 DW=2.0341

(32) OCORPFC = 0.0790 + 1.1178*UCORPFC − 0.3158*D73T75 − 0.5577*D0812
(0.04) (0.01) (0.06) (0.09) Adj. R^2=0.9931 DW=1.8893

(33) PCORPFC = -0.0175 + 0.9825*UCORPFC + 0.2850*D82 + 0.0522*D92T95
(0.01) (0.004) (0.03) (0.02) Adj. R^2=0.9992 DW=1.5920

(34) SCORPFC = 0.1078 + 1.0302*UCORPFC + 0.0811*D96T06 + 0.3443*D08 − 0.5629*D10
(0.03) (0.01) (0.03) (0.09) (0.09) Adj. R^2=0.9953 DW=1.5615

Table 5 Continued.

(35) TCORPFC = 0.2414 + 0.9785*UCORPFC + 0.1053*D92T05 + 0.1866*D8509
(0.02) (0.01) (0.02) (0.06) Adj. R^2=0.9958 DW=1.5243

Regional Expected Farm Price

(36) ACORPPC=MAX(LAG(ACORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(ACORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(ACORPFC),UCORPTC*(1-UCORARP/100-NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(ACORPFC),UCORPLC)*D9601+MAX(LAG(ACORPFC),UCORPTC*.85+MAX(LAG(ACORPFC),UCORPLC)*.15)*D0212

(37) CCORPPC=MAX(LAG(CCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(CCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(CCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(CCORPFC),UCORPLC)*D9601+MAX(LAG(CCORPFC),UCORPTC*.85+MAX(LAG(CCORPFC),UCORPLC)*.15)*D0212

(38) DCORPPC=MAX(LAG(DCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(DCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(DCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(DCORPFC),UCORPLC)*D9601+MAX(LAG(DCORPFC),UCORPTC*.85+MAX(LAG(DCORPFC),UCORPLC)*.15)*D0212

(39) LCORPPC=MAX(LAG(LCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(LCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(LCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(LCORPFC),UCORPLC)*D9601+MAX(LAG(LCORPFC),UCORPTC*.85+MAX(LAG(LCORPFC),UCORPLC)*.15)*D0212

(40) OCORPPC=MAX(LAG(OCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(OCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(OCORPFC),UCORPTC*(1-UCORARP/100-NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(OCORPFC),UCORPLC)*D9601+MAX(LAG(OCORPFC),UCORPTC*.85+MAX(LAG(OCORPFC),UCORPLC)*.15)*D0212

(41) PCORPPC=MAX(LAG(PCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(PCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(PCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(PCORPFC),UCORPLC)*D9601+MAX(LAG(PCORPFC),UCORPTC*.85+MAX(LAG(PCORPFC),UCORPLC)*.15)*D0212

(42) SCORPPC=MAX(LAG(SCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(SCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(SCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(SCORPFC),UCORPLC)*D9601+MAX(LAG(SCORPFC),UCORPTC*.85+MAX(LAG(SCORPFC),UCORPLC)*.15)*D0212

(43) TCORPPC=MAX(LAG(TCORPFC),UCORPLC*(1-UCORARP/100))*D5973+MAX(LAG(TCORPFC), UCORPTC*(1-UCORARP/100))*D7490+MAX(LAG(TCORPFC),UCORPTC*(1-UCORARP/100 -NORFLEX/100)+NORFLEX/100*UCORPLC)*D9195+MAX(LAG(TCORPFC),UCORPLC)*D9601+MAX(LAG(TCORPFC),UCORPTC*.85+MAX(LAG(TCORPFC),UCORPLC)*.15)*D0212

(44) UCORPPC=(CCORSPC*CCORPPC+LCORSPC*LCORPPC+ACORSPC*ACORPPC+DCORSPC*DCORPPC+SCORSPC*SCORPPC+PCORSPC*PCORPPC+TCORSPC*TCORPPC+OCORSPC*OCORPPC)/ (UCORSPC*1000)

Table 5 Continued.

U.S. Corn Demand, and Market Clearing Condition

(45) UCORDFC = -2872.842 − 803.9319*UCORPWC/UWPI67R + 39.1739*UHOGPFC/UFPI67 + 93.6365*UGCAUA − 640.7848*D60T72
(867.45) (134.36) (12.86) (7.98) (86.72)
− 799.6046*D09T12
(145.04) Adj. R^2=0.9374 DW=2.0271

(46) UCORDOC = 41442.97 − 192.1923*UCORPWC/UWPI67R + 143.0643*UWHEPFC/UFPI67 + 1.0734*UYDA/UCPI67
(10922.4) (62.82) (46.92) (0.22)
+ 0.8689*LAG(UCORDOC) − 21.3364*TIME + 215.4102*D8306 + 890.2176*D07T11 − 395.0986*D0811
(0.02) (5.60) (54.62) (58.91) (68.14)
Adj. R^2=0.9981 Dh=0.4693

(47) UCORMEC = -2613.938 + 3.8396*UCORPXA*XECUSA + 0.3979*LAG(UCORMEC) − 0.3471*RCORMEC
(410.42) (1.14) (0.08) (0.08)
+ 21.7164*(JGCAUA/1000+EGCAUA) + 305.8553*D75T80 − 491.7897*D8512 + 643.6149*D94
(3.12) (79.38) (136.97) (171.64)
Adj. R^2=0.9295 Dh=0.3916

(48) UCORHOC = -1839.07 − 264.4900*UCORPWC + 0.3646*UCORSPC + 0.4280*LAG(UCORHCC) + 0.4098*LAG(UCORHOC)
(185.62) (26.21) (0.02) (0.09) (0.03)
− 462.6438*DFB02 + 882.0963*D60T88 + 616.0774*D8192 + 1169.174*D8285 − 643.8321*D07T10
(100.60) (88.97) (134.43) (144.44) (123.71)
Adj. R2=0.9486 Dh=-0.3727

(49) UCORPFC = 0.0332 + 0.9061*UCORPWC
(0.05) (0.02) Adj. R2=0.9824 DW=2.1079

(50) UCORPXA = 30.9727 + 41.9329*UCORPWC − 34.0872*XECUSA + 19.6713*D7282 + 25.1935*D0509 − 49.8119*D12
(10.66) (1.13) (10.55) (5.31) (5.45) (8.60)
Adj. R2=0.9830 DW=2.0096

(51) UCORHOC=UCORHTC−UCORHCC

Corn demand for food use (UCORDOC) is significantly influenced by the wholesale price of corn, wholesale price of wheat, personal disposable income, and corn demand for food use lagged one year (equation (46) in Table 5). Time trend and dummy variables (D8306, D07T11, and D0811) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. The results show that a higher wholesale price of corn reduces corn demand for food use while a higher wholesale price of wheat and a higher personal disposable income increase corn demand for food use. Those variables in equation (46) in Table 5 account for 99.8% of the variation in the corn demand for food use equation. The value of Durbin-h is 0.4693, approximately close to 0, indicating no serial correlation.

The corn exports (UCORMEC) were estimated to be a function of the export price of U.S. corn multiplied by EU-US exchange rate, corn exports by non-U.S. corn exporting countries, grain consuming animal units in EU and Japan, and U.S. corn exports lagged one year (equation (47) in Table 5). All variables are statistically significant at the 1% level. The results show that a higher the EU import price of U.S. corn and greater numbers of grain consuming animal units in EU and Japan increase corn exports while greater corn exports by non-U.S. corn exporting countries decrease corn exports. Dummy variables (D75T80, D8512, and D94) are also added to capture the unobservable effects. Those variables in equation (47) in Table 5 account for 93% of the variation in the corn exports equation. The value of Durbin-h is 0.3916, approximately close to 0, indicating no serial correlation.

Corn private ending stocks (USOYHOC) are an identity in the model calculated as total ending stocks minus government ending stocks (equation (51) in Table 5). Note that private ending stocks of corn also were estimated to be a function of the wholesale price of corn, corn production, government beginning stocks, beginning private stocks of corn and indicator variable to capture the effects of the 1990 farm bill during 2002-2006 which equals 1 for 2002/03 through 2006/07 and 0 otherwise. (equation (48) in Table 5). Dummy variables (D60T88, D8192, D8285, and D07T10) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. A higher wholesale price of corn was found to significantly reduce private ending stocks of corn while a larger corn production was found to significantly increase those stocks. The results also show that larger government beginning stocks and beginning private stocks of corn increase private ending stocks while the 1990 farm bill decrease those stocks. Those variables in equation (48) in Table 5 account for 94.9% of the variation in the corn private ending stock equation. The value of Durbin-h is -0.3727, approximately close to 0, indicating no serial correlation.

The national farm price of corn (UCORPFC) is estimated in the model as a function of the national wholesale price of corn (equation (49) in Table 5). The coefficient of the national wholesale price of corn is statistically significant at the 1% level. On average, the farm price was found to 9.4% lower than the national soybean wholesale price. The national wholesale price of corn accounts for 98.2% of the variation in the national farm price of corn.

The U.S. export price of corn (UCORPXA) is linked in the model to the national wholesale price of corn (converted from bushels to tons) (equation (50) in Table 5). Dummy variables (D7282, D0509, and D12) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. A higher wholesale price of corn was found to significantly increase an export price of corn while a higher EU-US exchange rate was found to significantly decrease the export price. Those variables in equation (50) in Table 5 account for 98.3% of the variation in the export price of corn equation. The value of Durbin-Watson is 2.0096, approximately equal to 2, indicating no serial correlation.

Total corn ending stocks (UCORHTC) are calculated in the model as the sum of the total beginning stocks of corn, corn production, and corn imports minus the sum of feed and food use of corn, corn exports and seed and other use of corn (equation (52) in Table 5).

European Union (15/27) Sub Model

In the EU 15/27 sub-model, soybean crush demand (ESOYDCC) is specified to be a function of the crush margin, the stock of soybean checkoff expenditures for the promotion of soybeans in the EU 15/27, an indicator variable (DECRIS) to capture the effects of the economic crisis in the EU during 2008-2012 which equals 1 for 2008/09 through 2012/13 and 0 otherwise, and an indicator variable (BEBANM) to capture the effects of a ban on the use of meat and bone meal in animal feeds which equals 1 for 2000/01 through 2002/03 and 0 otherwise (equation (1) in Table 6). The crush margin is calculated as the sum of the EU 15/27 soymeal extraction rate multiplied by the EU 15/27 soymeal import price and the EU 15/27 soyoil extraction rate multiplied by the EU 15/27 soyoil export price minus the EU 15/27 import price of soybeans (import and export prices are based on CIF Rotterdam). Dummy variables (D7172, DESOYDC1, DESOYDC2, and DESOYDC3) are also added to capture the unobservable effects. The promotion expenditures are deflated by EU 15/27 wholesale price index and the expenditures are converted from dollars to Special Drawing Right (SDR). Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. All variables but the stock of soybean checkoff expenditures are statistically significant at the 1% level. A higher crush margin and the ban on the use of meat and bone meal in animal feeds were found to increase soybean crush demand while the economic crisis in the EU during 2008-2012 were found to decrease soybean crush demand. The stock of soybean checkoff expenditures is statistically significant at the 10% level. As expected, the results show that the crush margin and the stock of soybean checkoff expenditures for soybean promotion in the EU 15/27 are positively related to the EU 15/27 soybean crush demand. The estimated elasticities of the EU 15/27 soybean demand with respect to the EU 15/27 gross soybean crush margin and the stock of soybean checkoff expenditures to promote soybeans in the EU 15/27 are 0.055 and 0.027, respectively (Table 4). The results indicate that EU 15/27 crush demand is almost four times more elastic with respect to crush margin than U.S. crush demand. This may reflect the trend in the EU 15/27 that changing the plants from soybeans to rapeseed or multi-seed crushing plants. In addition, crush demand in the EU 15/27 is found to have a similar response to the promotion stock as that in the U.S.

The EU15/27 import price of soybeans (ESOYPIA, CIF Rotterdam) is linked in the model to the U.S. wholesale price of soybeans (converted from bushels to tons) (equation (2) in Table 6). A dummy variable (D06T12) is also added to capture the unobservable effects. The EU15/27 import price of soybeans are found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soybeans. Those variables in equation (2) in Table 6 account for 95.9% of the variation in the EU15/27 import price of soybeans. The value of Durbin-Watson is 2.2724, approximately equal to 2, indicating no serial correlation.

In the EU-soybean market clearing condition, EU 15/27 net imports of soybeans is (ESOMMIC) determined as the sum of soybean crush, the (exogenous) EU 15/27 ending stocks of soybeans, and EU 15/27 seed, feed and other use of soybeans minus the sum of the EU 15/27 soybean beginning stocks of soybeans and the small (exogenous) volume of EU 15/27 soybean production (equation (3) in Table 6).

Table 6. The EU 15/27 Component of the World Soybean Model

EU 15/27 Soybean Demand, and Market Clearing Condition

(1) ESOYDCC = 13093.34 + 4.2611*((ESOMQ*ESOMPIA+ESOOQ*ESOOPXA-ESOYPIA)*XECUSA/ECWPI2*1000)
(251.5) (0.55)
+ 137.6906*LAG(SQRT(ESOYEXPR)) − 1731.52*DECRIS + 1989.251*DEBANM − 5535.009*D7172 − 2368.13*DESOYDC1
(78.5) (208.9) (263.1) (283.0) (304.6)
+ 1203.453*DESOYDC2 − 652.3122*DESOYDC3
(117.5) (232.1) Adj. R2=0.9676 DW=2.2525

(2) ESOYPIA = 44.8508 + 29.7026*USOYPWC + 61.8033*D06T12
(13.14) (2.07) (12.92) Adj. R2=0.9590 DW=2.2724

(3) ESOYMIC = ESOYDCC + ESOYDZC + ESOYHEC - LAG(ESOYHEC) - ESOYSPC

EU 15/27 Soybean Meal Supply, Demand, and Market Clearing Condition

(4) ESOMSPC = ESOMQ*ESOYDCC

(5) ESOMDDC = 8430.979 − 1158.264*(ESOMPIA*XECUSA/ECWPI2) + 0.7873*LAG(ESOMDDC) + 270.7432*LAG(SQRT(ESOMEXPR))
(1132.6) (146.0) (0.03) (157.9)
− 2434.332*DEPRECAP93 + 3291.410*DESOMDD1 − 1950.32*DESOMDD2
(378.8) (454.2) (420.2) Adj. R2=0.9883 Dh=-0.4729

(6) ESOMPIA = -13.2177 + 1.1329*USOMPWC − 39.2104*D8812 + 35.9432*D9406
(7.31) (0.03) (11.26) (10.13) Adj. R2=0.9702 DW=2.3856

(7) ESOMMIC = ESOMDDC + ESOMDZC + ESOMHEC - LAG(ESOMHEC) - ESOMSPC

EU 15/27 Soybean Oil Supply, Demand, and Market Clearing Condition

(8) ESOOSPC = ESOOQ*ESOYDCC

Table 6 Continued.

(9) ESOODDC = 998.3777 −26.4739*(ESOOPXA*XECUSA/ECWPI2) + 0.4407*LAG(ESOODDC) + 33.1813*LAG(SQRT(ESOOEXPR))
(109.0) (6.84) (0.05) (13.43)
+ 335.3159*DEBIOFUEL + 767.4776*DEGERBF + 276.8694*D92T94 + 535.3035*D7310 − 329.26*D8511
(66.99) (73.23) (73.23) (97.48) (82.49)
Adj. R2=0.9536 Dh=-0.2733

(10) ESOOPXA = 38.1232 + 20.0751*USOOPWC + 97.6002*D05T11 − 180.0264*D74
(16.80) (0.69) (18.16) (34.05) Adj. R2=0.9786 DW=1.8403

(11) ESOOMXC = LAG(ESOOHEC) + ESOOSPC - ESOODDC - ESOODZC – ESOOHEC

The EU-27 soymeal production (ESOMSPC) is defined as the EU-27 soymeal extraction rate times the volume of EU-27 soybean crush (equation (4) in Table 6).

The EU-27 soymeal demand (ESOMDDC) is estimated as a function of the EU-27 import price of soymeal, lagged EU-27 soymeal demand, and the stock of soybean checkoff expenditures for EU-27 soymeal promotion (equation (5) in Table 6). Dummy variables (DEPRECAP93, DESOMDD1, and DESOMDD2) are also added to capture the unobservable effects. The promotion expenditures are deflated by EU 15/27 wholesale price index and the expenditures are converted from dollars to SDR. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. The signs and magnitudes of the estimated coefficients are consistent with prior expectations. As expected, EU-27 soymeal demand is significantly ($p<0.01$) and inversely related to the EU-27 soymeal import price but significantly ($p<0.1$) and positively related to the stock of soybean checkoff expenditures for EU-27 soymeal promotion. The estimated elasticity of the EU-27 soymeal demand with respect to the EU-27 soymeal import price and the promotion stock of soybean checkoff expenditures for EU 15/27 soymeal promotion are -0.128 and 0.030. According to the rich existence of substitute good such as rapeseed meal or canola meal, the EU 15/27 soymeal demand is more elastic with respect to soymeal price than U.S. soymeal demand. Soymeal demand in the EU 15/27 is found to a have similar response to the promotion stock as that in the U.S. Those variables in equation (5) in Table 6 account for 98.8% of the variation in the EU15/27 soymeal demand. The value of Durbin-h is -0.4729, approximately close to 0, indicating no serial correlation.

The EU15/27 import price of soymeal (ESOMPIA, CIF Rotterdam) is linked in the model to the U.S. wholesale price of soymeal (equation (6) in Table 6). Dummy variables (D8812 and D9406) are also added to capture the unobservable effects. The EU15/27 import price of soymeal is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soymeal. Those variables in equation (6) in Table 6 account for 97.0% of the variation in the EU15/27 import price of soymeal. The value of Durbin-Watson is 2.3856, approximately close to 2, indicating no serial correlation.

The EU 15/27 net imports of soymeal (ESOMMIC) is determined in the EU 15/27 soymeal market clearing condition as the sum of EU 15/27 soymeal use, EU 15/27 other use of soymeal, and EU 15/27 ending stocks of soymeal minus the sum of the EU 15/27 beginning stocks of soymeal and EU 15/27 soymeal production (equation (7) in Table 6).

The EU 15/27 soyoil production (ESOOSPC) is calculated in the model as the EU-27 soyoil extraction rate times the EU 15/27 soybeans crush (equation (8) in Table 6).

The EU 15/27 soyoil demand (ESOODDC) is explained in the model as a function of the EU 15/27 price of soyoil (export), the stock of soybean checkoff expenditures for soyoil demand promotion in the EU 15/27, and indicate variables for biodiesel use promotion policies (equation (9) in Table 6). The promotion expenditures are deflated by EU 15/27 wholesale price index and the expenditures are converted from dollars to SDR. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. EU 15/27 soyoil demand is significantly ($p<0.01$) and inversely related to the EU 15/27 soyoil price but significantly ($p<0.05$) and positively related to the stock of soybean checkoff expenditures for soyoil promotion in the EU 15/27. The indicate variable, DEBIOFUEL, is include in the equation to capture the effects of the period that EU 15/27 encouraged the use of biodiesel over the last decade in 2000s which equals 1 for 2000/01 through 2012/13 and 0 otherwise and DEBIOFUEL had a positive impact on EU-27 soyoil demand. The indicate variable, DEGERBF, is used to capture the effects of the period that biodiesel promotion policy in Germany in the mid-2000s which equals 1 for 2005/06 through 2007/08 and 0 otherwise. During that period, EU-27 soyoil demand was significantly increased. The estimated elasticities of EU-27 soyoil demand with respect to the EU-27 soyoil price and to the stock of soybean checkoff expenditures to promote EU-27 soyoil demand are -0.085 and 0.035 (Table 4). The EU 15/27 soyoil demand is more elastic with respect to soyoil price than U.S. soyoil demand. Soyoil demand in the EU 15/27 is found to a have similar response to the promotion stock as that in the U.S. Those variables in equation (9) in Table 6 account for 95.4% of the variation in the EU 15/27 soyoil demand equation. The value of Durbin-h is -0.02733, approximately close to 0, indicating no serial correlation.

The EU15/27 export price of soyoil (ESOOPXA, CIF Rotterdam) is linked in the model to the U.S. wholesale price of soyoil (equation (10) in Table 6). Dummy variables

(D05T11 and D74) are also added to capture the unobservable effects. The EU15/27 export price of soyoil is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soyoil. Those variables in equation (10) in Table 6 account for 97.9% of the variation in the EU15/27 export price of soyoil. The value of Durbin-Watson is 1.8403, approximately close to 2, indicating no serial correlation.

EU-27 net soyoil exports (ESOOMXC) are determined in the EU-27 soyoil market clearing condition as the sum of EU-27 soyoil beginning stocks and soyoil production minus the sum of EU-27 soyoil use, other use of soyoil, and soyoil ending stocks (equation (11) in Table 6).

Japan Sub Model

Japan produces only a small volume of soybeans compared to the volume of soybeans crushed. In addition, nearly all soybeans produced in Japan are food grade soybeans intended for the production of tofu and other Japanese food products. Little of the domestic soybean production in Japan is actually processed for the oil and meal. Consequently, Japanese soybean production is treated as an exogenous variable in the model.

Japanese soybean crush demand (JSOYDCC) is a function of the Japanese crush margin delated by the Japanese wholesale price index, the stock of soybean checkoff expenditures for soybean promotion in Japan, and lagged crush demand (equation (1) in Table 7). The promotion expenditures are deflated by the Japanese wholesale price index and the expenditures are converted from dollars to Yen. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. The lagged crush volume is used as proxy for the Japanese crush capacity. The signs and magnitudes of all estimated coefficients in this equation are consistent with a priori expectations. The Japanese crush margin is calculated in the same way as the crush margins in the U.S. and all other countries (the soymeal extraction rate multiplied by the soymeal plus the soyoil extraction rate multiplied by the soyoil price minus the price of soybeans). The Japanese crush margin and lagged crush demand are statistically significant at 10% level and lagged crush demand is statistically significant at 1% level. As expected, the Japanese soybean crush demand is positively related to both the Japanese soybean crush margin and the stock of soybean checkoff expenditures to promote Japanese soybean crush demand. The estimated elasticities of Japanese soybean demand with respect to the gross Japanese soybean crush margin and to the promotion stock of soybean checkoff expenditures to promote Japanese soybean crush demand are 0.012 and 0.035, respectively. The results indicate that Japan crush demand is found to have similar responses to crush margin and the promotion stock of soybean checkoff expenditures as those in the U.S.

The unit import price of soybeans (JSOYPUA) is linked in the model to the U.S. wholesale price of soybeans adjusted from bushels to metric tons (equation (2) in Table 7). The unit import price of soybeans was used rather than an import price because the former was available while another was not. Dummy variables (D71T98 and D99T03) are also added to capture the unobservable effects. The Japanese unit import price of soybeans is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soybeans. Those variables in equation (2) in Table 7 account for 97.5% of the variation in Japanese unit import price of soybeans. The value of Durbin-Watson is 1.7407, approximately close to 2, indicating no serial correlation.

Japanese net imports of soybeans (JSOYMIC) is determined in the Japanese soybean market clearing condition as the sum of the Japanese soybean crush demand, seed, feed and other use of soybeans (exogenous), and ending stocks of soybeans (exogenous) minus the sum of Japanese beginning stocks of soybeans (exogenous) and the Japanese soybean production (exogenous) (equation (3) in Table 7).

Table 7. The Japan Component of the World Soybean Model

Japan Soybean Demand, and Market Clearing Condition

(1) JSOYDCC = 324.2435 + 6.0132*(JSOMQ*JSOMPUA+JSOOQ*JSOOPUA-JSOYPUA)*XJAUSA/JWPI85/1000 + 0.7553*LAG(JSOYDCC)
(158.7) (3.27) (0.05)
+ 0.4630*LAG(SQRT(JSOYEXPR)) + 419.5308* D74T01 + 259.3955*DJSOYDC + 807.7098*D02
(0.23) (62.14) (86.10) (157.0)
Adj. R^2=0.9410 Dh=-0.4883

(2) JSOYPUA = 106.4110 + 41.8791*USOYPWC − 94.0059*D71T98 − 58.8506*D99T03
(19.59) (1.84) (10.39) (13.83) Adj. R^2=0.9745 DW=1.7407

(3) JSOYMIC = JSOYDCC + JSOYDZC + JSOYHEC - LAG(JSOYHEC) - JSOYSPC

Japan Soybean Meal Supply, Demand, and Market Clearing Condition

(4) JSOMSPC = JSOMQ*JSOYDCC

(5) JSOMDDC = 1717.758 − 10.3889*(JSOMPUA*XJAUSA/JWPI85/1000) + 0.5520*LAG(JSOMDDC) + 0.6279*LAG(SQRT(JSOMEXPR))
(261.43) (1.77) (0.06) (0.26)
+ 384.4388*D01T11 + 224.565*D7276 − 310.9052*D74
(69.44) (93.71) (114.98) Adj. R^2=0.9671 Dh=0.4638

(6) JSOMPUA = 24.7730 + 1.1869*USOMPWC − 93.3954*D72 − 32.0520*D84T90 + 46.7747*D03T11
(8.41) (0.04) (16.59) (6.90) (7.11) Adj. R^2=0.9751 DW=2.0444

(7) JSOMMIC = JSOMDDC + JSOMDZC + JSOMHEC - LAG(JSOMHEC) - JSOMSPC

Japan Soybean Oil Supply, Demand, and Market Clearing Condition

(8) JSOOSPC = JSOOQ*JSOYDCC

Table 7 Continued.

(9) JSOODDC = 87.8013 − 0.1497*(JSOOPUA*XJAUSA/JWPI85/1000) + 0.8464*LAG(JSOODDC) + 0.2147* LAG(SQRT(JSOOEXPR))
(30.29) (0.08) (0.04) (0.03)
+ 36.7814*D96T03 − 52.9913*DJSOODD − 117.2686*D74
(10.18) (10.05) (23.73) Adj. R^2=0.9518 Dh=-0.1843

(10) JSOOPUA= -126.0805 + 22.6056*USOOPWC + 2.7059*D71T99*JTRPREWTO/XJAUSA + 4.8715*D00T12*JTRAFTWTO/XJAUSA
(72.96) (2.32) (0.53) (0.70)
+ 981.4840*D8586
(84.70) Adj. R^2=0.9067 DW=1.7492

(11) JSOOMIC = JSOODDC + JSOODZC + JSOOHEC - LAG(JSOOHEC) – JSOOSPC

Japanese soymeal production (JSOMSPC) is calculated in the model as the Japanese soymeal extraction rate times the Japanese soybean crush demand (equation (4) in Table 7).

Japanese soymeal demand (JSOMDDC) is specified in the model as a function of the Japanese import price of soymeal in U.S. dollars multiplied by the Japan Yen/U.S. dollar exchange rate deflated by the Japanese wholesale price index and a stock of soybean checkoff expenditures for soymeal (equation (5) in Table 7). The promotion expenditures are deflated by the Japanese wholesale price index and the expenditures are converted from dollars to Yen. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. The signs and magnitudes of all estimated coefficients are consistent with expectations. Japanese demand for soymeal is estimated to be significantly ($p<0.01$) and negatively related to the real Japanese price of soymeal and significantly ($p<0.05$) and positively relate to the stock of real soybean checkoff expenditures for the promotion of Japanese soymeal. The estimated elasticities of soymeal demand with respect to the real import price of soymeal and to the real stock of soybean checkoff expenditures for the promotion of Japanese soymeal demand are -0.133 and 0.044, respectively (Table 4). Japanese soymeal demand is less elastic with respect to soymeal price than U.S. soymeal demand. Soymeal demand in Japan is found to a have similar response to the promotion stock as that in the U.S. Those variables in equation (5) in Table 7 account for 96.7% of the variation in Japanese soymeal demand.

The value of Durbin-h is 0.4638, approximately close to 0, indicating no serial correlation.

Japanese unit import price (JSOMPUA) of soymeal is linked in the model to the U.S. wholesale price of soymeal (equation (6) in Table 7). Dummy variables (D72, D84T90 and D03T11) are also added to capture the unobservable effects. The Japanese unit import price of soymeal is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soymeal. Those variables in equation (6) in Table 7 account for 97.5% of the variation in the Japanese unit import price of soymeal. The value of Durbin-Watson is 2.0444, approximately equal to 2, indicating no serial correlation.

Japanese net imports of soymeal (JSOMMIC) are determined in the Japanese soymeal market clearing condition as the sum of Japanese soymeal use, other use, and ending stocks minus Japanese soymeal beginning stocks and soymeal production (equation (7) in Table 7).

Japanese soyoil production (JSOOSPC) is defined in the model as the exogenous Japanese soyoil extraction rate times the crush volume of Japanese soybeans (equation (8) in Table 7).

Japanese soyoil demand (JSOODDC) is specified in the model as a function of the Japanese import price of soyoil (in U.S. dollars per metric ton) multiplied by the Japanese yen/U.S. dollar exchange rate and deflated by the Japanese wholesale price index, lagged Japanese soyoil demand, and the stock of soybean checkoff expenditures for the promotion of Japanese soyoil demand (equation (9) in Table 7). The promotion expenditures are deflated by the Japanese wholesale price index and the expenditures are converted from dollars to Yen. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. The regression results indicate that Japanese soyoil demand is significantly ($p<0.1$) and negatively related to the real Japanese import price of soyoil and significantly ($p<0.01$) and positively related to the stock of soybean checkoff expenditures for the promotion of Japanese soyoil demand with estimated elasticities of -0.031 and 0.047, respectively (Table 4). The results indicate that Japan soyoil demand is found to have similar responses to price of soyoil and the promotion stock of soybean checkoff expenditures as those in the U.S. Those variables in equation (9) in Table 7 account for 95.2% of the variation in the Japanese soyoil demand equation. The value of Durbin-h is -0.1843, approximately equal to 0, indicating no serial correlation.

Japanese import price of soyoil (JSOOPUA) is linked in the model to the U.S. wholesale price of soyoil (equation (10) in Table 7). Variables for exchange rates and tariffs on imports of soyoil are included in the equation. Since Japan implemented tariff on imports of soyoil to protect domestic industry (17,000 yen/ton until 1999 and 10,900 yen/ton after 2000), two indicate variables, JTRPREWTO and JTRAFTWTO, were generated. JTRPREWTO equals 1 for the period until 1999/2000 and 0 otherwise and JTRAFTWTO equals 1 for the period after 1999/2000 and 0 otherwise. A dummy variable (D8586) is also added to capture the unobservable effects. Japanese import price of soyoil is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soyoil. Those variables in equation (10) in Table 7 account for 90.7% of the variation in the Japanese import price of soyoil. The value of Durbin-Watson is 1.7492, approximately close to 2, indicating no serial correlation.

Japanese net imports of soyoil (JSOOMIC) are explained in the model by the Japanese soyoil market clearing identity as the sum of Japanese soyoil use, other use, and ending soyoil stocks minus the sum of Japanese soyoil beginning stocks and soyoil production equation (11) in Table 7).

China Sub Model

Given that China is a major force in world soybean markets, the Chinese production of soybeans is endogenized in the model. Chinese soybean acreage harvested (HSOYSHC) is specified as a function of last year's acreage harvested and the Chinese farm prices of soybeans and corn (equation (1) in Table 8). Corn is the major substitute in production for soybeans in most areas of Chinese soybean production. Dummy variables (D90T92, DHSOYSH, and D9300) are also added to capture the unobservable effects. All variables are statistically significant at the 1% level. As expected, a higher farm price of soybeans was found to increase soybean acreage harvested while a higher farm price of corn was found to decrease soybean acreage harvested. Those variables in equation (1) in Table 8 account for 82.7% of the variation in the Chinese soybean acreage harvested. The value of Durbin-Watson is 1.9978, approximately equal to 2, indicating no serial correlation.

Chinese soybean production (HSOYSPC) is calculated in the model as the (exogenous) Chinese soybean yield times the Chinese soybean acreage harvested (equation (2) in Table 8).

Chinese soybean crush demand (HSOYDCC) is specified to be a function of the Chinese crush margin deflated by the Chinese wholesale price index (HIPPI05), China crush demand lagged one year, the availability of soybeans for crushing in China, the stock of soybean checkoff expenditures for the promotion of Chinese soybean demand, and time trend (equation (3) in Table 8). The promotion expenditures are deflated by the Chinese wholesale price index and the expenditures are converted from dollars to yuan. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. The lagged crush demand variable is used as a proxy for crush capacity and time trend variable is used as a proxy for crushing technology development. The Chinese crush margin is calculated as the (exogenous) Chinese soymeal extraction rate multiplied by the Chinese wholesale price of soymeal plus the (exogenous) Chinese soyoil extraction rate multiplied by the Chinese wholesale price of soyoil minus an import price of soybeans.

Because Chinese soybean crush was almost entirely from domestic production until the opening of Chinese soybean market in 1996 and thereafter depended primarily on imports, Chinese domestic soybean production and imports are used as proxy variables for the availability of soybeans in China for crushing during those two periods of time. All variables but crush margin are statistically significant at the 1% level. Crush margin is statistically significant at the 10% level. As expected, the results show that a higher crush margin and a larger stock of soybean checkoff expenditures for promotion of China soybean demand tend to increase China's soybean demand. The time trend variable also has a positive impact on crush demand implying that technological developments in crushing have allowed larger amounts of soybean crushed. The estimated elasticities of Chinese soybean crush demand with respect to the real China soybean crush margin and the stock of soybean checkoff expenditures for the promotion of the demand for soybeans in China are 0.059 and 0.044, respectively (Table 4). The promotion elasticity for China is somewhat higher than for Japan (0.035) and the EU-27 (0.027).

Chinese import price of soybeans (HSOYPIA) is linked in the model to the U.S. wholesale price of soybeans converted from bushels to metric tons and multiplied by the China yuan/U.S. dollar exchange rate (equation (4) in Table 8). A dummy variable (D05T07) is also added to capture the unobservable effects. The Chinese import price of soybeans is found to be significantly ($p<0.01$) and positively influenced by the changes in the U.S. wholesale price of soybeans. Those variables in equation (4) in Table 8 account for 95.6% of the variation in the Chinese import price of soybeans. The value of Durbin-Watson is 1.8321, approximately equal to 2, indicating no serial correlation.

Table 8. The China Component of the World Soybean Model

China Soybean Supply, Demand, and Market Clearing Condition

(1) HSOYSHC = 2470.474 + 84.7717*LAG(HSOYPFA/HFPI85) − 177.7912*LAG(HCORPFA/HFPI85) + 0.6943*LAG(HSOYSHC)
(754.13) (22.59) (47.58) (0.09)
− 768.9675*D90T92 − 883.3901*DHSOYSH + 1287.968*D9300
(232.10) (199.24) (272.56) Adj. R2=0.8266 DW=1.9978

(2) HSOYSPC = HSOYSYC * HSOYSHC

(3) HSOYDCC = -655772.9 + 51.1667*(HSOMQ*HSOMPWA+HSOOQ*HSOOPWA-HSOYPIA)/HIPPI05 + 0.4812*LAG(HSOYDCC)
(125295) (26.43) (0.04)
+ 155.6095*LAG(SQRT(HSOYEXPR)) + 0.4344*HSOYMIC*DPSWTO + 0.1686*HSOYSPC*DPREWTO + 329.3210*TIME
(38.16) (0.03) (0.03) (62.65)
− 1649.025*D88T91 + 1157.563*D0410 − 2330.305*DHSOYDC
(338.26) (446.81) (266.32) Adj. R^2=0.9992 Dh=-0.6017

(4) HSOYPIA = -177.2439 + 43.1279*USOYPWC*XCHUSA + 658.0709*D05T07
(86.10) (1.76) (135.57) Adj. R^2=0.9556 DW=1.8321

(5) HSOYPFA = 130.9177 + 1.1715*HSOYPIA + 623.2601*D0206 − 722.7466*D0407
(70.48) (0.04) (146.58) (154.22) Adj. R^2=0.9739 DW=1.9595

(6) HSOYMIC = HSOYDCC + HSOYDZC + HSOYHEC - LAG(HSOYHEC) - HSOYSPC

China Soybean Meal Supply, Demand, and Market Clearing Condition

(7) HSOMSPC = HSOMQ*HSOYDCC

(8) HSOMDDC = -10984.12 − 45.2338*HSOMPWA/HGDPI05 + 0.4268*LAG(HSOMDDC) + 60.6665* LAG(SQRT(HSOMEXPR))
(4833.8) (26.2) (0.1) (34.9)
+ 5.8048*HGDP05 + 0.0100*HPOP + 2269.637* DHSOMDD1 − 1207.050*DHSOMDD2 − 1926.712*DHSOMDD3
(0.8) (0.004) (343.8) (375.1) (443.2)
− 3340.737*D0608
(453.7) Adj. R^2=0.9985 Dh=-0.7317

Table 8 Continued.

(9) HSOMPWA = 608.8966 + 1.2423*USOMPWC*XCHUSA + 396.1549*D80T88 + 633.8578*D0607
(149.5) (0.09) (128.6) (166.8) Adj. R^2=0.9242 DW=1.8054

(10) HSOMMXC = LAG(HSOMHEC) + HSOMSPC - HSOMDDC - HSOMHEC - HSOMDZC

China Soybean Oil Supply, Demand, and Market Clearing Condition

(11) HSOOSPC = HSOOQ*HSOYDCC

(12) HSOODDC = -40849.2 − 20.6742*HSOOPWA/HGDPI05 + 278.8939* LAG(SQRT(HSOOEXP)) + 38.2904*HPOP/1000 + 2389.858*D80T83
(2021.6) (6.5) (116.9) (1.61) (505.1)
− 1770.350*D99T01 − 2297.148*D90T05
(455.0) (303.2) Adj. R^2=0.9711 DW=1.9418

(13) HSOOPWA = 1108.454 + 34.2431*USOOPWC*XCHUSA − 1856.580*D83T86 − 1262.119*D02T11
(375.05) (2.31) (494.37) (425.98) Adj. R^2=0.9277 DW=2.020

(14) HSOOMIC = HSOODDC + HSOOHEC + HSOODZC - LAG(HSOOHEC) - HSOOSPC

Chinese farm price of soybeans (HSOYPFC) is estimated in the model as a function of the Chinese import price of soybeans (equation (5) in Table 8). Dummy variables (D0206 and D0407) are also added to capture the unobservable effects. The coefficient of the Chinese import price of soybeans is statistically significant at the 1% level. On average, the farm price was found to 17.2% higher than the Chinese import price of soybeans.

Chinese imports of soybeans (HSOYMIC) are determined in the model as sum of the Chinese soybean crush, seed, feed and other use, and (exogenous) ending stocks minus the sum of Chinese soybean beginning stocks and soybean production (equation (6) in Table 8).

Chinese soymeal production (HSOMSPC) is calculated in the model as the (exogenous) Chinese soymeal extraction rate times Chinese soybean crush (equation (7) in Table 8).

Chinese soymeal demand (HSOMDDC) is specified in the model to be a function of the lagged Chinese soymeal demand, the Chinese wholesale price of soymeal adjusted for inflation by the Chinese GDP deflator, the stock of soybean checkoff expenditures for the promotion of Chinese soymeal demand, the real Chinese GDP index, and Chinese national population (equation (8) in Table 8). Dummy variables (DHSOMDD1, DHSOMDD2, DHSOMDD3, and D0608) are also added to capture the unobservable effects. The promotion expenditures are deflated by the Chinese GDP deflator and the expenditures are converted from dollars to yuan. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. As expected, Chinese soymeal demand is found to be significantly ($p<0.1$) but negatively related to the real Chinese wholesale price of soymeal and significantly ($p<0.1$) and positively related to the stock of soybean checkoff expenditures for the promotion of Chinese soymeal use with elasticities of -0.120 and 0.041, respectively. Those elasticities are found to be similar to Japanese elasticities. However, soymeal demand in China is found to be more elastic with respect to the soymeal price and the promotion stock than that in the U.S. Those variables in equation (8) in Table 8 account for 99.9% of the variation in the Chinese soymeal demand. The value of Durbin-h is -0.7317, approximately close to 0, indicating no serial correlation.

Chinese wholesale price of soymeal (HSOMPWA) is linked in the model to the U.S. wholesale price of soymeal adjusted from tons to metric tons and multiplied by the Chinese yuan/U.S. dollar exchange rate (equation (9) in Table 8). Dummy variables (D80T88 and D0607) are also added to capture the unobservable effects. The coefficient of the U.S. wholesale price of soymeal is statistically significant at the 1% level. On average, the farm price was found to 24.2% higher than the Chinese wholesale price of soymeal. Those variables in equation (9) in Table 8 account for 92.4% of the variation in the Chinese wholesale price of soymeal. The value of Durbin-Watson is 1.8054, approximately equal to 2, indicating no serial correlation.

Chinese net exports of soymeal (HSOMMXC) are determined in the model in the Chinese soymeal clearing condition as the sum of the Chinese soymeal beginning stocks and soymeal production minus the sum of Chinese soymeal use, other use, and ending stocks (equation (10) in Table 8).

Chinese soyoil production (HSOOSPC) is calculated in the usual way in the model as the Chinese (exogenous) soyoil extraction rate times Chinese soybean crush (equation (11) in Table 8).

Chinese soyoil demand (HSOODDC) is specified as a function of the wholesale price of soyoil deflated by the Chinese GDP deflator, Chinese population, and the stock of soybean checkoff expenditures for the promotion of Chinese soyoil demand (equation (12) in Table 8). Dummy variables (D80T83, D99T01 and D90T05) are also added to capture the unobservable effects. The promotion expenditures are deflated by the Chinese GDP deflator and the expenditures are converted from dollars to yuan. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. Chinese soyoil demand is found to be significantly ($p<0.01$) and positively influenced by the changes in Chinese population. The estimated parameter of the real wholesale price of soyoil is statistically significant ($p<0.01$) and negative as expected while those of both the promotion stock and Chinese population are statistically significant ($p<0.05$) and positive as expected. The estimated elasticities of Chinese soyoil demand with respect to the real Chinese price of soyoil and to the promotion stock are -0.027 and 0.029, respectively (Table 4). The Chinese soyoil demand is less elastic with respect to soyoil price than other soyoil importing countries, EU 15/27 and Japan. Those variables in equation (12) in Table 8 account for 97.1% of the variation in the Chinese soyoil demand equation. The value of Durbin-Watson is 1.9418, approximately equal to 2, indicating no serial correlation.

The Chinese wholesale price of soyoil (HSOOPWA) is linked in the model to the exchange rate adjusted U.S. wholesale price of soyoil (equation (13) in Table 8). Dummy variables (D83T86 and D02T11) are also added to capture the unobservable effects. The Chinese wholesale price of soyoil is found to be significantly ($p<0.01$) and positively influenced by the changes in the exchange rate adjusted U.S. wholesale price of soyoil. Those variables in equation (13) in Table 8 account for 92.8% of the variation in the Chinese wholesale price of soyoil. The value of Durbin-Watson is 2.020, approximately equal to 2, indicating no serial correlation.

Chinese net imports of soyoil (HSOOMIC) is determined in the Chinese soyoil market clearing condition as the sum of Chinese soyoil consumption, and ending stocks of soyoil, Chinese other use minus the sum of Chinese soyoil beginning stocks and soyoil production (equation (14) in Table 8).

Rest-of-the-World (ROW) Region Sub Model

The Rest-of-the-World (ROW) importing region includes the net imports of soybean trading countries except the U.S., the EU-15/27, Japan, China, Brazil, and Argentina. The ROW net soybean import data are calculated as the sum of the net imports of soybeans by the EU-15/27, Japan, and China minus the net exports of soybeans by the U.S., Brazil, and Argentina.

In the model, ROW net imports of soybeans (RSOYMIN) are specified to be a function of U.S. wholesale price of soybeans, the index of the real GDP of developing countries (RGDP85), the indicate variable (DRWTOAF) for the WTO period which equals to 1 for 2001/02 through 2012/13 and 0 otherwise, the indicate variable (DROILSK) for 1st Oil Crisis which equals to 1 for 1974/75, 1975/76, 1977/78, 1979/80, 1981/1982 and 0 otherwise, the indicate variable (DRECCRIS1) for the global economic recession which equals to 1 for 2011/12 and 0 otherwise, the indicate variable (DRECCRIS2) for the international monetary crisis which equals to 1 for 1971/72 and 2008/09 and 0 otherwise, the stock of checkoff expenditures to promote the demand for soybeans in ROW countries, and lagged ROW net soybean imports (equation (1) in Table 9). Dummy variables (DRSOYM1, DRSOYM2, DRSOYM3, DRSOYM4, D89 and D05) are also added to capture the unobservable effects. The promotion expenditures are deflated by RGDP85. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation.

Table 9. The Rest-of-the-World (ROW) Component of the World Soybean Model

ROW Soybean Demand, and Market Clearing Condition

(1) RSOYMIN = 7734.349 − 1238.78*USOYPWC + 0.0973*LAG(RSOYMIN) + 8.1929*LAG(SQRT(RSOYEXPR)) + 9547.285*RGDP85
(200.5) (c) (0.02) (4.8) (288.0)
+ 2193.810*DRWTOAF − 1652.211*DROILSK − 13337.88*DRECCRIS1 − 6007.311*DRECCRIS2 − 3320.645*DSRSOYM1
(239.9) (176.6) (367.6) (235.2) (112.9)
+ 2183.893*DSRSOYM2 + 1035.674*DSRSOYM3 + 780.6948*DSRSOYM4 + 400.1637*D89 − 7303.148*D05
(145.7) (118.5) (186.7) (320.2) (342.1)
Adj. R2=0.9958 Dh=-1.1237

ROW Soybean Meal Supply, Demand, and Market Clearing Condition

(2) RSOMSPN = .795*RSOYMIN*.8

(3) RSOMDDN = 13066.92 − 66.503*USOMPWC + 0.9542*LAG(RSOMDDN) + 15.0844*LAG(SQRT(RSOMEXPR)) − 8634.966*DRMECRIS .
(421.6) (c) (0.02) (8.6) (937.8)
+ 11223.81*D0406 + 28967.66*D0912 − 6057.975*DRSOMD1 − 6153.924*DRSOMD2 + 4977.812*D0002
(773.3) (746.6) (483.8) (327.5) (722.0)
+ 2464.732*DRSOMD3 + 3690.465*DRSOMD4 + 1875.450*DRSOMD5
(333.4) (589.2) (498.0) Adj. R2=0.9922 Dh=-0.8586

(4) RSOMMIN = RSOMDDC - RSOMSPN

ROW Soybean Oil Supply, Demand, and Market Clearing Condition

(5) RSOOSPN = .179*RSOYMIN*.8

(6) RSOODDN = 4165.777 − 149.27*USOOPWC + 7.2967*LAG(SQRT(RSOOEXPR)) + 4119.500*RGDP85 + 1822.918*DRSOOD1
(199.5) (c) (4.14) (169.0) (184.1)
+ 3198.127*D01T07 + 3477.659*D0910 − 1608.669*DRSOOD2 − 1208.870*DRSOOD3
(200.5) (348.4) (188.1) (158.3) Adj. R2=0.9747 DW=2.0362

(7) RSOOMIN = RSOODDC – RSOOSPN

The price elasticity is constrained to be -1 because the ROW is the residual region in the model and because developing country imports tend to be highly responsive to changes in price. The estimated elasticity of ROW soybean demand with respect to the soybean checkoff promotion is 0.048 ($p<0.1$) which is the most highest among that of other countries in the model. The ROW net imports of soybeans is found to be significantly ($p<0.01$) and positively influenced by the changes in the real GDP of developing countries. Estimation results showed that DRWTOAF is significantly ($p<0.01$) and positively influenced RSOYMIN implying that the trade liberalization driven by WTO after 2001/12 led to an increase of imports of soybeans.

Results also showed that DROILSK, DRECCRIS1 and DRECCRIS2 are significantly ($p<0.01$) and negatively influenced RSOYMIN implying that the global economic downturn led to a decrease of imports of soybeans.

ROW soymeal production (RSOMSPN) is calculated as the assumed soymeal extraction rate of 79.5% times 80% of the net imports of ROW soybeans (which assumes that 20% of ROW soybean imports are for food, seed, or other uses) (equation (2) in table 9).

ROW soymeal demand (RSOMDDN) is specified to be a function of the U.S. wholesale price of soymeal, the stock of soybean checkoff expenditures for the promotion of soymeal demand in ROW countries, and the indicate variable (DRMECRIS) for the international monetary crisis in Asia which equals to 1 for 1998/1999 and 0 otherwise. Dummy variables (DRSOMD1, DRSOMD2, DRSOMD3, DRSOMD4, D0406, D0912 and D0002) are also added to capture the unobservable effects. The promotion expenditures are deflated by RGDP85. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. Similar to soybean estimation, the price elasticity is constrained to be -0.8 because the ROW is the residual region in the model and because developing country imports tend to be highly responsive to changes in price. The stock of soybean checkoff expenditures for the promotion of ROW soymeal demand is a statistically significant ($p<0.1$) explanatory variable in the ROW soymeal demand equation with an elasticity of 0.048 which is the most highest among that of other countries in the model (Table 4). Those variables in equation (3) in Table 9 account for 99.2% of the variation in ROW soymeal demand.

ROW net soymeal imports (RSOMMIN) are determined in the ROW soymeal market clearing condition as the ROW soymeal use minus ROW soymeal production (equation (4) in table 9).

ROW soyoil production (RSOOSPN) is calculated as the assumed soyoil extraction rate of 17.9% times 80% of the net imports of ROW soybeans (which, again, assumes that 20% of ROW soybean imports are not processed but rather are used for food, seed, or other uses) (equation (5) in table 9).

ROW soyoil use (RSOODDN) is a function of the U.S. wholesale price of soyoil, a stock of soybean checkoff expenditures for soyoil, the index of the real GDP of developing countries (RGDP85), and lagged ROW soyoil demand (equation (6) in table 9). Dummy variables (DRSOOD1, DRSOOD2, DRSOOD3, D01T07 and D0910) are also added to capture the unobservable effects. All variables but the stock of soybean checkoff expenditures are statistically significant at the 1% level. The promotion expenditures are deflated by RGDP85. Since there are zero promotion expenditures in some years, a square root transformation is used to capture diminishing marginal returns instead of using a logarithmic transformation. Similar to the case for the ROW soymeal demand, the price elasticity of soyoil demand with respect to the U.S. soyoil price was constrained to be -0.8 because the ROW is the residual region in the model and because developing country imports tend to be highly responsive to changes in price. The stock of soybean checkoff expenditures for the promotion of ROW soyoil demand is a statistically ($p<0.1$) significant explanatory variable in the ROW soyoil demand equation with an elasticity of 0.049 which is the most highest among that of other countries in the model (Table 4).

ROW net soyoil imports (RSOOMIN) are determined in the ROW soyoil market clearing condition as the difference between ROW soyoil use and ROW soyoil production (equation (7) in table 9).

Brazil Sub Model

Because Brazil is a major world soybean producer, Brazilian soybean supply is determined endogenously in the model. Brazilian soybean acreage harvested (BSOYSHC) is specified to be a function of the lagged, dollar-denominated, Brazilian export price of soybeans converted to Brazilian currency by the Brazilian currency/U.S. dollar exchange rate and adjusted for inflation by the Brazilian wholesale price index, lagged Brazilian soybean acreage harvested, and a time trend (equation (1) in Table 10).

Dummy variables (D01T04 and D09T12) are also added to capture the unobservable effects. The estimated coefficients of all regressors are statistically significant ($p<0.01$) with expected signs. A high adjusted R-square (0.9938) indicates an excellent fit of the equation to the data. Brazilian soybean acreage harvested is found to be significantly and positively influenced by the changes in the Brazilian export price of soybeans.

Brazilian soybean production (BSOYSPC) is determined in the model as the (exogenous) Brazilian soybean yield times Brazilian soybean acreage harvested (equation (2) in Table 10).

Brazilian soybean crush demand (BSOYDCC) is specified as a function of the Brazilian soybean crush margin with the dollar-denominated Brazilian prices of soybeans, soymeal, and soyoil (converted to Brazilian currency with the exchange rate and deflated by the Brazilian wholesale price index) specified as separate regressors as return (weighted average of soymeal and soyoil prices) and cost (soybean price), lagged Brazilian soybean crush demand (equation (3) in Table 10). The estimated coefficients the real weighted average of soymeal and soyoil prices is positive as expected and statistically significant ($p<0.05$) while that of the real soybean price is negative as expected and statistically significant ($p<0.1$). Those variables in equation (3) in Table 10 account for 99.4% of the variation in the EU15/27 import price of soybeans. The Durbin-h statistic indicates the absence of serial correlation.

Table 10. The Brazil Component of the World Soybean Model

Brazil Soybean Supply, Demand, and Market Clearing Condition

(1) BSOYSHC = -197576 + 1.5119*LAG(BSOYPXC*XBZUSA/BWPI85) + 0.8117*LAG(BSOYSHC) + 100.008*TIME + 2251.427*D01T04
(47614.2) (0.39) (0.05) (24.14) (342.64)
+ 1963.130*D09T12
(398.96) Adj. R2=0.9938 Dh=1.0656

(2) BSOYSPC = BSOYSYC * BSOYSHC

(3) BSOYDCC = 2939.532 + 3.8424*(BSOMQ*BSOMPXC+BSOOQ*BSOOPXC)*XBZUSA/BWPI85 − 3.0952*BSOYPXC*XBZUSA/BWPI85
(745.77) (1.51) (1.83)
+ 0.9085*LAG(BSOYDCC) − 2641.397*D60T90 + 3970.54*D7909 + 2624.084*D8806 − 2858.220*D9596
(0.02) (517.21) (658.27) (669.99) (677.84)
Adj. R2=0.9939 Dh=0.0097

(4) BSOYPXC = -10.6962 + 1.0626*ESOYPIA − 46.0446*D7306
(3.10) (0.01) (6.71) Adj. R2=0.9930 DW=2.3061

(5) BSOYMXC = LAG(BSOYHEC) + BSOYSPC - BSOYDCC - BSOYDZC - BSOYHEC

Brazil Soybean Meal Supply, Demand, and Market Clearing Condition

(6) BSOMSPC = BSOMQ*BSOYDCC

(7) BSOMDDC = 247.4092 − 0.5599*BSOMPXC*XBZUSA/BWPI85 + 0.9500*LAG(BSOMDDC) + 0.5784*BGDP85/1000 + 1005.695*D7206
(276.57) (0.27) (0.04) (0.32) (268.44)
Adj. R2=0.9944 Dh=-0.5789

(8) BSOMPXC = 5.5305 + 0.944*ESOMPIA + 31.5432*D9712 − 35.8473*D02T06
(3.92) (0.02) (8.93) (5.64) Adj. R2=0.9830 DW=1.6261

(9) BSOMMEC = LAG(BSOMHEC) + BSOMMMC + BSOMSPC - BSOMDDC - BSOMDZC - BSOMHEC

Table 10 Continued.

Brazil Soybean Oil Supply, Demand, and Market Clearing Condition

(10) BSOOSPC = BSOOQ*BSOYDCC

(11) BSOODDC = -660.5320 − 0.0482*BSOOPXC*XBZUSA/BWPI85 + 3.0386*BGDP85/1000 + 451.5148*D6061 − 335.4179*D03T05
(69.85) (0.02) (0.05) (91.40) (74.69)
+ 740.1704*D09T12
(76.15) Adj. R^2=0.9941 DW=1.6391

(12) BSOOPXC = -47.3087 + 1.0372*ESOOPXA + 88.2388*D73T80
(13.07) (0.02) (16.23) Adj. R2=0.9749 DW=1.5994

(13) BSOOMXC = LAG(BSOOHEC) + BSOOSPC - BSOODDC - BSOODZC - BSOOHEC

Brazilian soybean export price (BSOYPXC) is linked in the model to the EU-15/27 soybean import price (equation (4) in Table 10). A dummy variable (D7306) is also added to capture the unobservable effects. The Brazilian soybean export price is found to be significantly ($p<0.01$) and positively influenced by the changes in the EU-15/27 soybean import price. Those variables in equation (4) in Table 10 account for 99.3% of the variation in the Brazilian soybean export price. The value of Durbin-Watson is 2.3061, approximately close to 2, indicating no serial correlation.

Brazilian soybean net exports (BSOYMXC) are determined in Brazilian soybean market clearing condition in the model as the sum of Brazilian soybean beginning stocks and soybean production minus the sum of soybean crush, seed, feed and other use, and (exogenous) ending stocks (equation (5) in Table 10).

Brazilian soymeal production (BSOMSPC) is determined in the model to be equal to the Brazilian soymeal extraction rate times the Brazilian soybean crush (equation (6) in Table 10).

Brazilian soymeal demand (BSOMDDC) is specified as a function of the real Brazilian price of soymeal, lagged Brazilian soymeal demand, and the real Brazilian GDP (equation (7) in table 10). A dummy variable (D7206) is also added to capture the unobservable effects. The real Brazilian soymeal price is significantly ($p<0.05$) and negatively related to the demand for Brazilian soymeal with an elasticity of -0.074. Those variables in equation (7) in Table 10 account for 99.4% of the variation in the Brazilian soymeal demand. The value of Durbin-h is -0.5789, approximately close to 0, indicating no serial correlation.

Brazilian soymeal export price (BSOMPXC) is linked in the model to the EU soymeal import price of soymeal (equation (8) in Table 10). Dummy variables (D9712 and D02T06) are also added to capture the unobservable effects. The Brazilian soymeal export price is found to be significantly ($p<0.01$) and positively influenced by the changes in the EU soymeal import price of soymeal. Those variables in equation (8) in Table 10 account for 98.3% of the variation in the Brazilian soymeal export price. The value of Durbin-Watson is 1.6261, approximately close to 2, indicating no serial correlation.

Brazilian soymeal exports (BSOMMEC) are determined in the Brazilian soymeal market clearing condition as the sum of the Brazilian soymeal beginning stocks, soymeal imports, and soymeal production minus Brazilian soymeal demand, other use, and (exogenous) ending stocks (equation (9) in Table 10).

Brazilian soyoil production (BSOOSPC) is calculated in the model as the Brazilian soyoil extraction rate times Brazilian soybean crush (equation (10) in Table 10).

Brazilian soyoil demand (BSOODDC) is specified in the model to be a function of the real deflated export price of soyoil (converted from U.S. dollars to Brazilian currency) and the real Brazilian GDP (equation (11) in Table 10). Dummy variables (D6061, D03T05 and D09T12) are also added to capture the unobservable effects. The estimated coefficient of the real Brazilian soyoil price is significant ($p<0.1$) and negative with a price elasticity of -0.033. Brazilian soyoil demand is found to be significantly ($p<0.01$) and positively influenced by the changes in the real Brazilian GDP. Those variables in equation (11) in Table 10 account for 99.4% of the variation in the Brazilian soyoil demand equation. The value of Durbin-Watson is 1.6391, approximately close to 2, indicating no serial correlation.

Brazilian soyoil export price (BSOOPXC) is linked in the model to the EU soyoil export price of soyoil (equation (12) in Table 10). A dummy variables (D73T80) is also added to capture the unobservable effects. The Brazilian soyoil export price is found to be significantly ($p<0.01$) and positively influenced by the changes in the EU soyoil export price of soyoil. Those variables in equation (12) in Table 10 account for 97.5% of the variation in the Brazilian soyoil export price. The value of Durbin-Watson is 1.5994, approximately close to 2, indicating no serial correlation.

Brazilian net soyoil exports (BSOOMXC) are determined in the model as the sum of Brazilian soyoil beginning stocks and soyoil production minus the sum of Brazilian soyoil demand, other use, and (exogenous) ending stocks of soyoil (equation (13) in Table 10).

Argentina Sub Model

Argentina is also a major world soybean producer. Consequently, Argentina's soybean supply is also determined endogenously in the model. Argentina soybean acreage harvested (GSOYSHC) is specified to be a function of the lagged, dollar-denominated, Argentinian export price of soybeans converted to Argentinian currency by the Argentina currency/U.S. dollar exchange rate and adjusted for inflation by the Argentina wholesale price index, lagged Argentina soybean acreage harvested, and a time trend (equation (1) in Table 11). The estimated coefficients of all regressor are statistically significant ($p<0.05$) with expected signs. The Durbin-h statistic indicates the absence of serial correlation. A high adjusted R-square indicates an excellent fit of the equation to the data. Argentina soybean acreage harvested is found to be significantly and positively influenced by the changes in the Argentina export price of soybeans. Results also show that time trend had significant positive effects on Argentina soybean acreage harvested and it explains the steady soybean acreage extension in Argentina.

Argentina's soybean production (GSOYSPC) is determined in the model as the Argentina (exogenous) soybean yield times the Argentina soybean acreage harvested (equation (2) in Table 11).

Argentina soybean crush demand (GSOYDCC) is specified in the model to be a function of Argentina's crush margin, lagged Argentina crush, and the indicate variable (DGREEXB) for the period that allowed crushers to import soybeans from Paraguay and re-export the soymeal and soyoil which equals 1 for 2004/05 through 2006/07 and 0 otherwise (equation (3) in Table 11). Argentina crush margin is calculated as the (exogenous) Argentina soymeal extraction rate multiplied by Argentina soymeal price (converted to Argentina currency from U.S. dollars with the Argentina/U.S. dollar exchange rate and divided by one plus export tax rates and then deflated by the Argentina wholesale price index) plus the (exogenous) Argentina soyoil extraction rate multiplied by the Argentina soyoil price (also converted to Argentine currency from dollars and divided by one plus export tax rates and deflated by the Argentina wholesale price index) minus the export price of soybeans (which has also been converted to

Argentina currency and divided by one plus export tax rates and deflated by the same index). Dummy variables (DGPREEX, D7778, and D09) are also added to capture the unobservable effects.

The indicate variable (DGREEXB) is significant ($p<0.01$) and positive implying that the Argentina action allowed crushers to import soybeans from Paraguay and re-export the soymeal and soyoil by only paying the value added tax, not the full export tax significantly increased soybean crush in Argentina. As expected, the Argentina crush margin is a positive and statistically significant ($p<0.1$) determinant of the Argentina soybean crush with an elasticity of 0.01. The results indicate that Argentina soybean crush demand is found to have similar responses to crush margin as that in the U.S. Those variables in equation (3) in Table 11 account for 98.1% of the variation in the Argentina soybean crush demand. The value of Durbin-h is 0.2778, approximately equal to 0, indicating no serial correlation.

Argentina soybean export price (GSOYPXA) is linked in the model to the EU 15/27 soybean import price (equation (4) in Table 11). A dummy variable (D7306) is also added to capture the unobservable effects. The Argentina soybean export price is found to be significantly ($p<0.01$) and positively influenced by the changes in the EU 15/27 soybean import price. Those variables in equation (4) in Table 11 account for 97.8% of the variation in the Argentina soybean export price. The value of Durbin-Watson is 2.0304, approximately equal to 2, indicating no serial correlation.

Table 11. The Argentina Component of the World Soybean Model

Argentina Soybean Supply, Demand, and Market Clearing Condition

(1) GSOYSHC = -57483.83 + 1.4079*LAG(GSOYPXA*XARUSA/GWPI85) + 0.9749*LAG(GSOYSHC) + 28.9281*TIME + 834.9026*D00T03
(20064.8) (0.65) (0.02) (10.10) (196.58)
− 1523.928*DSGSOYSH
(211.16) Adj. R^2=0.9967 Dh=-0.7390

(2) GSOYSPC = GSOYSYC * GSOYSHC

(3) GSOYDCC = 1398.217 + 16.3279*(GSOMQ*GSOMPXA/(1+GSOMTX)+GSOOQ*GSOOPXA/(1+GSOOTX)− GSOYPXA/(1+GSOYTX))
(430.21) (8.76)
*XARUSA/GWPI85 + 0.9150*LAG(GSOYDCC) − 1688.81*DGPREEX + 4807.36*DGREEXB − 2005.348*D7778
(0.03) (709.2) (1151.98) (1381.98)
+ 11578.62*D09
(1814.47) Adj. R^2=0.9809 Dh=0.2778

(4) GSOYPXA = 4.4520 + 0.9938*ESOYPIA − 53.6202*D72 + 77.3818*D75
(5.25) (0.02) (15.79) (15.78) Adj. R2=0.9779 DW=2.0304

(5) GSOYMEC = LAG(GSOYHEC) + GSOYMMC + GSOYSPC - GSOYDCC - GSOYDZC - GSOYHEC

Argentina Soybean Meal Supply, Demand, and Market Clearing Condition

(6) GSOMSPC = GSOMQ*GSOYDCC

(7) GSOMDDC = 307.0265 − 0.2863*GSOMPXA/(1+GSOMTX)*XARUSA/GWPI85 − 194.1335*D60T73 + 325.8099*D03T08 + 722.7642*D09T12
(36.22) (0.15) (23.28) (31.26) (36.31)
Adj. R^2=0.9325 DW=1.2247

(8) GSOMPXA = 22.0162 + 0.8133*ESOMPIA − 111.2599*D72 − 49.3562*D0306 + 75.8227*D1012
(6.52) (0.03) (18.89) (13.55) (15.42) Adj. R^2=0.9536 DW=1.5927

(9) GSOMMEC = LAG(GSOMHEC) + GSOMMMC + GSOMSPC - GSOMDDC - GSOMDZC - GSOMHEC

Table 11 Continued.

Argentina Soybean Oil Supply, Demand, and Market Clearing Condition

(10) GSOOSPC = GSOOQ*GSOYDCC

(11) GSOODDC = 36.3990 − 0.0371* GSOOPXA/(1+GSOOTX)*XARUSA/GWPI85 + 0.9583*LAG(GSOODDC) + 274.5534*D06
(12.12) (0.02) (0.01) (25.30)
+ 513.791*D07T10 + 109.8736*D0810 − 347.5238*D12
(20.08) (25.24) (32.76) Adj. R^2=0.9986 DW=2.0078

(12) GSOOPXA = 12.6907 + 0.9455*ESOOPXA + 308.0443*D7172 + 175.7993*D7577
(17.20) (0.03) (39.67) (39.15) Adj. R^2=0.9494 DW=1.6318

(13) GSOOMEC = LAG(GSOOHEC) + GSOOSPC - GSOODDC - GSOODZC - GSOOHEC

Argentina's net soybean exports (GSOYMEC) are determined in the Argentina soybean market clearing condition as the sum of Argentina's soybean beginning stocks and production minus the sum of Argentina's soybean crush, (exogenous) seed, feed and other use, and (exogenous) ending stocks (equation (5) in Table 11).

Argentina soymeal production (GSOMSPC) is determined in the model as the (exogenous) Argentina soymeal extraction rate times the Argentina soybean crush (equation (6) in Table 11).

Argentina soymeal demand (GSOMDDC) is specified in the model to be a function of real soymeal price (converted to Argentina currency from U.S. dollars with the Argentina/U.S. dollar exchange rate and divided by one plus export tax rates and then deflated by the Argentina wholesale price index) and dummy variables (equation (7) in Table 11). The Argentina real soymeal price is negatively and significantly related to the Argentina soymeal demand with an estimated elasticity of -0.251. Argentina soymeal demand is more elastic with respect to soymeal price than that of the U.S. Those variables in equation (7) in Table 11 account for 93.3% of the variation in the Argentina soymeal demand equation.

Argentina soymeal export price (GSOMPXA) is linked in the model to the EU-15/27 soymeal import price (equation (8) in Table 11). Dummy variables (D71, D0306 and D1012) are also added to capture the unobservable effects. The coefficient of the EU-15/27 soymeal import price is statistically significant at the 1% level. On average, the Argentina soymeal export price was found to 18.8% lower than the EU-15/27 soymeal import price. Those variables in equation (8) in Table 11 account for 95.4% of the variation in the Argentina soymeal export price. The value of Durbin-Watson is 1.5927, approximately close to 2, indicating no serial correlation.

Argentina soymeal exports (GSOMMEC) are determined in the Argentina soymeal market clearing condition as the sum of the Argentina soymeal beginning stocks, (exogenous, minor) imports, and production minus the sum of Argentina's soymeal demand, other use, and (exogenous) ending stocks (equation (9) in Table 11).

Argentina soyoil production (GSOOSPC) is determined in the model as the (exogenous) Argentina soyoil extraction rate times the Argentina soybean crush (equation (10) in Table 11).

Argentina soyoil demand (GSOODDC) is explained by the Argentina soyoil export price converted from dollars to Argentina currency by the exchange rate and deflated by the Argentina wholesale price index and the lagged dependent variable (equation (11) in Table 11). Dummy variables (D06, D07T10, D0810 and D12) are also added to capture the unobservable effects. The real Argentina soyoil price is found to be negatively and significantly ($p<0.05$) related to the Argentina soyoil demand with an estimated elasticity of -0.070. Soyoil demand in Argentina is found to be less elastic with respect to the Argentina soyoil price than that in the U.S. Those variables in equation (11) in Table 11 account for 99.9% of the variation in the Argentina soyoil demand equation. The value of Durbin-Watson is 2.0078, approximately close to 2, indicating no serial correlation.

Argentina soyoil export price (GSOOPXA) is linked in the model to the EU soyoil export price of soyoil (equation (12) in Table 11). Dummy variables (D7172 and

D7577) are also added to capture the unobservable effects. The Argentina soyoil export price is found to be significantly ($p<0.01$) and positively influenced by the changes in the EU soyoil export price of soyoil. Those variables in equation (12) in Table 11 account for 94.9% of the variation in the Argentina soyoil export price. The value of Durbin-Watson is 1.6318, approximately close to 2, indicating no serial correlation.

Argentina net soyoil exports (GSOOMEC) are determined in the Argentina soyoil market clearing condition in the model as the sum of the Argentina soyoil beginning stocks and production minus the sum of the Argentina soyoil demand, (exogenous) other use, and (exogenous) ending stocks (equation (13) in Table 11).

World Market Clearing Conditions

The U.S. soybean export (USOYMEC) are calculated in the model as the sum of the EU 15/27 soybean imports, the Japanese soybean imports, the Chinese soybean imports, and the ROW soybean imports minus the sum of the Brazil soybean exports and the Argentina soybean exports (converted from metric tons to bushels) (equation (1) in Table 12). This is the market clearing identity in the world soybean model.

Table 12. World Market Clearing Conditions of the World Soybean Model

(1) USOYMEC=(RSOYMIN-BSOYMXC-GSOYMEC+ESOYMIC+JSOYMIC+HSOYMIC)/27.21555

(2) USOMMEC=(RSOMMIN-BSOMMEC-GSOMMEC+ESOMMIC+JSOMMIC-HSOMMXC)/0.907185

(3) USOOMTC=(RSOOMIN-BSOOMXC-GSOOMXC-ESOOMXC+JSOOMIC+HSOOMIC)/0.4535925

The U.S. soymeal export (USOMMEC) are calculated in the model as the sum of the EU 15/27 soymeal imports, the Japanese soymeal imports, and the ROW soymeal imports minus the sum of the Chinese soymeal exports, the Brazil soybean exports and the Argentina soybean exports (converted from metric tons to tons) (equation (2) in Table 12). This is the market clearing identity in the world soybean model.

The U.S. soyoil export (USOOMTC) are calculated in the model as the sum of the EU 15/27 soyoil imports, the Japanese soyoil imports, the Chinese soyoil imports, and the ROW soyoil imports minus the sum of the Brazil soyoil exports and the Argentina soyoil exports (converted from metric tons to tons) (equation (3) in Table 12). This is the market clearing identity in the world soybean model.

Data Sources

The model described above and used in the analysis in chapter 5 includes 194 equations and endogenous variables and 462 exogenous variables. In the development of the model, two types of data were needed: (1) annual data to support the soybean model such as soybean supply, demand, price, policy of each countries and U.S. corn supply, demand, price, policy, and (2) annual soybean checkoff expenditures by country, commodity (soybean, soymeal, and soyoil), and type (soybean production research, U.S. domestic demand promotion, and international marketing promotion).

Because soybean and corn supply were analyzed by production region in the United States, the data include regional acres planted, harvested, yield and production. these data were obtained from USDA-NASS for 1960/61 through 2012/13. Data for U.S.

soybean, soymeal, and soyoil use and corn use were taken from USDA-ERS. Supply and demand data for other exporting and importing countries in the model were obtained from USDA-FAS for 1960/61 through 2012/13. Price data for soybeans and products in other countries were obtained from numerous public sources, including FAO, IMF, Japan Oil & Fat Importers & Exporters Association and National Bureau of Statistics of China. Macroeconomic data such as real GDP, GDP deflator, population, and exchange rates were obtained from the World Bank and IMF.

Three types of soybean checkoff expenditure data were collected for the analysis: (1) USB and QSSB checkoff expenditures on soybean production research, (2) USB and QSSB expenditures on the domestic promotion of soybeans and soybean products, and (3) USB, QSSB, and USDA expenditures on the international promotion of soybeans and soybean products. The USB and QSSB production research expenditures data for 1970/71 through 2007/08 were provided by Keith Smith and Associates. The production research data for 2008/07 through 2011/12 were collected from Smith Bucklin Corp. (a management contractor of the USB) and the QSSBs. Expenditures for domestic promotion were also obtained from Smith Bucklin Corp. and the QSSB. Expenditures for international promotion were obtained from the U.S. Soybean Export Council (USSEC), Smith Bucklin Corp., the QSSBs, and the Foreign Agriculture Service (FAS) of the USDA.

Model Validation

Validation of the model was conducted with a check of its ability to replicate actual data over the sample period using dynamic, within-sample (*ex-post*) simulation statistics and a sensitivity analysis to check the stability of the model. The model was first simulated over the common time period across all data types (1980/81 to 2012/13). The simulation results (the baseline historical simulation) were then compared with actual data using dynamic simulation statistics including the Theil forecast error (i.e., the Mean Square Error (MSE) Decomposition Proportion Inequality Coefficients).

The Theil forecast error can be split in two kinds of inequality proportions: (1) the UM (bias error), US (variance error), and UC (covariance error) which sum to one and (2) the UM (bias error), UR (regression error), and UD (disturbance error) which also sum to one. A well-developed model requires small UM, US, and UR proportions, while UC or UD proportions should be close to one. The Theil forecast error simulation validation statistics are reported in Appendix B. Those statistics indicate a highly satisfactory fit of the historical, dynamic simulation solution values to actual data indicating that the model adequately replicates the structure of the world soybean market.

Those statistics are derived as:

(11) $UM = (A_{\mu} - S_{\mu})^2 / MSE,$

(12) $US = (D_R - D_P)^2 / MSE,$

(13) $UC = 2 \bullet (1 - r) \bullet D_R \bullet D_P \; / MSE,$

(14) $UR = (D_P - r \bullet D_R)^2 / MSE,$

(15) $UD = (1 - r^2) \bullet D_P^2 / MSE$

where A_μ = mean of actual variable; S_μ = mean of simulated variable; D_R = standard deviation of actual variable; D_P = standard deviation of simulated variable; r = correlation coefficient between simulated and actual variable and MSE = mean square error.

The Theil U statistic is a relative accuracy measure that compares the simulated values with the results of naïve expectation. If the Theil's U statistic is less than one, the simulation with the model is superior to the naïve expectation. The Theil statistics reported in appendix B are all but one less than 0.3. The one variable with high Theil statistic is Japanese soyoil imports which have been extremely small and have fluctuated from positive to (small imports) to negative (small exports) over time.

(16) $$Theil\ U = \frac{\sqrt{\frac{1}{n}\sum_{t=1}^{T}(A_t - S_t)^2}}{\sqrt{\frac{1}{n}\sum_{t=1}^{T}A_t^{\,2}} + \sqrt{\frac{1}{n}\sum_{t=1}^{T}S_t^{\,2}}}$$

The stability of the model depends largely on the model's sensitivity to a single shock in checkoff expenditures. Therefore, all nominal expenditures in the model were increased by 10% at the first year of the simulation period, then re-simulated over the 1980/81 to 2012/13. The sensitivity of the model found to be satisfactory because all endogenous variables returned to equilibrium, most within 5 years.

CHAPTER V

SCENARIO SIMULATION AND EVALUATION

The primary objective of this study is to measure the effects of various simplifying assumptions commonly made in checkoff program analyses on the transmission of the benefits to producers using the soybean checkoff program as the case for analysis. To measure the effects of various simplifying assumptions on the transmission of the benefits of soybean checkoff expenditures to soybean producers, a base case of the overall, the net producer returns from the soybean checkoff program are first simulated with the overall structure of a partial equilibrium model of the world soybean market. The model is then simulated under alternative simplifying assumptions as discussed in Chapter 3. The simulation results are then compared to those of the base case to measure the effects of the various simplifying assumptions on the transmission of the benefits of checkoff expenditures to producers.

The first step in the analysis was to isolate the effects of the soybean checkoff program expenditures on U.S. and world soybean and soybean product markets from all other forces that may have affected those same markets over the years. The results of statistically estimating the relationship between those expenditures and the respective domestic and foreign soybean demand and supply variables were reported and discussed in the previous chapter. In this chapter, the results of using the model of world soybean and product markets presented and validated in the previous chapter to simulate the effects of specific simplifying assumptions commonly made in the analyses of checkoff programs on the transmission of checkoff benefits to producers are presented. The eight most prevalent simplifying assumptions made in checkoff program analyses, and those analyzed in this chapter, include the following:

(a) a perfectly inelastic supply curve (no supply response to a promotion-induced demand shift);

(b) a perfectly elastic supply curve (no price response to a promotion-induced demand shift);

(c) no U.S. government intervention in supporting farm price or per unit revenue;

(d) no free-rider gains (where Brazil and Argentina are the potential free riders in this case).

(e) no domestic supply chain effects,

(f) no global supply chain effects,

(g) no checkoff investments in production research (only in demand promotion), and

(h) no promotion programs at multiple levels of the supply chain (promotion occurs at only the retail level of the market).

As a benchmark for comparison, a base case scenario was first simulated with the world soybean and soybean products model which measures the effects of the soybean checkoff program when all simplifying assumptions are relaxed. In the base case scenario, the soybean model was first simulated over the period of 1980/91 through 2011/12 with all checkoff expenditures set to their actual, historical levels. The model was then again simulated over the same period with all checkoff expenditures set to zero.

The differences in the simulated values of the endogenous variables in the model (supply, demand, prices, trade, etc. across all countries and commodities in the model) between the two simulations were calculated and taken as measures of the effects of the soybean checkoff program when none of the simplifying assumptions are made. Because no other exogenous variable in the model (e.g., levels of inflation, exchange rates, income levels, agricultural and trade policies, etc.) other than checkoff expenditures was allowed to change in the second simulation, this process effectively isolates the net effects of the soybean checkoff program on the U.S. and world soybean markets, prices, and trade.

Additional simulations of the model were then conducted in which one of the simplifying assumptions were imposed. The results of each the simulations were compared to those of the base case to calculate the effects of the respective assumptions on the transmission of the soybean checkoff benefits to soybean producers. After presenting the results of the base case simulation analysis, the effects of the simplifying assumptions are presented and discussed through a comparison of their respective simulation results to those of the base case.

Base Case Result

Before altering the structure of the world soybean and soybean products model presented in the previous chapter to reflect the various simplifying assumptions often made in analyzing checkoff programs, a base case is first presented against which the changes in the effects of the soybean checkoff program resulting from altering the assumptions can be measured. The base case reflects the domestic and international market and price effects and the U.S. producer benefit-cost ratio (BCR) resulting from the soybean checkoff program over the 1980/81-2012/13 period when none of the simplifying assumptions are imposed on the model.

To generate the soybean checkoff program market effects and the producer BCR in the base case, the world soybean and products model was first simulated over the 1980/81-2012/13 period assuming that none of the simplifying assumptions hold and that all soybean checkoff expenditures during that period were made exactly as was done historically. Those results are termed the "baseline simulation" or the "with checkoff expenditures simulation." Then continuing to assume that the simplifying assumptions do not hold, the model was simulated again over the same period with all soybean checkoff expenditures in all countries for all commodities and types of activity (research, domestic promotion, foreign market promotion) in all years set to zero. This simulation is termed the "zero expenditure simulation base case" or the "without soybean checkoff expenditures base case simulation." The differences in the values of the endogenous variables in the baseline simulation from those in the zero expenditure simulation base case reflect the impact of the soybean checkoff program when none of the simplifying assumptions are imposed on the model. The differences in the values of the endogenous variables between those two simulations are referred to collectively as the "base case."

Key market and price effects from the base case are presented in Tables 13 and 14. For example, U.S. soybean planted acreage was 3.5% higher on average over the 1980/81-2012/13 period in the baseline simulation (which includes the effects of the checkoff expenditures) than over the same period in the zero checkoff expenditure simulation (which represents the effects of removing all soybean checkoff expenditures from the model) (Table 13). With yield growth in addition to acreage growth occurring as a result of soybean checkoff expenditures on production research over the years, U.S. soybean production was even higher in the baseline simulation base case relative to the zero expenditure simulation (5.2%) than was the case for acreage.

Also, given a higher U.S. crush margin in the baseline simulation than in the zero expenditure simulation (7.2%) and the effects of the soybean checkoff expenditures for domestic soybean demand promotion, U.S. soybean crush demand was 3.6% higher in the baseline simulation than in the zero expenditure simulation. Also, U.S. soymeal demand was 4.0% higher and U.S. soyoil demand 3.9% higher in the baseline simulation compared to the zero expenditure simulation (Table 14). Although U.S. prices of soybeans, soymeal, and soyoil also were all higher in the baseline simulation than in the zero expenditure simulation (1.0%, 2.4%, and 1.3%, respectively) reflecting the effects of the domestic and foreign checkoff promotion expenditures, the increase in the production of soybeans as a result of the checkoff expenditures on production research resulted in a smaller percentage increase in those prices than in their respective demands.

Table 13. Base Case: Soybean Checkoff Program Effect on U.S. Soybean Supply, 1980/81-2012/13

Annual Average Change	Base Scenario	
	Base Case Results	% change
U.S. Soybean Planted Acres	1,000 acres	
Cornbelt	947.8	3.0
Delta	283.5	4.1
South	219.1	4.8
Plains	418.0	4.1
Lakes	298.4	3.6
Atlantic	117.2	3.4
Other	30.0	5.9
Total	2,314.1	3.5
U.S. Soybean Yield	bu./acres	
Cornbelt	0.60	1.5
Delta	0.25	0.9
South	0.14	0.5
Plains	0.52	1.6
Lakes	0.64	1.7
Atlantic	0.62	2.3
Other	0.23	0.6
U.S. Soybean Production	mil. bu.	
Cornbelt	60.0	4.7
Delta	9.7	5.3
South	6.7	5.5
Plains	21.7	6.4
Lakes	17.2	5.6
Atlantic	5.1	5.8
Other	1.2	6.7
Total	121.6	5.2

Table 14. Base Case: Soybean Checkoff Program Effect on U.S. Soybean Demand and Prices, 1980/81-2012/13

Annual Average Change	Base Scenario	
	Base Case Results	% Change
U.S. Soybean Crush (mil. bu.)	42.6	3.6
U.S. Soymeal Consumption (1,000 tons)	1,005.6	4.0
U.S. Soyoil Consumption (mil. lb.)	536.2	3.9
	536.2	3.9
U.S. Soybean Farm Prices ($/bu)	0.07	1.0
U.S. Soybean and Product Wholesale Prices		
Soybean ($/bu)	0.07	1.0
Soymeal ($/ton)	5.3	2.4
Soyoil (cents/lb)	0.4	1.3
Crush Margin ($/bu)	0.1	7.2

The soybean checkoff program also had a net positive effect on foreign demand soybeans and soybean products (Table 15). For soybeans, the checkoff promotion program had the largest quantity and percentage impact on Chinese soybean imports. The ROW and EU-15/27 also experience a substantial increase in soybean imports. For the last 20 years, the growing importance of China and the countries in the ROW as markets for soybeans resulted in an increase in the share of checkoff expenditures allocated to those markets.

Table 15. Base Case: Soybean Checkoff Program Effects on World Soybean and Products Trade – Base case, 1980/81-2012/13

Annual Average Change	Base Scenario	
	Base Case Results	Base Case %
World Soybean Imports	1,000 mt	
EU-15/27	554.1	4.1
Japan	110.9	2.6
China	1220.5	9.9
Rest of the world	446.4	4.6
Total	2332.0	5.8
World Soybean Exports		
United States	2112.1	9.2
Brazil	78.0	0.6
Argentina	141.8	3.0
Total	2332.0	5.8
World Soymeal Imports		
EU-15/27	192.5	1.3
Japan	49.6	5.4
China	-78.0	-
Rest of the world	366.3	2.6
Total	530.4	1.8
World Soymeal Exports		
United States	5.5	0.1
Brazil	45.4	0.4
Argentina	53.0	0.4
China	426.5	-
Total	530.4	1.7
World Soyoil Imports		
Japan	2.8	22.8
China	-127.1	-11.5
Rest of the world	164.0	4.1
Total	39.7	0.8
World Soyoil Exports		
United States	-24.7	-
Brazil	9.6	0.7
Argentina	11.1	0.4
EU-15/27	43.7	10.6
Total	39.7	0.8

The U.S. soybean industry was the biggest beneficiary of the increase in soybean imports induced by the international market promotion expenditures of soybean checkoff funds. U.S. soybean exports were higher by 9.2% as a result of the checkoff program whereas Brazilian and Argentine soybean exports were higher by only 0.6% and 3.0%, respectively.

The soybean checkoff program also resulted in greater foreign market demand for soymeal by 1.8% over the sample period. The checkoff program resulted in an increase in Chinese soybean crush demand and, therefore, in the Chinese production of soybean products. The increase in Chinese soymeal demand induced by the checkoff program was smaller than the increase in Chinese soymeal production leading to an increase in the net exports of soymeal by China. Without soybean checkoff expenditures, the zero checkoff simulation indicates that China would have been a net soymeal importing country (78.0 mt of soymeal imports). With the checkoff expenditures in the baseline simulation, China becomes a net soymeal exporter (426.5 mt of soymeal exports). The large increase in the availability on soymeal for export from China fills most of the increased foreign demand for soymeal as a result of the soybean checkoff program. As a result, U.S. soymeal exports increased by only 0.1% in the base case. On average over the entire 1980/81-2012/13 period, soyoil imports by ROW increased by 4.1% while soyoil imports by China decreased by 11.5%. Similar to soymeal case, this result is the consequence of the increase in soybean oil production in China given the large increase in Chinese soybean crush. Although world soyoil imports increase by 0.8%

in the base case, the larger annual increase in soyoil demand in the U.S. results in a decrease in U.S. soyoil exports.

As usually calculated, the producer profit Benefit Cost Ratio (PBCR) is the additional industry profits (additional cash receipts net of additional production costs and checkoff assessments) earned by producers as a consequence of the checkoff expenditures (as measured through the scenario analyses) divided by the historical level of checkoff expenditures made to generate those additional profits. For the soybean checkoff program, the additional soybean industry profits (in $ million) generated by the program in any given year (t) are calculated as:

$$(17)\ R_t = (p^w{}_t \bullet q^w{}_t - C^w{}_t) - (p^{wo}{}_t \bullet q^{wo}{}_t - C^{wo}{}_t)$$

where p is the farm price of soybeans ($/bu.); C is production cost; q is production of soybeans (million bu.) which is the product of yield (y) and “w” and “wo” indicate the values from the with checkoff expenditure scenario (baseline simulation) and the without checkoff expenditures scenario (zero checkoff expenditures), respectively. Since the estimated production cost (C) varies depending on the basis (cost per bushel or cost per acreage), this study used the average value of costs of added production from both basis; C = [cost per bushel ($/bu) * total production (million bu) + cost per acreage ($/acre) * total acre (million acres)]/2.

Then the grower profit BCR is calculated as:

(18) $$PBCR = \sum_{t=1}^{T} \frac{R_t}{E_t}$$

where E is total checkoff expenditures ($ million) (production research, domestic promotion, and international market promotion). Because the checkoff represents a cost to producers, checkoff expenditures in each year (E_t) must be netted out of the additional profit generated (R_t) in those years (i.e., R_t - E_t) to arrive at the net grower profit BCR:

(19) $NBCR = PBCR - 1$

The benefit-cost analysis of the soybean checkoff program under the base case results is summarized in Table 16.

Table 16. U.S. Soybean Checkoff Program Benefit-Cost Analysis – Base case, 1980/81-2012/13

Added Soybean Cash Receipts ($ million)	35,219.3
Soybean Checkoff Investment ($ million)	1,356.2
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	26.0
Cost of Production ($/acre)	240.45
Cost of Production ($/bu)	6.58
Cost of Added Production ($ million)	24,546.5
Net revenue ($ million)	10,672.9
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	7.9
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	6.9

Over the 1980/81 to 2012/13 sample period, the soybean checkoff program added $35,219.3 million to U.S. soybean cash receipts. The Gross Revenue Benefit-Cost Ratio (RBCR) is calculated as added soybean cash receipts divided by the aggregate soybean checkoff investments across all countries, commodities, and types across all sample years. Over that period, a sum of $1,356 million of soybean checkoff funds were invested. Consequently, the RBCR is $26.0 (or 26-to-1). Because the checkoff program induced additional soybean production over the years, the additional cost to producers of that production needs to be deducted from the gross revenues to determine a producer BCR net of the additional production costs. The cost of added production is $24,546.5 million. Net revenue is calculated as the added soybean cash receipts minus the cost of the added production, a total of $10,672.9 million.

Given the base case results for the 1980/81 through 2012/13 period, the NBCR is calculated to be $6.9, indicating that the producer benefits from the soybean checkoff program exceeded the total expenditure of checkoff funds over that period.

Effects of Simplifying Assumptions

Using the results from the base case as presented in Tables 13, 14, 15, and 16 as the basis for comparison, the effects of the eight major simplifying assumptions on U.S. and world soybean an products markets and on the producer BCR are analyzed in this section.

Perfectly Inelastic Supply Curve Assumption
(No supply response to a promotion-induced demand shift)

As discussed in the previous chapter, the assumption of a perfectly inelastic supply curve implies that the production of soybeans does not change with a checkoff-induced shift in demand. Thus, to measure the U.S. and world soybean and product market effects of the soybean checkoff program in the absence of supply response, the price elasticities of the U.S. regional soybean acreage equations are set to zero and a new zero expenditure simulation is then conducted with the model. The changes in the endogenous values from their baseline simulation values in this case then measures the effects of the soybean checkoff program when U.S. supply is not allowed to respond to any price changes that the soybean checkoff program may induce. Note that U.S. regional acreages and yields are still allowed to be affected by soybean checkoff production research expenditures.

The differences between the base case results and those of the price inelastic supply case (no supply response) results are provided in Tables 17, 18, 19, and 20. The inelastic supply makes a difference in effects of checkoff expenditures in U.S. soybean and products markets (Table 17). Even with a price inelastic supply, yield growth and acreage growth occurring as a result of the soybean checkoff expenditures on production research over the years results in an increase in U.S. soybean production of 58.6 million. However, with no supply response to the higher soybean price, soybean production increase from the soybean checkoff program is only half the increase in the base case so that the measured impact on U.S. soybean production is 63.0 million bushels lower in the no supply response case compared to the base case.

Table 17. Effect of Supply Response in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No Supply Response Case and Base case

	Inelastic Supply Case Results	% Change from Baseline	Base Case Results	% change from baseline	Difference in Effects from Base Case
U.S. Soybean Planted Acres (1,000 acres)					
Cornbelt	239.9	0.9	947.8	3.0	-653.9
Delta	49.9	0.7	283.5	4.1	-233.6
South	49.4	1.0	219.1	4.8	-169.7
Plains	77.1	0.7	418.0	4.1	-340.9
Lakes	38.4	0.4	298.4	3.6	-260.0
Atlantic	14.3	0.4	117.2	3.4	-102.9
Other	6.0	1.1	30.0	5.9	-24.0
Total	529.1	0.8	2,314.1	3.5	-1,785.0
U.S. Soybean Production (mil. bu.)					
Cornbelt	32.7	2.5	60.0	4.7	-27.3
Delta	3.1	1.6	9.7	5.3	-6.6
South	2.1	1.7	6.7	5.5	-4.6
Plains	10.0	2.8	21.7	6.4	-11.7
Lakes	7.8	2.5	17.2	5.6	-9.4
Atlantic	2.4	2.7	5.1	5.8	-2.7
Other	0.4	1.9	1.2	6.7	-0.8
Total	58.6	2.5	121.6	5.2	-63.0

Note: (1) Price inelastic case results, (2) Price inelastic % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between price inelastic results and base case results ((1) minus (3))

Also, the U.S. soybean farm price increases by $0.27/bu more in the price inelastic supply case than in the base case (Table 18). Because of the limited availability of soybeans for crush, U.S. soybean crush is 0.9 million bushels smaller in the price inelastic supply case. Also, the U.S. soymeal and soyoil prices are \$10.1/ton and 0.83 cents/lb higher than those of base case, respectively.

Table 18. Effect of Supply Response in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No Supply Response case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	41.7	3.0	42.6	3.6	-0.9
U.S. Soymeal Consumption	1,000 tons				
	877.6	3.4	1,005.6	4.0	-128.0
U.S. Soyoil Consumption	mil. lbs.				
	500.5	3.7	536.2	3.9	-35.7
U.S. Soybean Farm Prices	\$/bu				
	0.33	5.0	0.07	1.0	0.26
U.S. Soybean and Product Wholesale Prices	\$/unit				
Soybean (\$/bu)	0.34	4.9	0.07	1.0	0.27
Soymeal (\$/ton)	10.1	4.7	5.3	2.4	4.88
Soyoil (cents/lb)	0.83	3.2	0.35	1.3	0.48
Crush Margin (\$/bu)	0.0	0.3	0.1	7.2	-0.09

Note: (1) Price inelastic case results, (2) Price inelastic % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between price inelastic results and base case results ((1) minus (3))

Table 19. Effect of Supply Response in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No Supply Response case and Base case					
	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	477.9	3.5	554.1	4.1	-76.2
Japan	107.2	2.5	110.9	2.6	-3.7
China	637.4	4.9	1220.5	9.9	-583.1
Rest of the world	114.0	1.1	446.4	4.6	-332.4
Total	1336.5	3.3	2332.0	5.8	-995.5
World Soybean Exports					
United States	439.6	1.8	2112.1	9.2	-1672.5
Brazil	334.5	2.8	78.0	0.6	256.5
Argentina	562.4	12.9	141.8	3.0	420.5
Total	1336.5	3.3	2332.0	5.8	-995.5
World Soymeal Imports					
EU-15/27	203.9	1.6	192.5	1.3	11.4
Japan	45.2	1.7	49.6	5.4	-4.3
China	-78.0	-	-78.0	-	0
Rest of the world	253.3	0.6	366.3	2.6	113.0
Total	424.5	1.4	530.4	1.8	-105.9
World Soymeal Exports					
United States	103.3	1.6	5.5	0.1	-97.8
Brazil	43.2	0.4	45.4	0.4	2.2
Argentina	17.4	0.1	53.0	0.4	35.7
China	260.5	-	426.5	-	165.9
Total	424.5	1.4	530.4	1.7	105.9
World Soyoil Imports					
Japan	3.3	27.7	2.8	22.8	-0.5
China	-112.4	-10.3	-127.1	-11.5	-14.7
Rest of the world	140.4	3.5	164.0	4.1	23.6
Total	31.4	0.6	39.7	0.8	8.3
World Soyoil Exports					
United States	-12.8	-	-24.7	-	-11.9
Brazil	8.7	0.7	9.6	0.7	0.9
Argentina	3.3	0.1	11.1	0.4	7.8
EU-15/27	31.1	7.6	43.7	10.6	11.6
Total	31.4	0.6	39.7	0.8	8.3

Note: (1) Price inelastic case results, (2) Price inelastic % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between price inelastic results and base case results ((1) minus (3))

The assumption of a price inelastic supply also makes a difference in effects of checkoff expenditures on world soybean and products markets and trade (Table 19). With no supply response, prices increase by more than in the base case resulting in less growth in foreign market demand than in the base case. Furthermore, U.S. exports are restricted by the lower increase in production. For soybeans, U.S. exports are 1,672.5 thousand mt smaller in the price inelastic supply than in the base case. On the other hand, soybean exports of competing countries are greater in the price inelastic supply. A greater increase in prices in the absence of supply response leads to a smaller increase in domestic consumption of soymeal and soyoil. Thus, the increase in exports of soymeal is greater and the decrease in exports of soyoil is less than in the base case.

By comparing the effects of the checkoff program on the benefits to U.S. soybean producers in the price inelastic supply case and in the base case, the impact of supply response on the upstream transmission of benefits can be seen examined (Table 20). Because of the relatively greater increase in soybean price in the price inelastic supply case, added soybean cash receipts and the RBCR are $6,421.9 million and $4.7 higher, respectively, than in the base case. Meanwhile, the smaller increase in soybean production leads to a much lower cost of added production. Thus, in the inelastic supply case, increased net revenue is $21,097.6 million higher than the base case. In the price inelastic supply case, PBCR and NBCR are both $15.6 higher than in the base case.

Table 20. The Impact of Supply Response on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	41,641.2	35,219.3	6,421.9
Soybean Checkoff Investment ($ million)	1,356.2	1,356.2	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	30.7	26.0	4.7
Cost of Added Production ($ million)	9,870.7	24,546.5	-14,675.7
Net revenue ($ million)	31,770.5	10,672.9	21,097.6
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	23.4	7.9	15.6
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	22.4	6.9	15.6

Note: (1) Price inelastic case results, (2) Base case results, (3) Difference between price inelastic results and base case results ((1) minus (2))

The assumption of no supply response results in a much higher soybean price and lower production than in the base case resulting in relatively higher benefits and lower costs to U.S. soybean producers in the no supply response case. Clearly, the more likely the gain in producer surplus with a perfectly inelastic supply curve is more than the gain in the case of a sloped supply curve. Studies of the effects of checkoff-funded demand promotion expenditures for commodities that assume that supply is price inelastic can lead to overestimated benefits to producers.

Perfectly Elastic Supply Curve Assumption

(No price response to a promotion-induced demand shift)

The assumption of a perfectly elastic supply implies that price does not change in the model when demand changes. To measure the effect of the soybean checkoff expenditures in the absence of a response of U.S. soybean supply, this scenario requires that the U.S. farm price of soybeans be exogenized in the world soybean and products model (fixed exogenously). Then the zero expenditure simulation scenario is again conducted with the modified model and the changes from the baseline results are calculated. The changes in the endogenous variables from their baseline values results are then compared to the base case results to determine the effects of this simulation on the calculated producer benefits from the soybean checkoff program. The simplifying assumption of a perfectly elastic U.S. supply (no price effects) has an important effect on the calculated impacts on U.S. and world soybean markets and on the calculated benefits to producers. (Table 21, 22, 23, and 24).

Table 21. Effect of Price Response in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No Price Response case and Base case

	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	1178.1	3.7	947.8	3.0	230.3
Delta	248.4	3.6	283.5	4.1	-35.1
South	163.6	3.5	219.1	4.8	-55.5
Plains	458.9	4.5	418.0	4.1	40.9
Lakes	233.5	2.7	298.4	3.6	-64.9
Atlantic	52.7	1.5	117.2	3.4	-64.5
Other	28.5	5.5	30.0	5.9	-1.5
Total	2363.6	3.6	2,314.1	3.5	49.5
U.S. Soybean Production	mil. bu.				
Cornbelt	78.7	6.2	60.0	4.7	18.7
Delta	10.1	1.6	9.7	5.3	0.3
South	5.9	1.7	6.7	5.5	-0.8
Plains	26.4	2.8	21.7	6.4	4.7
Lakes	17.8	2.5	17.2	5.6	0.6
Atlantic	4.3	2.7	5.1	5.8	-0.7
Other	1.3	1.9	1.2	6.7	0.1
Total	144.5	2.5	121.6	5.2	22.9

Note: (1) Perfectly elastic case Results, (2) Perfectly elastic % change from baseline, (3) Base case Results, (4) Base case %, (5) Difference between perfectly elastic case results and base case results ((1) minus (3))

Table 22. Effect of Price Response in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No Price Response case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	42.9	3.6	42.6	3.6	0.3
U.S. Soymeal Consumption	1,000 tons				
	1046.3	4.1	1,005.6	4.0	40.8
U.S. Soyoil Consumption	mil. lbs.				
	547.7	4.0	536.2	3.9	11.5
U.S. Soybean Farm Prices	$/bu				
	0.00	0.0	0.07	1.0	-0.07
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.00	0.0	0.07	1.0	-0.07
Soymeal ($/ton)	4.1	1.8	5.3	2.4	-1.2
Soyoil (cents/lb)	0.23	0.9	0.35	1.3	-0.12
Crush Margin ($/bu)	0.12	9.4	0.1	7.2	0.02

Note: (1) Perfectly elastic case results, (2) Perfectly elastic, (3) Base Case results, (4) Base case %, (5) Difference between perfectly elastic case results and base case results ((1) minus (3))

With perfectly elastic supply, U.S. soybean production is higher 22.9 million bushels than the base case because the increase in soybean demand from the checkoff expenditures is not required to adjust to a price change induced by the demand shift (Table 21). As a consequence, supply increases to equal the larger demand in the price elastic supply case. Although total increased soybean planted acres are greater than the base case, planted acres are less increased in some region. Because higher price of soybeans in the base case results in greater soybean production compared to the perfectly elastic supply case in the region that has relatively large price elasticity such as South, Atlantic, Lakes and Other (Table 2).

With perfectly elastic supply, there are no changes for the U.S. soybean farm price. Because of relatively lower price of soybeans, U.S. soybean crush is 0.3 million bushels greater in the perfectly elastic supply case (Table 22). In this scenario, only soybean price is exogenized in the model, prices of products are allowed to be changed. In the perfectly elastic supply case, the U.S. soymeal price and the U.S. soyoil price are 1.2 $/bu and 0.12 cents/lb lower than those of base case, respectively.

Perfectly elastic supply also makes differences in effects of checkoff expenditures in world soybean and products trade (Table 23). With no price response, relatively lower prices result in more growth in demands in foreign markets than the base case. Greater soybean production in the U.S. leads to a growth in U.S. exports. For soybeans, the U.S. exports are 612.1 thousand mt greater in the perfectly elastic supply case than in the base case. On the other hand, soybean exports of competing countries are smaller in the perfectly elastic supply case. Less increased prices in the absence of price response lead more increased domestic consumption of soymeal and soyoil thus exports of both products are decreased while exports of competing countries are more increased.

Table 23. Effect of Price Response in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No Price Response case and Base case

	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	595.4	4.4	554.1	4.1	41.3
Japan	112.6	2.6	110.9	2.6	1.7
China	1351.5	11.0	1220.5	9.9	131.0
Rest of the world	532.5	5.6	446.4	4.6	86.1
Total	2592.1	6.5	2332.0	5.8	260.1
World Soybean Exports					
United States	2724.2	12.2	2112.1	9.2	612.1
Brazil	-50.8	-0.4	78.0	0.6	-128.9
Argentina	-81.3	-1.6	141.8	3.0	-223.1
Total	2592.1	6.5	2332.0	5.8	260.1
World Soymeal Imports					
EU-15/27	180.5	1.2	192.5	1.3	-12.0
Japan	51.0	5.6	49.6	5.4	1.4
China	-78.0	-	-78.0	-	0
Rest of the world	390.6	2.7	366.3	2.6	24.4
Total	544.2	1.8	530.4	1.8	13.8
World Soymeal Exports					
United States	-24.1	-0.4	5.5	0.1	-29.6
Brazil	47.3	0.4	45.4	0.4	1.8
Argentina	66.9	0.5	53.0	0.4	13.8
China	454.2	-	426.5	-	27.7
Total	544.2	1.8	530.4	1.7	13.8
World Soyoil Imports					
Japan	2.6	20.5	2.8	22.8	-0.2
China	-125.9	-11.4	-127.1	-11.5	1.2
Rest of the world	169.3	4.2	164.0	4.1	5.2
Total	45.9	0.9	39.7	0.8	6.2
World Soyoil Exports					
United States	-28.2	-	-24.7	-	-3.5
Brazil	10.2	0.8	9.6	0.7	0.6
Argentina	13.9	0.6	11.1	0.4	2.8
EU-15/27	50.0	12.3	43.7	10.6	6.4
Total	45.9	0.9	39.7	0.8	6.2

Note: (1) Perfectly elastic case results, (2) Perfectly elastic %, (3) Base case results, (4) Base case %, (5) Difference between perfectly elastic case results and base case results ((1) minus (3))

By comparing effects of the checkoff program on benefits to U.S. soybean producers in the perfectly elastic supply case and in the base case, the impact of price response on the upstream transmission of benefits is examined (Table 24). Because of the relatively larger production in the perfectly elastic supply case, added soybean cash receipts is $1,020.3 million higher and RBCR is $0.7 higher than those in the base case are. Meanwhile, more increased production leads to a much higher cost of added production. Thus, in the perfectly elastic supply case, net revenue is $3,566.6 million lower than the base case. In the perfectly elastic supply case, PBCR and NBCR are $2.6 lower than those of the base case, respectively.

Table 24. The Impact of Price Response on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	36,239.7	35,219.3	1,020.3
Soybean Checkoff Investment ($ million)	1,356.2	1,356.2	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	26.7	26.0	0.7
Cost of Added Production ($ million)	28,989.4	24,546.5	4,586.9
Net revenue ($ million)	7,250.2	10,672.9	-3,566.6
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	5.3	7.9	-2.6
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	4.3	6.9	-2.6

Note: (1) Perfectly elastic case results, (2) Base case results, (3) Difference between perfectly elastic case results and base case results ((1) minus (2))

No price response introduces the relatively lower soybean price and larger production than the base case, thus results in relatively higher benefits but much higher costs to U.S. soybean producers. Clearly, the gain in producer surplus with a perfectly elastic supply curve is less than the gain in the case of price response. Studies of the effects of checkoff-funded demand promotion expenditures for commodities often assume that supply is perfectly elastic can lead to underestimated benefits.

No U.S. Government Intervention Assumption

U.S. farm policy has prescribed different types of intervention in the soybean sector over time (equation 5). The effects of government intervention on the transmission of the benefits from checkoff expenditures have been different over time given the changing form of intervention by the government in the soybean sector.

To measure the effect of the checkoff expenditure in the absence of government intervention, the model is modified to remove price supports by government policy. For this purpose, the expected soybean farm price for each region is replaced with lagged farm price in the acreage equations.

Any exogenous (farm policy) determination of the soybean farm price in each year is removed in the model. The modified model is then used to simulate the effects of removing all soybean checkoff expenditures (again, over all countries, commodities, and types of expenditure over the 1980/81 to 2012/13 sample period (the “no government intervention” simulation). The resulting changes in the endogenous variables in the “no government simulation" are then compared to those of base case to determine the extent of the impact of the "no government" assumption in the impact of the soybean checkoff program and the calculation of the producer BCR. The "no government" simulation results are compared to those of the base case in Tables 25, 26, 27, and 28.

Table 25. Effect of Government Intervention in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No Government Intervention case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	958.0	3.0	947.8	3.0	10.1
Delta	283.4	4.1	283.5	4.1	-0.1
South	235.0	5.2	219.1	4.8	15.9
Plains	418.9	4.1	418.0	4.1	0.9
Lakes	301.9	3.6	298.4	3.6	3.6
Atlantic	118.0	3.5	117.2	3.4	0.8
Other	30.7	6.0	30.0	5.9	0.7
Total	2346.0	3.6	2,314.1	3.5	32.0
U.S. Soybean Production	mil. bu.				
Cornbelt	60.3	4.8	60.0	4.7	0.3
Delta	9.7	5.2	9.7	5.3	0.0
South	7.1	5.9	6.7	5.5	0.4
Plains	21.7	6.4	21.7	6.4	0.0
Lakes	17.4	5.7	17.2	5.6	0.2
Atlantic	5.0	5.7	5.1	5.8	0.0
Other	1.2	6.7	1.2	6.7	0.0
Total	122.5	5.3	121.6	5.2	0.9

Note: (1) No government intervention case results, (2) No government intervention % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no government intervention case results and base case results ((1) minus (3))

Table 26. Effect of Government Intervention in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No Government Intervention case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	42.6	3.6	42.6	3.6	0.0
U.S. Soymeal Consumption	1,000 tons				
	1,006.0	4.0	1,005.6	4.0	0.4
U.S. Soyoil Consumption	mil. lbs.				
	536.3	3.7	536.2	3.9	0.1
U.S. Soybean Farm Prices	$/bu				
	0.06	0.9	0.07	1.0	-0.01
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.06	0.9	0.07	1.0	-0.01
Soymeal ($/ton)	5.1	2.3	5.3	2.4	-0.2
Soyoil (cents/lb)	0.34	3.2	0.35	1.3	-0.01
Crush Margin ($/bu)	0.1	7.4	0.1	7.2	0.0

Note: (1) No government intervention case results, (2) No government intervention % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no government intervention case results and base case results ((1) minus (3))

The existence of government intervention makes differences in effects of checkoff expenditures in U.S. soybean and products markets (Table 25 and 26). Under government intervention, if market prices were below the supported price, increased demand brought on by checkoff promotion programs does not introduce a growth in acreage planted (Figure 30). Thus, the effect of checkoff expenditure for promotion on an increase of acreage planted is greater in the no government intervention case than the base case. Since soybean production is relatively larger, the soybean farm price become $0.01 lower in the no government intervention case.

The government intervention does not make notable differences in effects of checkoff expenditures in world soybean and products trade (Table 27). With no government intervention, less increased prices result in more growth in demands in foreign markets than the base case. Furthermore, U.S. exports are increased by additional production. For soybeans, the U.S. exports are 18.1 thousand mt greater in the no government intervention case than in the base case. Less increased prices in the absence of government intervention lead more increased total consumption of soymeal and soyoil in foreign markets thus an increase in total imports of soymeal and soyoil are greater than in the base case.

Table 27. Effect of Government Intervention in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No Government Intervention case and Base case

	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	556.6	4.1	554.1	4.1	2.5
Japan	111.0	2.6	110.9	2.6	0.1
China	1225.4	9.9	1220.5	9.9	4.9
Rest of the world	456.6	4.6	446.4	4.6	10.2
Total	2349.6	5.9	2332.0	5.8	17.6
World Soybean Exports					
United States	2130.2	9.2	2112.1	9.2	18.1
Brazil	78.4	0.6	78.0	0.6	0.4
Argentina	141.0	3.0	141.8	3.0	-0.8
Total	2349.6	5.9	2332.0	5.8	17.6
World Soymeal Imports					
EU-15/27	192.1	1.3	192.5	1.3	-0.4
Japan	49.7	5.4	49.6	5.4	0.1
China	-78.0	-	-78.0	-	0
Rest of the world	369.6	2.6	366.3	2.6	3.4
Total	533.6	1.8	530.4	1.8	3.1
World Soymeal Exports					
United States	5.5	0.1	5.5	0.1	0.0
Brazil	45.5	0.4	45.4	0.4	0.0
Argentina	53.5	0.4	53.0	0.4	0.4
China	429.1	-	426.5	-	2.6
Total	533.6	1.8	530.4	1.7	3.1
World Soyoil Imports					
Japan	2.8	22.5	2.8	22.8	0.0
China	-127.4	-11.5	-127.1	-11.5	-0.2
Rest of the world	164.7	4.1	164.0	4.1	0.7
Total	40.2	0.8	39.7	0.8	0.5
World Soyoil Exports					
United States	-24.8	-	-24.7	-	0.0
Brazil	9.6	0.7	9.6	0.7	0.0
Argentina	11.3	0.4	11.1	0.4	0.1
EU-15/27	44.0	10.7	43.7	10.6	0.4
Total	40.2	0.8	39.7	0.8	0.5

Note: (1) No government intervention case results, (2) No government intervention %, (3) Base case results, (4) Base case %, (5) Difference between No government intervention results and base case results

By comparing effects of the checkoff program on benefits to U.S. soybean producers in no government intervention case and in the base case, the impact of supply response on the upstream transmission of benefits is examined (Table 28). Because of the lower soybean price in no government intervention case, added soybean cash receipts is $159.3 million lower and RBCR is $0.1 lower than those in the base case are. Meanwhile, more increased production leads to a higher cost of added production in no government intervention case. Thus, in no government intervention case, increased net revenue is $456.8 million lower than the base case. Also, PBCR and NBCR are $0.4 lower than those of the base case, respectively.

Table 28. The Impact of Government Intervention on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	35,060.0	35,219.3	-159.3
Soybean Checkoff Investment ($ million)	1,356.2	1,356.2	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	25.9	26.0	-0.1
Cost of Added Production ($ million)	24,843.9	24,546.5	297.4
Net revenue ($ million)	10,216.1	10,672.9	-456.8
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	7.5	7.9	-0.4
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	6.5	6.9	-0.4

Note: (1) No government intervention case results, (2) Base case results, (3) Difference between government intervention c results and base case results ((1) minus (2))

No government intervention introduces the much lower soybean price but more added production driven by checkoff programs than the base case, thus results in relatively lower benefits and higher costs to U.S. soybean producers. Clearly, the gain in producer surplus with no government intervention is less than the gain with government intervention. Studies of the effects of checkoff expenditures for commodities often assume that there are no price supports by the government can lead to underestimated benefits.

No Free-Rider Gains Assumption

A free rider, in the upstream transmission of checkkoff benefits, refers to some country that benefits from a checkoff-promotion-induced change in global demand without paying for the checkoff program. In world soybean markets, major export competitors include Brazil and Argentina are exporting more soybeans and soybean products than they would have been without U.S. checkoff program.

To measure the effects of free rider gains on the transmission of the benefits from checkoff expenditures for domestic soybean promotion, soybean, soymeal and soyoil exports by Brazil and Argentina exogenized (historical levels) in the model. U.S. soybean, soymeal, and soyoil exports, on the other hand, are left as endogenously determined variables in the model.

The modified world soybean and products model is then simulated by setting all checkoff expenditures to zero as done in the preceding simulation (the "no free rider" case). The "no free rider" simulation changes in the endogenous variables in the model from their baseline simulation values are compared to the base case to determine the effect of the "no free rider" assumption on the measured changes in world soybean and products supplies, demands, prices, and trade and the producer BCR. A comparison of the "no free rider" case from those of the base case is provided in Table 29, 30, 31, and 32.

Table 29. Effect of Free Riders in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No free rider case and Base case

	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	979.8	3.1	947.8	3.0	32.0
Delta	306.3	4.5	283.5	4.1	22.7
South	247.1	5.5	219.1	4.8	28.0
Plains	438.7	4.3	418.0	4.1	20.7
Lakes	330.3	3.9	298.4	3.6	31.9
Atlantic	135.6	4.0	117.2	3.4	18.4
Other	32.1	6.3	30.0	5.9	2.1
Total	2,469.8	3.8	2,314.1	3.5	155.8
U.S. Soybean Production	mil. bu.				
Cornbelt	61.2	4.8	60.0	4.7	1.3
Delta	10.4	5.6	9.7	5.3	0.6
South	7.4	6.2	6.7	5.5	0.8
Plains	22.4	6.6	21.7	6.4	0.7
Lakes	18.4	6.0	17.2	5.6	1.1
Atlantic	5.5	6.3	5.1	5.8	0.5
Other	1.3	7.1	1.2	6.7	0.1
Total	126.7	5.5	121.6	5.2	5.0

Note: (1) No free rider case results, (2) No free rider % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no free rider case results and base case results ((1) minus (3))

Table 30. Effect of Free Riders in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No free rider case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	42.7	3.9	42.6	3.6	0.1
U.S. Soymeal Consumption	1,000 tons				
	977.8	3.8	1,005.6	4.0	-27.8
U.S. Soyoil Consumption	mil. lbs.				
	527.2	3.9	536.2	3.9	-8.9
U.S. Soybean Farm Prices	$/bu				
	0.10	1.4	0.07	1.0	0.03
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.10	1.4	0.07	1.0	0.03
Soymeal ($/ton)	6.4	2.9	5.3	2.4	1.1
Soyoil (cents/lb)	0.45	1.7	0.35	1.3	0.1
Crush Margin ($/bu)	0.1	7.9	0.1	7.2	0.01

Note: (1) No free rider case results, (2) No free rider % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no free rider case results and base case results ((1) minus (3))

The existence of free riders makes differences in effects of checkoff expenditures in U.S. soybean and products markets (Table 29 and 30). Checkoff promotion programs in domestic and foreign market shift out the demand of soybeans. Soybean production is 5.1 million bushels greater than that in the base case. As shown in Table 30, U.S. soybean producers face greater demand in the case of without free riders, an annual average of soybean farm price is $0.03 higher than the base case.

The existence of free riders also makes differences in effects of checkoff expenditures in world soybean and products trade (Table 31). With the existence of free riders, programs raised not only U.S. soybean exports but also soybean exports by Brazil and Argentina. Without free riders, higher prices result in less growth in demands in foreign markets. In the no free rider case, checkoff programs are forced to have no effects on exports by Brazil and Argentina. Thus, the U.S is able to export more soybeans than the base case. Compared to the base, U.S. soymeal and soyoil exports are greater than those in the case of no free rider.

By comparing effects of the checkoff program on benefits to U.S. soybean producers in the no free rider case and in the base case, the impact of the free rider on the upstream transmission of benefits is examined (Table 32). Without free riders, a greater soybean production results in greater added soybean cash receipts than the base case. In no free rider case, added soybean cash receipts are $3,300.6 million higher and RBCR is $2.4 higher than those in the base case are. Meanwhile, a greater soybean production leads to a higher cost of added production. However, an increase in added soybean cash receipts is higher than an increase in cost of added production. Thus, in no free rider case, increased net revenue is $2,196.1 million higher than the base case. Without free riders, PBCR and NBCR are $1.6 higher than those of the base case, respectively.

Table 31. Effect of Free Riders in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No free rider case and Base case

	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	576.1	4.2	554.1	4.1	21.9
Japan	111.0	2.6	110.9	2.6	0.1
China	1149.1	9.2	1220.5	9.9	-71.4
Rest of the world	410.1	4.2	446.4	4.6	-36.4
Total	2246.2	5.6	2332.0	5.8	-85.7
World Soybean Exports					
United States	2246.2	9.8	2112.1	9.2	134.1
Brazil	0	-	78.0	0.6	-78.0
Argentina	0	-	141.8	3.0	-141.8
Total	2246.2	5.6	2332.0	5.8	-85.7
World Soymeal Imports					
EU-15/27	161.0	1.1	192.5	1.3	-31.5
Japan	47.6	5.2	49.6	5.4	-1.9
China	-78.0	-	-78.0	-	0
Rest of the world	314.6	2.2	366.3	2.6	-51.7
Total	445.3	1.5	530.4	1.8	-85.2
World Soymeal Exports					
United States	33.1	0.5	5.5	0.1	27.6
Brazil	0	-	45.4	0.4	-45.4
Argentina	0	-	53.0	0.4	-53.0
China	412.2	-	426.5	-	-14.3
Total	445.3	1.4	530.4	1.7	-85.2
World Soyoil Imports					
Japan	2.8	22.5	2.8	22.8	-0.1
China	-127.4	-11.5	-127.1	-11.5	-2.1
Rest of the world	164.7	4.1	164.0	4.1	-9.6
Total	40.2	0.8	39.7	0.8	-11.8
World Soyoil Exports					
United States	-20.1	-	-24.7	-	4.6
Brazil	0	-	9.6	0.7	-9.6
Argentina	0	-	11.1	0.4	-11.1
EU-15/27	48.0	11.8	43.7	10.6	4.4
Total	27.9	0.6	39.7	0.8	-11.8

Note: (1) No free rider case results, (2) No free rider % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no free rider case results and base case results ((1) minus (3))

Table 32. The Impact of Free Riders on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	38,519.9	35,219.3	3,300.6
Soybean Checkoff Investment ($ million)	1,356.2	1,356.2	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	28.4	26.0	2.4
Cost of Added Production ($ million)	25,651.0	24,546.5	1,104.5
Net revenue ($ million)	12,869.0	10,672.9	2,196.1
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	9.5	7.9	1.6
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	8.5	6.9	1.6

Note: (1) No free rider case results, (2) Base case results, (3) Difference between no free rider results and base case results ((1) minus (2))

No free rider introduces the much higher soybean exports by the U.S. and more production than the base case, thus results in relatively higher benefits to U.S. soybean producers. Clearly, the more likely the gain in producer surplus without free riders is more than the gain in the case with free riders. Studies of the effects of checkoff-funded demand promotion expenditures for commodities often assume that no free riders lead to overestimated benefits.

No Domestic Supply Chain Assumption

Some analyses of checkoff programs ignore the process of simultaneous interactions between the soybean level of the supply chain and the soybean product levels of the supply chain. As represented in Figure 32, if domestic soybean use is promoted, then the soybean price increases. However, an increase in the supply of the joint products reduces prices in the markets for both joint products and the lower prices for the soybean products shift the soybean demand curve back resulting a smaller initial increases of the soybean price and soybean production. The assumption of no domestic supply implies that soybean markets are not influenced by feedback effects from joint product markets.

In addition, there are no market effects of promotion for joint products on benefits to U.S. soybean producers in the absence of a domestic supply chain. To distinguish the effect of a domestic supply chain from effects of promotions for joint products, the base case here also needs to be modified. In the base case in this scenario, the soybean model was first simulated over the period of 1980/91 through 2011/12 with all checkoff expenditures set to their actual, historical levels. The model was then again simulated over the same period with only checkoff expenditures for soybean promotion set to zero. The differences in the simulated values of the endogenous variables in the model (supply, demand, prices, trade, etc. across all countries and commodities in the model) between the two simulations were calculated and taken as measures of the effects of checkoff expenditures for soybean promotion when the assumption of no domestic supply chain is made.

To measure the U.S. and world soybean and product market effects of the soybean checkoff program in the absence of domestic supply chain effects, the U.S. crush margin variable (equation (4) in Table 3) was allowed to respond only to the soybean price. In the base model, the crush margin is calculated using soybean farm price, soymeal wholesale price and soyoil wholesale price. This scenario requires that the U.S. wholesale prices of soymeal and soyoil in the crush margin equation to be exogenized at historical levels in the model. However, the U.S. soybean farm price in the crush margin equation is the value that is determined endogenously to satisfy the market clearing condition.

The modified model is then used to simulate the effects of removing only checkoff expenditures for soybean promotion in both cases. Other checkoff funds for production research and joint products are retained in the model in both cases. The differences between the base case results and those of no domestic supply chain case results are provided in impacts of domestic supply chain on the transmission of the returns of the soybean checkoff program to soybean producers (Tables 33, 34, 35, and 36).

Table 33. Effect of Domestic Supply Chain in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No Domestic Supply Chain case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	144.2	0.4	140.0	0.4	4.2
Delta	134.9	1.9	130.8	1.9	4.1
South	163.2	3.5	158.6	3.4	4.6
Plains	99.3	0.9	96.4	0.9	2.9
Lakes	136.8	1.6	132.7	1.5	4.1
Atlantic	109.4	3.2	106.4	3.1	3.0
Other	12.9	2.4	12.5	2.4	0.4
Total	800.8	1.2	777.5	1.2	23.3
U.S. Soybean Production	mil. bu.				
Cornbelt	6.1	0.5	5.9	0.5	0.2
Delta	4.2	2.2	4.1	2.2	0.1
South	4.9	4.0	4.8	3.9	0.1
Plains	3.5	1.0	3.4	0.9	0.1
Lakes	5.2	1.6	5.0	1.6	0.2
Atlantic	3.2	3.6	3.1	3.5	0.1
Other	0.5	2.5	0.5	2.5	0.0
Total	27.6	1.1	26.8	1.1	0.8

Note: (1) No domestic supply chain case results, (2) No domestic supply chain % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no domestic supply chain results and base case results ((1) minus (3))

Table 34. Effect of Domestic Supply Chain in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No Domestic Supply Chain case and Base case

	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	39.6	1.6	36.4	1.5	0.2
U.S. Soymeal Consumption	1,000 tons				
	170.6	0.6	164.9	0.6	5.7
U.S. Soyoil Consumption	mil. lbs.				
	82.1	0.6	79.0	0.6	3.1
U.S. Soybean Farm Prices	$/bu				
	0.25	3.7	0.24	3.6	0.01
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.25	3.6	0.24	3.5	0.01
Soymeal ($/ton)	-12.8	-5.4	-12.5	-5.2	-0.3
Soyoil (cents/lb)	-1.1	-4.0	-1.1	-3.9	0.00
Crush Margin ($/bu)	-0.2	-14.7	-0.7	-31.4	0.5

Note: (1) No domestic supply chain case results, (2) No domestic supply chain % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no domestic supply chain results and base case results ((1) minus (3))

The existence of a domestic supply chain makes differences in effects of checkoff expenditures in U.S. soybean and products markets as shown in Tables 33 and 34). With domestic supply chain, a smaller initial increase in soybean price occurs as a result of the lower prices of joint products. In other words, the U.S. soybean price is $0.01 higher in the no domestic supply chain case. A higher soybean price in the no domestic supply chain case leads to larger planted acres than in the base case. Therefore, soybean production is 0.8 million bushels higher compared to the base case. Because there is no feedback effect from the prices of joint products, U.S. soybean crush is 0.2 million bushels greater in the case without a domestic supply chain.

The existence of a domestic supply chain also makes differences in the effects of checkoff expenditures on world soybean and products trade (Table 35). Assuming away a domestic supply chain results in a greater increase in prices resulting in less growth in soybean demand in foreign markets than in the base case. In both cases, U.S. exports are restricted by higher domestic consumption. On the other hand, soybean exports of competing countries increase in both cases. Without a domestic supply chain, U.S. exports of soybeans are smaller than in the base case as result of larger a U.S. soybean crush. A greater increase in the production of joint products in the no domestic supply chain case leads to a larger increase in U.S. exports of soymeal and soyoil than in the base case.

Table 35. Effect of Domestic Supply Chain in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No Supply Response case and Base case					
	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	-293.7	-	-276.8	-	-16.9
Japan	90.5	2.1	90.9	2.1	-0.4
China	516.0	3.9	533.8	4.1	-17.8
Rest of the world	218.7	2.2	225.5	2.3	-6.8
Total	531.4	1.3	573.4	1.4	-42.0
World Soybean Exports					
United States	-321.7	-	-259.1	-	-62.6
Brazil	295.5	2.5	288.4	2.4	7.1
Argentina	557.6	12.8	544.0	12.5	13.6
Total	531.4	1.3	573.4	1.4	-42.0
World Soymeal Imports					
EU-15/27	343.3	2.4	327.0	2.3	16.3
Japan	-52.6	-	-53.4	-	0.8
China	-78.0	-	-78.0	-	0
Rest of the world	711.9	5.1	685.2	4.9	26.7
Total	924.7	3.2	880.9	2.5	43.8
World Soymeal Exports					
United States	697.6	11.7	635.6	10.6	62.0
Brazil	-97.3	-	-94.8	-	-2.5
Argentina	-243.7	-	-237.5	-	-6.2
China	568.1	-	577.5	-	-9.4
Total	924.7	3.1	880.9	2.9	43.8
World Soyoil Imports					
Japan	-16.2	-	-16.3	-	0.1
China	-90.6	-	-94.1	-	3.5
Rest of the world	134.8	3.3	129.1	3.2	5.7
Total	28.0	0.5	18.7	0.4	9.3
World Soyoil Exports					
United States	164.9	24.3	150.4	21.7	14.5
Brazil	-22.7	-1.7	-22.1	-	-0.6
Argentina	-57.0	-2.2	-55.6	-	-1.4
EU-15/27	-57.2	-11.2	-54.1	-10.6	-3.1
Total	28.0	0.5	18.7	0.4	9.3

Note: (1) No domestic supply chain case results, (2) No domestic supply chain %, (3) Base case results, (4) Base case %, (5) Difference between no domestic supply chain results and base case results ((1) minus (3))

Table 36. The Impact of Domestic Supply Chain on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	29,254.6	28,577.5	677.1
Soybean Checkoff Investment ($ million)	268.1	268.1	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	109.1	106.6	2.5
Cost of Added Production ($ million)	6,802.0	6,601.2	200.8
Net revenue ($ million)	22,452.6	21,976.3	476.3
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	83.7	82.0	1.7
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	82.7	81.0	1.7

Note: (1) No domestic supply chain case results, (2) Base case results, (3) Difference between no domestic supply chain results and base case results ((1) minus (2))

By comparing effects of the checkoff program on benefits to U.S. soybean producers in the no domestic supply chain case and in the base case, the impact of the existence of a domestic supply chain on the upstream transmission of the benefits of the soybean checkoff program to soybean producers is examined (Table 36). Because of the relatively greater increase in both the soybean price and soybean production in the no domestic supply chain case, added soybean cash receipts are $677.1 million higher and the RBCR is $2.5 higher than those in the base case. The greater increase in soybean production leads to a higher cost of added production as well. Thus, in the no domestic supply case, the increase in soybean net revenue is $476.3 million higher than in the base case. In the no domestic supply chain case, the PBCR and NBCR are each $1.7 higher than those of the base case, respectively.

The no domestic supply chain assumption results in a much higher soybean price and more soybean production than the base case, thus leading to relatively higher benefits to U.S. soybean producers. Clearly, the gain in producer surplus if the existence of a supply is assumed away is higher than the in the base case. Studies of the effects of checkoff-funded demand promotion expenditures for commodities often ignore the process of simultaneous interactions between multilevel level markets leading to overestimated benefits.

No Global Supply Chain Assumption

Some analyses of checkoff programs ignore the process of simultaneous interactions between domestic and foreign markets. Increased consumption from promotion can have effects across the entire global soybean and products supply chain as the demand shift affects prices and trade of soybeans, meal, and oil. Failure to account for those effects can also seriously bias the calculation of producer benefits from checkoff promotion.

In addition, there are no market effects of international promotions for soybeans and products on benefits of U.S. soybean producers in the absence of global supply chain. To distinguish the effect of a global supply chain from effects of international promotions for soybeans and products, the base case here also must be modified. In the base case in this scenario, the soybean model was first simulated over the period of

1980/91 through 2011/12 with all checkoff expenditures set to their actual, historical levels. The model was then again simulated over the same period with only checkoff expenditures for domestic promotions for soybeans and products set to zero. The differences in the simulated values of the endogenous variables in the model (supply, demand, prices, trade, etc. across all countries and commodities in the model) between the two simulations were calculated and taken as measures of the effects of checkoff expenditures for domestic promotions when the assumption of no global supply chain is made.

To measure the effects of global supply chain on the transmission of the benefits from checkoff expenditures from only domestic soybean promotion, soybean, soymeal and soyoil exports by the U.S. are exogenized at their historical levels in the model. The modified world soybean and products model is then simulated by setting all checkoff expenditures for domestic promotions for soybean and products to zero as done in the preceding simulation (the “no global supply chain” case). Other effects of checkoff funds for production research and international promotions are retained in both cases. The changes in the simulated values of the endogenous variables in the model in the “no global supply chain” case from their baseline simulation values are compared to the base case to determine the effect of the “no global supply chain” assumption on the measured changes in domestic soybean and products supplies, demands, prices, and trade and the producer BCR. A comparison of the “no global supply chain” case from those of the base case is provided in Tables 37, 38, 39, and 40.

Table 37. Effect of Global Supply Chain in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No global supply chain case and Base case

	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	221.4	0.7	70.5	0.2	50.9
Delta	169.6	2.4	79.6	1.1	90.0
South	250.9	5.5	93.1	2.0	157.8
Plains	124.4	1.2	55.2	0.5	69.2
Lakes	175.5	2.1	67.6	0.8	107.9
Atlantic	159.7	4.7	64.7	1.9	95.0
Other	18.9	3.6	8.1	1.5	10.8
Total	1120.4	1.7	438.6	0.6	681.8
U.S. Soybean Production	mil. bu.				
Cornbelt	9.8	0.7	3.2	0.2	6.6
Delta	5.8	3.1	2.7	1.4	3.1
South	7.9	6.6	3.0	2.4	4.9
Plains	4.5	1.3	2.0	0.6	2.5
Lakes	7.1	2.2	2.7	0.8	4.4
Atlantic	5.0	5.6	2.0	2.2	3.0
Other	0.8	4.0	0.3	1.7	0.5
Total	40.8	1.7	15.9	0.7	24.9

Note: (1) No global supply chain case results, (2) No global supply chain % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no global supply chain case results and base case results ((1) minus (3))

Table 38. Effect of Global Supply Chain in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No global supply chain case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	39.4	2.9	41.5	3.0	-2.1
U.S. Soymeal Consumption	1,000 tons				
	936.9	3.7	1,059.8	4.2	-122.9
U.S. Soyoil Consumption	mil. lbs.				
	446.4	3.3	531.4	3.9	-85.0
U.S. Soybean Farm Prices	$/bu				
	0.45	7.0	0.13	1.9	0.32
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.46	6.7	0.14	1.9	0.32
Soymeal ($/ton)	-0.2	-	3.3	1.5	-3.5
Soyoil (cents/lb)	0.6	1.3	0.4	1.3	0.2
Crush Margin ($/bu)	-0.4	-	0.0	-	-0.4

Note: (1) No global supply chain case results, (2) No global supply chain % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no global supply chain case results and base case results ((1) minus (3))

The existence of a global supply chain makes a difference in effects of checkoff expenditures on U.S. soybean and products markets (Table 37 and 38). Checkoff promotion programs in the domestic market shift out the demand of soybeans. With the existence of global supply chain, programs also affect exports, imports and world soybean prices. When exports are exogenously fixed in the no global supply chain case, checkoff expenditures in U.S. soybean market result in a higher U.S. soybean price than the base case. With the higher soybean price, soybean production is greater by 24.9 million bushels and soybean crush is lower by 2.1 million bushels than in the base case.

Table 39. The Impact of Global Supply Chain on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	58,585.1	16,709.4	41,875.7
Soybean Checkoff Investment ($ million)	256.6	256.6	0
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	228.3	65.1	163.2
Cost of Added Production ($ million)	11,282.7	4,245.4	7,037.3
Net revenue ($ million)	47,302.5	12,464.0	34,838.5
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	184.3	48.6	135.7
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	183.3	47.6	135.7

Note: (1) No global supply chain case results, (2) Base case results, (3) Difference between no global supply chain results and base case results ((1) minus (2))

By comparing the effects of the checkoff program on the returns of the soybean checkoff program to U.S. soybean producers in the no global supply chain case to those in the base case, the impact of the global supply chain on the upstream transmission of benefits is examined (Table 39). If the existence of a global supply chain is assumed away, soybean producers face a higher soybean farm price and increased production results in greater added soybean cash receipts than in the base case. In the no global supply chain case, added soybean cash receipts are $41,875.7 million higher and the

RBCR is $163.2 higher than those in the base case are. Meanwhile, more a greater increase in production leads to a higher cost of added production. However, the increase in added soybean cash receipts is higher than the increase in the cost of added production. Thus, in the no global supply chain case, increased net revenue is $34,838.5 million higher than in the base case. Without a global supply chain, the PBCR and NBCR are $135.7 higher than those of the base case, respectively.

The assumption of no global supply chain results in a much higher soybean price and production than in the base case, resulting in higher benefits to U.S. soybean producers. Clearly, the measured gain to producers in terms of producer surplus is much higher is the global supply chain is assumed away than is the global supply chain linkages are taken into account in the analysis. Studies of the effects of checkoff-funded demand promotion expenditures for commodities hat assume away the global supply chain linkages in the markets they analyze will likely overestimate the benefits of a checkoff program to producers.

No Checkoff Investments in Production Research

(Only in demand promotion)

As discussed in the previous chapter, many checkoff programs studies analyze only the promotion effects of checkoff programs and ignore the fact that those programs simultaneously invest in production research. Therefore, those often ignore that the price-reducing effects of supply enhancement from research investments mute the price increasing effects of demand promotion. To measure the U.S. and world soybean and product market effects of the soybean checkoff program in the case of ignoring the effects of checkoff investments in production research, the modified world soybean and products model is simulated by setting all checkoff expenditures for demand promotion to zero as done in the preceding simulation (the "no production research" case). The "no production research" simulation changes in the endogenous variables in the model from their baseline simulation values are compared to the base case to determine the effect of the "no production research" assumption on the measured changes in world soybean and products supplies, demands, prices, and trade and the producer BCR. A comparison of the "no production research" case from those of the base case is provided in Tables 40, 41, 42, and 43.

Checkoff investments in production research make differences in the effects of checkoff expenditures in U.S. soybean and products markets (Table 40 and 41). Assuming no investments in production research, there is no price-reducing effects from the resulting supply expansion. Therefore, ignoring the effects of checkoff investments in production research leads to a much higher soybean price than in the base case. The U.S. soybean farm price is 0.34 $/bu higher in the no investments in research case. No checkoff investments in production research also makes difference in effects of checkoff expenditures on world soybean and products trade (Table 42). Because of the higher soybean price, soybean consumption in world markets is lower in the no investments in research case. For soybeans, the U.S. exports are 1,816.8 thousand mt smaller in the no investments in research case than in the base case.

Table 40. Effect of Checkoff Investments in Research in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No production research case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	288.4	0.9	947.8	3.0	-659.4
Delta	261.2	3.8	283.5	4.1	-22.3
South	308.9	6.9	219.1	4.8	89.8
Plains	196.0	1.9	418.0	4.1	-222
Lakes	281.5	3.3	298.4	3.6	-16.9
Atlantic	205.3	6.2	117.2	3.4	88.1
Other	23.8	4.6	30.0	5.9	-6.2
Total	1,565.1	2.4	2,314.1	3.5	-749.0
U.S. Soybean Production	mil. bu.				
Cornbelt	11.8	0.9	60.0	4.7	-48.2
Delta	7.8	4.2	9.7	5.3	-1.9
South	9.1	7.7	6.7	5.5	2.4
Plains	6.7	1.9	21.7	6.4	-15
Lakes	10.4	3.3	17.2	5.6	-6.8
Atlantic	5.8	6.7	5.1	5.8	0.7
Other	0.9	4.6	1.2	6.7	-0.3
Total	52.5	2.2	121.6	5.2	-69.1

Note: (1) No production research case results, (2) No production research % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no production research results and base case results ((1) minus (3))

Table 41. Effect of Checkoff Investments in Research in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No production research case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	41.8	3.3	42.6	3.6	-0.8
U.S. Soymeal Consumption	1,000 tons				
	870.8	3.4	1,005.6	4.0	-124.8
U.S. Soyoil Consumption	mil. lbs.				
	494.8	3.6	536.2	3.9	-41.4
U.S. Soybean Farm Prices	$/bu				
	0.40	6.1	0.07	1.0	0.33
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	0.41	5.9	0.07	1.0	0.34
Soymeal ($/ton)	11.8	5.5	5.3	2.4	6.5
Soyoil (cents/lb)	1.0	3.8	0.35	1.3	0.65
Crush Margin ($/bu)	0.0	-0.5	0.1	7.2	-0.1

Note: (1) No production research case results, (2) No production research % change from baseline, (3) Base case results, (4) Base case %, (5) Difference between no production research results and base case results ((1) minus (3))

Table 42. Effect of Checkoff Investments in Research in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No production research case and Base case					
	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	498.1	3.7	554.1	4.1	-56.0
Japan	107.3	2.5	110.9	2.6	-3.6
China	410.0	3.1	1220.5	9.9	-810.5
Rest of the world	29.8	0.3	446.4	4.6	-416.6
Total	1045.2	2.5	2332.0	5.8	-1286.8
World Soybean Exports					
United States	295.3	1.2	2112.1	9.2	-1816.8
Brazil	293.5	2.5	78.0	0.6	215.5
Argentina	456.4	10.3	141.8	3.0	314.6
Total	1045.2	2.5	2332.0	5.8	-1286.8
World Soymeal Imports					
EU-15/27	183.4	1.3	192.5	1.3	-9.1
Japan	43.9	4.7	49.6	5.4	-5.7
China	-78.0	-	-78.0	-	0
Rest of the world	198.5	1.4	366.3	2.6	-167.8
Total	347.9	1.2	530.4	1.8	-182.5
World Soymeal Exports					
United States	110.8	1.7	5.5	0.1	105.3
Brazil	46.9	0.4	45.4	0.4	1.5
Argentina	21.9	0.2	53.0	0.4	-31.1
China	168.3	-	426.5	-	-258.2
Total	347.9	1.1	530.4	1.7	-182.5
World Soyoil Imports					
Japan	3.3	27.3	2.8	22.8	0.5
China	-95.2	-8.9	-127.1	-11.5	31.9
Rest of the world	131.4	3.3	164.0	4.1	-32.6
Total	39.4	0.8	39.7	0.8	-0.3
World Soyoil Exports					
United States	-9.7	-	-24.7	-	15.0
Brazil	9.6	0.7	9.6	0.7	0.0
Argentina	3.9	0.2	11.1	0.4	-7.2
EU-15/27	35.6	8.5	43.7	10.6	-8.1
Total	39.4	0.8	39.7	0.8	-0.3

Note: (1) No production research case results, (2) No production research %, (3) Base case results, (4) Base case %, (5) Difference between no production research results and base case results ((1) minus (3))

By comparing effects of the checkoff program on the benefits to U.S. soybean producers in the no investments in research case and in the base case, the impact of checkoff investments in production research on the upstream transmission of benefits is examined (Table 43). Because of the higher soybean price in the no investments in research case, added soybean cash receipts is $11,375.8 million higher and RBCR is $32.6 higher than those in the base case are. Meanwhile, a smaller increase in production leads to a much lower increase in the cost of added production. Thus, in the no investments in research case, increased net revenue is $23,485.8 million higher than the base case. Also, the PBCR and NBCR are $35.1 higher than those of the base case, respectively.

Assuming no checkoff investments in research results in a much higher soybean price and much lower soybean production than the base case, thus resulting in relatively higher benefits and lower costs to U.S. soybean producers. Clearly, producer surplus is higher with checkoff investments in production research than in the case without checkoff investments in production research. Studies of the effects of checkoff-funded demand promotion expenditures for commodities often ignore that checkoff expenditures are also invested in production research which can lead to a serious overestimation of the benefits of demand promotion alone to producers.

Table 43. The Impact of Checkoff Investments in Research on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	46,595.1	35,219.3	11,375.8
Soybean Checkoff Investment ($ million)	794.9	1,356.2	-561.3
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	58.6	26.0	32.6
Cost of Added Production ($ million)	12,436.5	24,546.5	-12,110.0
Net revenue ($ million)	34,158.7	10,672.9	23,485.8
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	43.0	7.9	35.1
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	42.0	6.9	35.1

Note: (1) No production research case results, (2) Base case results, (3) Difference between no production research results and base case results ((1) minus (2))

No Promotion Programs at Multiple Levels of the Supply Chain

(Promotion occurs at only the Retail Level of the Market)

Some analyses of checkoff programs ignore the potentially important checkoff-promotion-induced simultaneous interactions among different levels of the supply chain on the transmission of benefits to producers. Consequently, many studies often only analyze effects of checkoff expenditures at the retail level of the market.

To measure the U.S. and world soybean and product market effects of the soybean checkoff program in the case of ignoring the effects of checkoff investments in soybean promotion, the modified world soybean and products model is simulated by setting only checkoff expenditures for soymeal and soyoil demand promotion and production research to zero as done in the preceding simulation (the "no soybean promotion" case). The "no soybean promotion" simulation changes in the endogenous variables in the model from their baseline simulation values are compared to those in the base case to determine the effects of the "no soybean promotion" assumption on the measured changes in world soybean and products supplies, demands, prices, and trade, and the producer BCR. A comparison of the "no soybean promotion" case to those of the base case is provided in Tables 44, 45, 46, and 47.

Table 44. Effect of No Promotion Programs at Multiple Levels of the Supply Chain in U.S. Soybean Supply, 1980/81-2012/13

The Difference between No soybean promotion case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Planted Acres	1,000 acres				
Cornbelt	784.8	2.4	947.8	3.0	-163.0
Delta	127.0	1.8	283.5	4.1	-156.5
South	32.2	0.7	219.1	4.8	-186.9
Plains	316.2	3.1	418.0	4.1	-101.8
Lakes	152.9	1.8	298.4	3.6	-145.5
Atlantic	-2.3	-0.1	117.2	3.4	-119.5
Other	15.7	3.0	30.0	5.9	-14.3
Total	1,426.6	2.1	2,314.1	3.5	-887.5
U.S. Soybean Production	mil. bu.				
Cornbelt	53.3	4.2	60.0	4.7	-6.7
Delta	4.7	2.5	9.7	5.3	-5.0
South	0.9	0.7	6.7	5.5	-5.8
Plains	18.2	5.3	21.7	6.4	-3.5
Lakes	11.8	3.8	17.2	5.6	-5.4
Atlantic	1.7	1.8	5.1	5.8	-3.4
Other	0.7	3.6	1.2	6.7	-0.5
Total	91.3	3.9	121.6	5.2	-30.3

Note: (1) No soybean promotion case Results, (2) No soybean promotion programs % change from baseline, (3) Base case Results, (4) Base case %, (5) Difference between no soybean promotion case results and base case results ((1) minus (3))

Table 45. Effect of No Promotion Programs at Multiple Levels of the Supply Chain in U.S. Soybean Demand and Prices, 1980/81-2012/13

The Difference between No soybean promotion case and Base case					
	(1)	(2)	(3)	(4)	(5)
U.S. Soybean Crush	mil. bu.				
	6.1	1.8	42.6	3.6	-36.5
U.S. Soymeal Consumption	1,000 tons				
	825.0	3.2	1,005.6	4.0	-180.6
U.S. Soyoil Consumption	mil. lbs.				
	452.8	3.3	536.2	3.9	-83.4
U.S. Soybean Farm Prices	$/bu				
	-0.16	-2.3	0.07	1.0	-0.2
U.S. Soybean and Product Wholesale Prices	$/unit				
Soybean ($/bu)	-0.16	-2.2	0.07	1.0	-0.2
Soymeal ($/ton)	18.0	8.7	5.3	2.4	12.7
Soyoil (cents/lb)	1.5	5.8	0.35	1.3	1.1
Crush Margin ($/bu)	0.8	108.9	0.1	7.2	0.7

Note: (1) No soybean promotion case results, (2) No soybean promotion case %, (3) Base Case results, (4) Base case %, (5) Difference between no soybean promotion case results and base case results ((1) minus (3))

Ignoring wholesale level promotion of soybeans and focusing only on the promotion of soybean products at retail make a difference in effects of checkoff expenditures on U.S. soybean and products markets (Table 44 and 45). Without investments in soybean promotion, soybean crush is smaller than in the base case. Therefore, a lower increase in the supply of joint products results in higher prices of joint products. In addition, ignoring the effects of checkoff investments in soybean promotion leads to a much lower soybean price than the base case. The U.S. soybean farm price is 0.2 $/bu lower in the case of only promoting at the retail level (Table 45).

No checkoff investments in soybean promotion also make a difference in the effects of checkoff expenditures on world soybean and products trade (Table 46). In the retail-only promotion case, checkoff expenditures result in an increase in exports of soybeans and a decrease in exports of joint products compared to the base case. Total imports and exports of soybeans and soybean products were smaller than the base case.

By comparing effects of the checkoff program on benefits to U.S. soybean producers in the retail-only promotion case and in the base case, the impact of checkoff investments in the retail-only promotion case on the upstream transmission of benefits is examined (Table 47). Because of the lower soybean price in the retail-only promotion case, added soybean cash receipts are $27,342.4 million lower and the RBCR is $18.8 lower than those in the base case. Meanwhile, a smaller increase in production leads to a lower cost of added production. Since the cost of added production is larger than added soybean cash receipts, checkoff effects on net revenue is negative in the retail-only promotion case. Thus, assuming only retail level promotion, net revenue is $19,787.3 million lower than in the base case. In the retail-only promotion case, the PBCR and the NBCR are $16.3 lower than those of the base case, respectively.

Table 46. Effect of No Promotion Programs at Multiple Levels of the Supply Chain in World Soybean and Products Trade, 1980/81-2012/13

The Difference between No soybean promotion case and Base case					
	(1)	(2)	(3)	(4)	(5)
World Soybean Imports 1,000 mt					
EU-15/27	827.2	6.2	554.1	4.1	273.9
Japan	19.7	0.4	110.9	2.6	-94.7
China	642.5	5.0	1220.5	9.9	-578.0
Rest of the world	201.9	2.0	446.4	4.6	-244.5
Total	1691.3	4.2	2332.0	5.8	-640.7
World Soybean Exports					
United States	2276.3	10.0	2112.1	9.2	164.2
Brazil	-199.1	-1.6	78.0	0.6	-277.1
Argentina	-385.9	-7.3	141.8	3.0	-527.7
Total	1691.3	4.2	2332.0	5.8	-640.7
World Soymeal Imports					
EU-15/27	-133.3	-0.9	192.5	1.3	-325.8
Japan	102.8	11.9	49.6	5.4	53.2
China	-78.0	-	-78.0	-	0
Rest of the world	-324.1	-2.2	366.3	2.6	-690.4
Total	-432.5	-1.4	530.4	1.8	-962.9
World Soymeal Exports					
United States	-616.9	-8.5	5.5	0.1	-622.4
Brazil	139.8	1.3	45.4	0.4	94.4
Argentina	288.4	2.4	53.0	0.4	235.4
China	-243.9	-	426.5	-	-670.4
Total	-432.5	-1.4	530.4	1.7	-962.9
World Soyoil Imports					
Japan	19.2	-481.8	2.8	22.8	16.4
China	-30.9	-3.1	-127.1	-11.5	96.2
Rest of the world	33.4	0.8	164.0	4.1	-130.6
Total	21.6	0.4	39.7	0.8	-18.1
World Soyoil Exports					
United States	-173.4	-17.1	-24.7	-	-148.7
Brazil	31.6	2.4	9.6	0.7	22.0
Argentina	66.2	2.7	11.1	0.4	55.1
EU-15/27	97.1	27.1	43.7	10.6	53.4
Total	21.6	0.4	39.7	0.8	-18.1

Note: (1) No soybean promotion case results, (2) No soybean promotion %, (3) Base case results, (4) Base case %, (5) Difference between no soybean promotion case and base case results ((1) minus (3))

Table 47. The Impact of No Promotion Programs at Multiple Levels of the Supply Chain on the Upstream Transmission of Benefits to U.S. Soybean Producers, 1980/81-2012/13

	(1)	(2)	(3)
Added Soybean Cash Receipts ($ million)	7,876.9	35,219.3	-27,342.4
Soybean Checkoff Investment ($ million)	1,088.1	1,356.2	-268.1
Revenue Benefit-Cost Ratio (RBCR) ($/$ spent)	7.2	26.0	-18.8
Cost of Added Production ($ million)	16,991.3	24,546.5	-7,555.2
Net revenue ($ million)	-9,114.4	10,672.9	-19,787.3
Grower Profit Benefit-Cost Ratio (PBCR) ($/$ spent)	-8.4	7.9	-16.3
Grower Net Profit Benefit-Cost Ratio (NBCR) ($/$ spent)	-9.4	6.9	-16.3

Note: (1) No soybean promotion case results, (2) Base case results, (3) Difference between no soybean promotion case results and base case results ((1) minus (2))

Assuming retail-only promotion results in lower production than in the base case, thus resulting in much lower benefits and lower costs to U.S. soybean producers. Clearly, the gain in producer surplus without checkoff investments in soybean promotion is less than the gain in the case with all checkoff investments. Studies of the effects of checkoff-funded demand promotion expenditures for commodities often ignore that checkoff expenditures are also invested at the wholesale level which can lead to underestimating the benefits of the promotion.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Most evaluations of checkoff programs make one or more assumptions to simplify their analyses without realizing the impact that such assumptions may have on the measured transmission of checkoff program returns along the supply chain back to producers. Typical simplifying assumptions that are made in the checkoff evaluation literature include no supply response, no price response, no government intervention in supporting farm prices and influencing farm supply, no free-rider gains, no domestic supply chains, no global supply chains, no checkoff investments in production research, and no promotion programs at multiple levels of the supply chain. These assumption could have serious effects on the measured upstream transmission of the benefits of generic promotion programs to producers.

Summary

This study empirically analyzed the effects of key simplifying assumptions often made in analyses of checkoff programs that may affect the upstream transmission of the benefits of commodity checkoff programs to producers. Prior to examining those effects, the first part of this study concentrated on a qualitative analysis of the world soybean and products market as a background for constructing a world soybean model. A conceptual model of world soybean and soybean products markets was first proposed and discussed. Then an econometric simulation model of world soybean and soybean products markets that relaxes all of the simplifying assumption was developed to examine the effects of imposing those assumption on the transmission of the benefits of a commodity checkoff program to producers.

Using the world soybean and soybean products model, a baseline case was simulated over the period of 1980/81 to 2012/13 in which none of the simplifying assumptions were made. The baseline simulation measured the effects of no expenditures on soybean checkoff production research or demand promotion. In this case, the soybean checkoff program boosts U.S. soybean production by an annual average of 5.2% compared to what would have been the case without a soybean checkoff program. The U.S. soybean crush also averaged 3.1% higher than would have been the case without the checkoff program. Also, the price farmers receive for soybeans averaged 1% higher and U.S. soybean exports 9% higher than would have been the case without the program. The benefit-cost ratio (BCR) of the soybean checkoff program was positive at $6.9 of returns to producers per dollar spent on promotion indicating that the U.S. soybean checkoff program has been highly effective in benefitting soybean producers over the study period.

Conclusions

As expected, whether a supply response was allowed for in the analysis had an impact on the measured transmission of benefits to producers. The U.S. soybean farm price is higher if supply is not allowed to respond than in the base case in which supply responds to price changes. However, U.S. soybean production is lower without allowing a supply response case compared to the base case while the soybean price is higher. The lower increase in production than in the base case, results in relatively higher benefits and lower costs to U.S. soybean producers. It implies that benefits would be overestimated if supply response is not considered in the analysis.

Assuming no price response (a perfectly elastic supply) also had important impacts on the transmission of the benefits of the soybean checkoff program to producers. With a perfectly elastic supply curve so that a promotion-enhanced demand curve has no effect on price, the U.S. soybean production is higher than in the base case because supply increases to equal the larger demand in the perfectly price elastic supply case. Because of the relatively larger soybean production in the perfectly elastic supply case, added soybean cash receipts and the RBCR are higher than those in the base case. Assuming no price response results in a relatively lower soybean price and larger production than in the base case. The result is higher measured benefits to producers because of much higher costs of a much higher soybean production. Thus, assuming a perfectly elastic supply so that price does not increase as promotion shifts demand leads to an underestimation of the producer benefits of a soybean checkoff program.

Assuming away the complexities of government intervention in commodity markets also impacts the measurement of the producer benefits of checkoff promotion. U.S. farm policy intervention in the soybean industry over the years has meant that supply does not respond to price when the price is below the government mandated support price level (loan rate or target price). Thus, assuming away government intervention results in more production than would actually occur (the base case).

Although soybean production increased more in the “no government intervention” simulation, a lower soybean farm price results in lower added soybean cash receipts than in the base case. Thus, when government intervention is assumed away, the increase in net revenues to producers as a result of checkoff programs is lower than in the base case. the result is an underestimation of he returns to producers if government intervention in commodity markets is ignored.

Failure to consider free riders in the analysis caused differences in the effects of checkoff programs on U.S. soybean production and U.S. soybean farm price. Because Brazilian and Argentine soybean and product markets are assumed not to respond to the foreign demand increases generated by U.S. soybean heckoff promotion, both U.S. soybean exports and U.S. soybean production are higher without the export response of the free riders (Brazil and Argentina) than in the base case. As a consequence, the annual average U.S. soybean farm price is somewhat lower without free riders but revenue to producers is higher given the increase in U.S. production relative to he price decline compared to the base case. The result is higher estimated returns to U.S. soybean producers when the free rider problem is assumed away. Thus, assuming away the free rider problem results in an overestimation of the benefits of te checkoff program to producers.

Assuming away the dometic supply chain linkages between soybeans and soybean products in the analysis of the soybean checkoff program also impacts the calculation of the benefits of the program to producers. The assumption of no domestic supply chian implies that U.S. soybean markets prices and markets are not influenced by feedback effects from the joint product markets (soymeal and soyoil). When the supply chain linkages are included, lower prices of joint products lead a moderate the positive soybean price effect of the soybean checkoff program. In other words, the U.S. soybean price increases by more in the "no domestic supply chain case" compared to the "base case". The higher soybean price in the no domestic supply chain case leads to larger planted acres than the base case and, therefore, a higher level of soybean production compared to the base case. Because of the higher soybean price and the greater production in the "no domestic supply chain case," added soybean cash receipts and the net revenue BCR are higher than those in the base case, resulting in higher estimated benefits of the soybean checkoff program to U.S. soybean producers. In other words, assuming away domestic supply chain linkages in the analysis of the effects of a commodity checkoff program can lead to oversestimating the producer returns from that checkoff program.

Assuming away global supply chain effects while accounting for domestic supply chain effects also impacts the measured returns of the soybean checkoff program to producers. Assuming away any linkage of domestic U.S. soybean and product markets to global markets results in a higher U.S. soybean farm price and production resulting in higher added soybean cash receipts than the base case. In the "no global supply chain case," the added soybean cash receipts and the net revenue BCR are higher than those in the base case. The increase in added soybean cash receipts is greater than the increase in the cost of added production. Thus, in the "no global supply chain case," the increase in net revenue to U.S. soybean producers is higher than the base case. The effects of assuming no global supply chain linkages introduces a much higher soybean price and higher production than the base case, resulting in higher benefits to U.S. soybean producers leading to an over-estimation of the returns to producers.

Some checkoff programs like soybean invest in not only demand promotion but also production research. Failure to account for the price-reducing effects of supply enhancement from production research investments made with checkoff funds results in a higher market price from demand promotion. In the case of the soybean checkoff program, when the supply effects of production research investments are not included in the analysis, the soybean price as well as the added soybean cash receipts and the net revenue BCR are all higher than those in the base case. Soybean production is also lower but the increase in price more than offsets the reduction in production to generate increased revenues. At the same time, the lower soybean production in the "no production research case" leads to a lower cost of added production than the base case. With higher cash receipts and lower total costs of production from the lower production, net revenue to farmers increases. The result is an overestimation of the returns from the soybean checkoff program to producers if the checkoff investments in production research are ignored in the analysis.

Some analyses of checkoff programs ignore the potentially important checkoff-promotion-induced simultaneous interactions among different levels of the supply chain on the transmission of benefits to producers. Consequently, many studies often only analyze effects of checkoff expenditures only at the retail level of the market and ignore the checkoff promotion expenditures at other levels of the market. To measure this effect, the model was simulated once again this time assuming only retail level promotion of soybean products occurs (soymeal and soyoil) while the promotion expenditures on soybean promotion are ignored. Without investments in soybean promotion, the U.S. soybean crush is smaller than in the base case. Consequently, the production of soybean products is also lower resulting in higher prices of the joint products than in the base case. At the same time, the U.S. soybean price is much lower and, therefore, soybean production is also lower than in the base case. The consequence is a smaller increase in net revenue to producers but also lower total costs of production. In this case, the cost of added production is larger than added soybean cash receipts leading to a lower measure net revenue BCR to producers. The implication is that ignoring the multiple levels of the market at which checkoff expenditures are made can lead to an underestimation of the producer returns from a checkoff program.

Despite the large and growing literature that evaluates the producer benefits of commodity checkoff programs, little empirical research has focused on the various simplifying assumptions that are often made in such analyses. This study demonstrates that such assumption can influence the rate and extent of the retail-to-farm transmission of generic advertising and promotion effects. The overall implication of these findings is that ignoring the effects of those assumptions on the upstream transmission of the benefits of generic promotion programs in the study of checkoff programs can result in often substantial over- or under-estimation of the producer returns from checkoff programs.

Limitations of this Study

The results of the study may be subject to a number of possible limitations. First, this study is limited to the soybean markets. The results of the study focused only on the effects of assumptions on the upstream transmission of the benefits of generic promotion programs in the case of soybeans, which may be different in cases of other commodities. Second, the study did not examined effects of simultaneously imposed assumptions but just analyzed the effects of each assumption. Consequently, this analysis ignores the potentially important simultaneous interactions among effects of assumptions. Third, when estimating demand equations of soybean products in the international markets, considering sufficient and appropriate substitutes may improve the reliability of the model. Fourth, uses of soyoil could be subdivided into purposes – food use and industrial use. Unfortunately, the model used in this study includes only aggregated soyoil demand for the simplicity of estimating equations in soyoil blocks. In addition, having livestock sectors exogenous prevents this study from fully capturing the feedbacks from the sectors.

Suggestions for Further Research

Given that this study has some shortcomings in terms of scope of research objects, some work may be needed in future. First, additional studies on different commodity sectors will be needed to verify how effects of those assumptions differ from the effects in the case of soybeans. Second, considering that earlier studies were not based on single assumption, but were based on multiple assumptions, examining effects of simultaneously imposed assumptions will serve as a useful guideline for future efforts to conduct more precise evaluation of upstream transmission effects of the checkoff benefits. Third, a bias resulted from the effects of assumptions would be differently estimated according to sizes of elasticities and a structure of supply chain. Efforts to examine conditions for each assumption that lead seriously under- or over-estimated benefits should help resolve the objective of this study.

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APPENDIX A

Variable Variables

Endogenous Variables

U.S. Regional Soybean Variables

Region	Acres Planted (1,000 acres)	Acres Harvested (1,000 acres)	Yield[1] (bu/acres)	Production (1,000 bu)	Market Price[2] ($/bu)	Expected Price[3] ($/bu)
Atlantic	ASOYSAC	ASOYSHC	ASOYSYC	ASOYSPC	ASOYPFC	ASOYPCC
Cornbelt	CSOYSAC	CSOYSHC	CSOYSYC	CSOYSPC	CSOYPFC	CSOYPCC
Delta	DSOYSAC	DSOYSHC	DSOYSYC	DSOYSPC	DSOYPFC	DSOYPCC
Lakes	LSOYSAC	LSOYSHC	LSOYSYC	LSOYSPC	LSOYPFC	LSOYPCC
Other	OSOYSAC	OSOYSHC	OSOYSYC	OSOYSPC	OSOYPFC	OSOYPCC
Plains	PSOYSAC	PSOYSHC	PSOYSYC	PSOYSPC	PSOYPFC	PSOYPCC
South	SSOYSAC	SSOYSHC	SSOYSYC	SSOYSPC	SSOYPFC	SSOYPCC

[1] Weighted Average regional yields with weighs equal to the share of regional production accounted for by each state in the region.
[2] Average farm price over all states in the respective regions weighted by production in each state in the region.
[3] Expected price at the farm calculated as given in the model.

U.S. National Soybean and Product Market Variables

UCOMDPC U.S. cottonseed meal share of high protein meal use (soymeal equivalents), marketing year
UCOODPC U.S. cottonseed oil share of oleic/linoleic oil use, marketing year
UHPMDCC U.S. high protein meal use, 1,000 tons, marketing year (calculated as in model)
UHPMPWC U.S. high protein meal price, $/tons, marketing year, wtd ave. (calculated as in model)
UOLODDC U.S. oleic/linoleic oil use, mil lb., marketing year (calculated as in model)
UOLOPWC U.S. oleic/linoleic oil price, ¢/lb, marketing year, wtd ave. (calculated as in model)
USOMDDC U.S. soymeal use, 1,000 tons, marketing year
USOMDPC U.S. soymeal share of high protein meal use, marketing year
USOMHEC U.S. soymeal ending stocks, 1,000 tons, September 30
USOMMEC U.S. soymeal exports, 1,000 tons, marketing year
USOMPWC U.S. wholesale price of soymeal, $/ton, marketing year
USOMSPC U.S. soymeal production, 1,000 tons, marketing year
USOODDC U.S. soyoil use, mil lb., marketing year
USOODPC U.S. soyoil share of oleic/linoleic oil use, marketing year
USOOHEC U.S. soyoil ending stocks, mil lb., September 30
USOOHTC U.S. soyoil total ending stocks, mil lb., September 30
USOOMEC U.S. soyoil commercial exports, mil lb., marketing year

USOOMTC U.S. soyoil total exports, mil lb., marketing year
USOOPWC U.S. wholesale price of soyoil, ¢/lb, marketing year
USOOSPC U.S. soyoil production, mil lb., marketing year
USOYDCC U.S. soybean crush, million bu., crop year
USOYEHR U.S. soybean stock to use ratio, crop year
USOYGCC U.S. soybean crush margin, $/bu, crop year (calculated as in model)
USOYHEC U.S. soybean private ending stocks, million bu., August 31
USOYHTC U.S. soybean total ending stocks, million bu., August 31
USOYMEC U.S. soybean exports, mil bu., crop year
USOYPFC U.S. farm price of soybeans, $/bu, crop year
USOYPWC U.S. wholesale price of soybeans, $/bu, crop year
USOYSAC Total U.S. soybean acreage planted, million acres, crop year
USOYSHC Total U.S. soybean acreage harvested, million acres, crop year
USOYSPC Total U.S. soybean production acreage harvested, million bu., crop year

U.S. Regional Corn Variables

Region	Acres Planted (1,000 acres)	Acres Harvested (1,000 acres)	Production (1,000 bu)	Market Price[1] ($/bu)	Expected Price[2] ($/bu)
Atlantic	ACORSAC	ACORSHC	ACORSPC	ACORPFC	ACORPCC
Cornbelt	CCORSAC	CCORSHC	CCORSPC	CCORPFC	CCORPCC
Delta	DCORSAC	DCORSHC	DCORSPC	DCORPFC	DCORPCC
Lakes	LCORSAC	LCORSHC	LCORSPC	LCORPFC	LCORPCC
Other	OCORSAC	OCORSHC	OCORSPC	OCORPFC	OCORPCC
Plains	PCORSAC	PCORSHC	PCORSPC	PCORPFC	PCORPCC
South	SCORSAC	SCORSHC	SCORSPC	SCORPFC	SCORPCC
Residual	TCORSAC	TCORSHC	TCORSPC	TCORPFC	TCORPCC

[1] Average farm price over all states in the respective regions weighted by production in each state in the region.
[2] Expected price at the farm calculated as given in the model.

U.S. National Corn Market Variables

UCORDFC U.S. feed demand for corn, million bu., marketing year
UCORDOC U.S. food demand for corn, million bu., marketing year
UCORHOC U.S. corn private ending stocks, million bu., September 30
UCORHTC U.S. corn total ending stocks, million bu., September 30
UCORMEC U.S. corn exports, million bu., marketing year
UCORPFC U.S. farm price of corn, $/bu, marketing year
UCORPPC U.S. weighted ave. expected farm price of corn, $/bu, marketing year (calculated as in model)
UCORPWC U.S. wholesale price of corn, $/bu, marketing year
UCORSAC Total U.S. corn acreage planted, million acres, crop year
UCORSHC Total U.S. corn acreage planted, million acres, crop year
UCORSPC Total U.S. corn production, million bu, crop year

European Union National Soybean and Product Market Variables

ECORPIA	EU import price of U.S. corn, cif Rotterdam, $/mt, annual
ESOMDDC	EU soymeal use, 1,000 mt, marketing year
ESOMMIC	EU net imports of soymeal (imports-exports), 1,000 mt, marketing year
ESOMPIA	EU import price of soymeal, cif Rotterdam, $/mt, annual
ESOMSPC	EU production of soymeal, 1,000 mt, marketing year
ESOODDC	EU soyoil use, 1,000 mt, marketing year
ESOOMXC	EU net exports of soyoil (exports-imports), 1,000 mt, marketing year
ESOOPXA	EU export price of soyoil, fob Rotterdam, $/mt, annual
ESOOSPC	EU production of soyoil, 1,000 mt, marketing year
ESOYDCC	EU soybean crush, 1,000 mt, marketing year
ESOYMIC	EU net imports of soybeans (imports-exports), 1,000 mt, marketing year
ESOYPIA	EU import price of soybeans, cif Rotterdam, $/mt, annual

Japan National Soybean and Product Market Variables

JSOMDDC	Japan soymeal use, 1,000 mt, marketing year
JSOMMIC	Japan net imports of soymeal (imports-exports), 1,000 mt, marketing year
JSOMPUA	Japan unit import price of soymeal, $/mt, annual
JSOMSPC	Japan production of soymeal, 1,000 mt, marketing year
JSOODDC	Japan soyoil use, 1,000 mt, marketing year
JSOOMIC	Japan net imports of soyoil (imports-exports), 1,000 mt, marketing year
JSOOPUA	Japan unit import price of soyoil, $/mt, annual
JSOOSPC	Japan production of soyoil, 1,000 mt, marketing year
JSOYDCC	Japan soybean crush, 1,000 mt, marketing year
JSOYMIC	Japan net imports of soybeans (imports-exports), 1,000 mt, marketing year
JSOYPUA	Japan unit import price of soybeans, $/mt, annual

China National Soybean and Product Market Variables

HSOMDDC	China soymeal use, 1,000 mt, marketing year
HSOMMXC	China net exports of soymeal (exports-imports), 1,000 mt, marketing year
HSOMPWA	China wholesale price of soymeal, RMB yuan/mt, annual
HSOMSPC	China production of soymeal, 1,000 mt, marketing year
HSOODDC	China soyoil use, 1,000 mt, marketing year
HSOOMIC	China net imports of soyoil (imports-exports), 1,000 mt, marketing year
HSOOPWA	China wholesale price of soyoil, RMB yuan/mt, annual
HSOOSPC	China production of soyoil, 1,000 mt, marketing year
HSOYDCC	China soybean crush, 1,000 mt, marketing year
HSOYMIC	China net imports of soybeans (imports-exports), 1,000 mt, marketing year
HSOYPFA	China farm price of soybeans, RMB yuan/mt, annual
HSOYPWA	China wholesale price of soybeans, RMB yuan/mt, annual

HSOYSHC China soybean acreage harvested, 1,000 ha, crop year
HSOYSPC China soybean production, 1,000 mt, marketing year

Rest of the World (ROW)[1] National Soybean and Product Market Variables

RSOMDDN ROW soymeal use, 1,000 mt (calculated as in model)
RSOMMIN ROW net imports of soymeal (imports-exports), 1,000 mt (residual calculated as in model)
RSOMSPN ROW soymeal production, 1,000 mt (calculated as in model)
RSOODDN ROW soyoil use, 1,000 mt (calculated as in model)
RSOOMIN ROW net imports of soyoil (imports-exports), 1,000 mt (residual calculated as in model)
RSOOSPN ROW soyoil production, 1,000 mt (calculated as in model)
RSOYMIN ROW net imports of soybeans (imports-exports), 1,000 mt (residual calculated as in model)

[1] Defined as all countries except the EU-15/27, Japan, China, Argentina, Brazil, and the U.S.

Brazil National Soybean and Product Market Variables

BSOMDDC Brazil soymeal use, 1,000 mt, marketing year
BSOMMEC Brazil exports of soymeal, 1,000 mt, marketing year
BSOMPXC Brazil export price of soymeal, $/mt, marketing year
BSOMSPC Brazil soymeal production, 1,000 mt, marketing year
BSOODDC Brazil soyoil use, 1,000 mt, marketing year
BSOOMXC Brazil net exports of soyoil (exports-imports), 1,000 mt, marketing year
BSOOPXC Brazil export price of soyoil, $/mt, marketing year
BSOOSPC Brazil soyoil production, 1,000 mt, marketing year
BSOYDCC Brazil soybean crush, 1,000 mt, marketing year
BSOYMXC Brazil net exports of soybeans (exports-imports), 1,000 mt, marketing year
BSOYPXC Brazil export price of soybeans, $/mt, marketing year
BSOYSHC Brazil soybean acreage harvested, 1,000 ha, crop year
BSOYSPC Brazil soybean production, 1,000 mt, marketing year

Argentina National Soybean and Product Market Variables

GSOMDDC Argentina soymeal use, 1,000 mt, marketing year
GSOMMEC Argentina exports of soymeal (exports-imports), 1,000 mt, marketing year
GSOMPXA Argentina export price of soymeal, $/mt, calendar year
GSOMSPC Argentina soymeal production, 1,000 mt, marketing year
GSOODDC Argentina soyoil use, 1,000 mt, marketing year
GSOOMEC Argentina exports of soyoil (exports-imports), 1,000 mt, marketing year
GSOOPXA Argentina export price of soyoil, $/mt, calendar year
GSOOSPC Argentina soyoil production, 1,000 mt, marketing year
GSOYDCC Argentina soybean crush, 1,000 mt, marketing year

GSOYMEC Argentina exports of soybeans (exports-imports), 1,000 mt, marketing year
GSOYPXA Argentina export price of soybeans, $/mt, calendar year (for 1972, ave. price 1971 and 1973 is used)
GSOYSHC Argentina soybean acreage harvested, 1,000 ha, crop year
GSOYSPC Argentina soybean production, 1,000 mt, marketing year

EXOGENOUS VARIABLES

General

Dn Indicator variable for year n such that n=1 and all other years=0
Dnm Indicator variable for years n and m such that years n and m =1 and all other years=0
DnTm Indicator variable for years n through m such that years n through m =1 and all other years=0
TIME Time trend (years=1960...2012)

United States

ACORSYC Atlantic region wtd average corn yield, bu/acre, crop year
AOATPPC Atlantic region expected farm price for oats (same formula as for corn, see model for formula)
ASOYPLC Atlantic region non-recourse soybean loan rate, $/bu, crop year
ASOYRESDF Atlantice region stock of soybean checkoff research expenditures, $US, crop year
CCORSYC Cornbelt region wtd average corn yield, bu/acre, crop year
CSOYPLC Cornbelt region non-recourse soybean loan rate, $/bu, crop year
CSOYRESDF Cornbelt region stock of soybean checkoff research expenditures, $US, crop year
DACORS1 Atlantic region weather indicator variable 1, 1961, 1987, 2008=1, all other years=0
DACORS2 Atlantic region weather indicator variable 1, 1973, 1977, 1984=1, all other years=0
DASOYSA Delta region weather indicator variable,1980=1, 1987=-1, all other years=0
DCCORS Cornbelt region weather indicator variable, 1960, 1962, 1981, 1987, 1995, 2002, 2006=1, all other years=0
DCORSYC Delta region wtd average corn yield, bu/acre, crop year
DCOYSYC Cornbelt region weather indicator variable 1, 1970, 1971, 1972, 1985, 1994, 2000=1, all other years=0
DDCORS Delta region weather indicator variable, 1996, 1998, 2002, 2009, 2011=1, 1976, 1999=-1, all other years=0
DFB02 Indicator variable for the effects of the 1990 farm bill, 2002-2006=1, all other years =0
DFB96 Indicator variable for the effects of the 1996 farm bill, 1996-2006=1, all other years =0
DLBW Lakes region weather indicator variable, 1989, 1990, 2004, 2005=1, 1991, 2003=-1, all other years=0
DLCORS Lakes region weather indicator variable, 1971, 1972, 1973, 1989=1, all other years=0

DOSOYSA1	Other region weather indicator variable 1, 1976, 2010, 2012=1, all other years=0
DOSOYSA2	Other region weather indicator variable 2, 1996, 2003=1, 1979, 1980, 2004=-1, all other years=0
DPCORS	Praines region weather indicator variable 4, 1961, 1975, 1976=1, 1973=-1, all other years=0
DPIK	Indicator variable for the 1982 U.S. payment-in-kind (PIK) program, 1982 =1, all other years =0
DPSOYSA1	Plains region weather indicator variable 1, 1977, 1996=1, 1965, 1984, 1994, 2006=-1, all other years=0
DPSOYSA2	Plains region weather indicator variable 2, 2007=1, 2008=-1, all other years=0
DPSOYSA3	Plains region weather indicator variable 3, 2005=1, 2009, 2010, 2012=-1, all other years=0
DRGHT07	Indicator variable for drought, 2007 = 1, all other years=0
DRICPPC	Delta region expected farm price for rice (same formula as corn,see model for formula)
DSCORS1	South region weather indicator variable 1, 1961, 1987, 2006=1, all other years=0
DSCORS2	South region weather indicator variable 2, 1977, 1984, 2007=1, all other years=0
DSOYPLC	Delta region non-recourse soybean loan rate, $/bu, crop year
DSOYRESDF	Delta region stock of soybean checkoff research expenditures, $US, crop year
DTCORS	Residual other region weather indicator variable, 1986, 1987, 2009, 2012=1, 1977, 1989, 2002, 2004=-1, all other years=0
DUECRIS	Dummy variable for U.S. recession, 2008, 2009, 2010=1, all other years=0
DUHPMDD	Indicator variable for high protein meal demand, 1993, 1995, 2001, 2001, 2006=1, all other years=0
DUSOMH	Indicator variable for soymeal ending stocks, 1984, 1998, 2000=1, 1985, 1987=-1 all other years=0
EL_NINO	Dummy variable for El Niño
EMBARGO	Dummy variable for the 1972 U.S. embargo of U.S. soybean and product exports
JGCAUA	Japan grain consuming animal units, million head, February 1
LA_NINA	Dummy variable for La Niña
LBARPPC	Lakes region expected farm price for barley (same formula as for corn, see model for formula)
LCORSYC	Lakes region wtd average corn yield, bu/acre, crop year
LSOYPLC	Lakes region non-recourse soybean loan rate, $/bu, crop year
LSOYRESDF	Lakes region stock of soybean checkoff research expenditures, $US, crop year
NORFLEX	Percent of acres required in the normal flex program under the 1990 farm bill, %
OCORSYC	Other region wtd average corn yield, bu/acre, crop year
OSOYPLC	Other region non-recourse soybean loan rate, $/bu, crop year
OSOYRESDF	Other region stock of soybean checkoff research expenditures, $US, crop year
OWHEPPC	Other region expected farm price for wheat (same formula as corn, see model for formula)
PCORSYC	Plains region wtd average corn yield, bu/acre, crop year
PSOYPLC	Plains region non-recourse soybean loan rate, $/bu, crop year
PSOYRESDF	Paines region stock of soybean checkoff research expenditures, $US, crop year
RCORMEC	Corn exports by non-U.S. corn exporting countries, mil bu., crop year
SCORSYC	South region wtd average corn yield, bu/acre, crop year
SSOYPLC	South region non-recourse soybean loan rate, $/bu, crop year

SSOYRESDF	South region stock of soybean checkoff research expenditures, $US, crop year
TCORSYC	Residual other region wtd average corn yield, bu/acre, crop year
UCOMPWC	U.S. wholesale price of cottonseed meal, $/ton, marketing year
UCOMSPC	U.S. production of cottonseed meal, 1,000 tons, marketing year
UCOODPC	U.S. cottonseed oil share of oleic/linoleic oils use, marketing year
UCOOPWC	U.S. wholesale price of cottonseed oil, ¢/lb, marketing year
UCOOSPC	U.S. production of cottonseed oil, mil lb, marketing year
UCORARP	Corn acreage reduction program requirement, %
UCORDZC	U.S. seed, feed, and other use of corn, mil bu, marketing year
UCORHCC	U.S. government stocks of corn (CCC+FOR), mil bu., crop year
UCORMMC	U.S. imports of corn, mil bu., crop year
UCORPDC	Corn acreage diversion payments, $/bu, crop year
UCORPLC	U.S. average corn loan rate, $/bu, crop year
UCORPTC	U.S. corn target price, $/bu, crop year
UCPI67	U.S. consumer price index, 1967=100, annual
UFPI67	U.S. farm price index, 1967=100, annual
UGCAUA	U.S. grain consuming animal units, million head, marketing year
UHOGPFC	U.S. farm price of hogs (barrow/guilt), $/cwt, marketing year
ULAOPWC	U.S. lauric oils price (wtd average of coconut and palm kernel oils), ¢/lb, marketing year
UOISCPC	U.S. soybean processing capacity, mil bu, marketing year
UPEMDPC	U.S. peanut meal share of high protein meal use, marketing year
UPEMPWC	U.S. wholesale price of peanut meal, $/ton, marketing year
UPEMSPC	U.S. production of peanut meal, 1,000 tons, marketing year
UPEODPC	U.S. peanut oil share of oleic/linoleic oils use, marketing year
UPEOPWC	U.S. wholesale price of peanut oil, ¢/lb, marketing year
UPEOSPC	U.S. production of peanut oil, mil lb, marketing year
USOMDZC	U.S. other use (statistical discrepancy) of soymeal, 1,000 tons, marketing year
USOMEXP	U.S. Stock of soybean checkoff demand promotion expenditures for soymeal, $US, mktg year
USOMMMC	U.S. imports of soymeal, 1,000 tons, marketing year
USOMQ	U.S. soymeal extraction rate, 1,000 tons/mil bu
USOODZC	U.S. other use (statistical discrepancy) of soyoil, 1,000 tons, marketing year
USOOEXP	U.S. Stock of soybean checkoff demand promotion expenditures for soyoil, $US, mktg year
USOOHGC	U.S. government stocks of soyoil, mil lb, marketing year
USOOMGC	U.S. government PL480 exports of soyoil, mil lb, marketing year
USOOMMC	U.S. imports of soyoil, mil lb, marketing year
USOOQ	U.S. soyoil extraction rate, lbs/ bu
USOYDZC	U.S. seed, feed, and other use of soybeans, mil bu, marketing year
USOYEXP	U.S. Stock of soybean checkoff demand promotion expenditures for soybeans, $US, mktg year
USOYHGC	U.S. government stocks of soybeans, mil bu, marketing year
USOYMMC	U.S. imports of soybeans, mil bu, marketing year
USOYPLC	U.S. average soybean loan rate, $/bu, crop year
USOYPTC	U.S. soybean target price, $/bu, crop year
UWHEPFC	U.S. farm price of wheat, $/bu, crop year

UWPI67R	U.S. wholesale price index, 1967=100, annual
UYDA	U.S. personal disposable income, bil $US, annual

European Union (15/27)

DEBANM	Dummy variable for EU-15/27 ban on meal imports, 2000, 2001, 2002=1, all other years=0
DEBIOFUEL	Dummy variable for EU-15/27 biofuel policy, from 2000 to 2012=1, all other years=0
DECRIS	Dummy variable for EU-15/27 recession, from 2008 to 2012=1, all other years=0
DEGERBF	Indicator variable for an increase in biofuel use in Germany, from 2005 to 2007=1, all other years=0
DEPRECAP93	Dummy variable for the period before the Common Agricultural Policy (CAP), from 2008 to 1992=1, all other years=0
DESOMDD1	Indicator variable 1 for EU-15/27 meal demand, 1972, 1981=1, 1995, 2008=-1, all other years=0
DESOMDD2	Indicator variable 2 for EU-15/27 meal demand, 1974, 1993, 2009=1, 2007=-1, all other years=0
DESOYDC1	Indicator variable 1 for EU-15/27 crush demand, from 1972 to 1976, 1984, 1988, 1993=1, all other years=0
DESOYDC2	Indicator variable 2 for EU-15/27 crush demand, 1979, 1981, 1997, 1998, 2001=1, 1983, 1985, 1987, 1990, 1991, 2012=-1 all other years=0
DESOYDC3	Indicator variable 3 for EU-15/27 crush demand, 1980, 1989, 1990=1, all other years=0
ECWPI2	EU-15/27 wtd average wholesale price index, 1985=100, annual
EGCAUA	EU-15/27 grain consuming animal units, million head, January 1
EGDP	EU-15/27 aggregate GDP, billions of SDRs
EPAOPIA	EU-15/27 palm oil price, cif NW Europe, $/mt, annual
ESOMDZC	EU-15/27 other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
ESOMEXPR	EU-15/27 stock of international market promotion expenditures for soymeal, real deflated SDRs
ESOMHEC	EU-15/27 ending stocks of soymeal, end of marketing year
ESOMQ	EU-15/27 soymeal extraction rate, mt of soymeal/mt of soybeans
ESOODZC	EU-15/27 other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
ESOOEXPR	EU-15/27 stock of international market promotion expenditures for soyoil, real deflated SDRs
ESOOHEC	EU-15/27 ending stocks of soyoil, end of marketing year
ESOOQ	EU-15/27 soyoil extraction rate, mt of soyoil/mt of soybeans
ESOYDZC	EU-15/27 seed, feed, and other use of soybeans, 1,000 mt, marketing year
ESOYEXPR	EU-15/27 stock of international market promotion expenditures for soybeans, real deflated SDRs
ESOYHEC	EU-15/27 ending stocks of soybeans, end of marketing year
ESOYSPC	EU-15/27 production of soybeans, marketing year
XECUSA	Exchange rate, SDRs$US, annual

Japan

DJSOYDC	Indicator variable for Japan crush demand, 1989, 1992, 2006=1, all other years=0
JSOMDZC	Japan other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
JSOMEXPR	Japan stock of international market promotion expenditures for soymeal, real deflated Yen
JSOMHEC	Japan ending stocks of soymeal, 1,000 mt, end of marketing year
JSOMQ	Japan soymeal extraction rate, mt of soymeal/mt of soybeans
JSOODZC	Japan other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
JSOOEXPR	Japan stock of international market promotion expenditures for soyoil, real deflated Yen
JSOOHEC	Japan ending stocks of soyoil, 1,000 mt, end of marketing year
JSOOQ	Japan soyoil extraction rate, mt of soyoil/mt of soybeans
JSOYDZC	Japan seed, feed, and other use of soybeans, 1,000 mt, marketing year
JSOYEXPR	Japan stock of international market promotion expenditures for soybeans, real deflated Yen
JSOYHEC	Japan ending stocks of soybeans, 1,000 mt, end of marketing year
JSOYSPC	Japan soybean production, 1,000 mt, Japan crop year
JTRAFTWTO	Japan tariff on soybean imports from 2000 to 2012, 10,900 yen/ton
JTRPREWTO	Japan tariff on soybean imports from 1971 to 1999, 17,000 yen/ton
JWPI85	Japan wholesale price index, 1985=100, annual
XJAUSA	Exchange rate, Japanese Yen/$US, annual

China

DHSOMDD1	Indicator variable 1 for China meal demand, from 1980 to 1983=1, from 1989 to 2001=-1 all other years=0
DHSOMDD2	Indicator variable 2 for China meal demand, 1983=1, 1996, 2000=-1 all other years=0
DHSOMDD3	Indicator variable 3 for China meal demand, 2003=1, 2005=-1 all other years=0
DHSOYDC	Indicator variable for China crush demand, 2006, 2007, 2008=1, 1998, 2001, 2002=-1 all other years=0
DHSOYSH	Indicator variable for China acres haversted, 1983, 1996, 2007, 2012=1, all other years=0
DPSWTO	Indicator variable for Chinese reform for WTO's rules, from 1995 to 2012 =1, all other years=0
DPSWTO	Indicator variable for the period before Chinese reform for WTO's rules, from 1980 to 1994 =1, all other years=0
HCORPFA	China farm price of corn, RMB Yuan/mt, annual
HFPI85	China farm price index, 1985=100, annual
HGDP05	China real gross domestic product, 2005 prices, annual
HGDPI05	China gross domestic product index, 2005=100, annual
HPOP	China national population, annual
HSOMDZC	China other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
HSOMEXPR	China stock of international market promotion expenditures for soymeal, real deflated Yuan
HSOMHEC	China ending stocks of soymeal, 1,000 mt, end of marketing year
HSOMQ	China soymeal extraction rate, mt of soymeal/mt of soybeans
HSOODZC	China other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year

HSOOEXPR	China stock of international market promotion expenditures for soyoil, real deflated Yuan
HSOOHEC	China ending stocks of soyoil, 1,000 mt, end of marketing year
HSOOQ	China soyoil extraction rate, mt of soyoil/mt of soybeans
HSOYDZC	China seed, feed, and other use of soybeans, 1,000 mt, marketing year
HSOYEXPR	China stock of international market promotion expenditures for soybeans, real deflated Yuan
HSOYHEC	China ending stocks of soybeans, 1,000 mt, end of marketing year
HSOYSYC	China soybean yield, mt/hectare, crop year
XCHUSA	Exchange rate, Chinese RMB Yuan/$US, annual

Rest-of-the-World (ROW)

DRECCRIS1	Dummy variable 1 for global recession, 2011=1, all other years=0
DRECCRIS2	Dummy variable 2 for global recession, 1971, 2008=1, all other years=0
DRMECRIS	Dummy variable for Asia economic crisis, 1998=1, all other years=0
DROILSK	Dummy variable for oil shock, 1974, 1975, 1977, 1979, 1981=1, all other years=0
DRSOMD1	Indicator variable 1 for ROW soymeal demand, 1974, 1984, 2002, 2005, 2009=1, all other years=0
DRSOMD2	Indicator variable 2 for ROW soymeal demand, 1971, 1990, 1999=1, 1972, 1987, 1996, 1997, 2008, 2009, 2010=-1 all other years=0
DRSOMD3	Indicator variable 3 for ROW soymeal demand, 1979, 1980, 1986, 1987, 1990, 1991=1, 1985, 1992=-1 all other years=0
DRSOMD4	Indicator variable 4 for ROW soymeal demand, 1999, 2003=1, 2004, 2009=-1 all other years=0
DRSOMD5	Indicator variable 5 for ROW soymeal demand, 1982=1, 1972, 1987, 2002=-1 all other years=0
DRSOOD1	Indicator variable 1 for ROW soyoil demand, 1983, 1997, 2000=1, 1971, 1990=-1 all other years=0
DRSOOD2	Indicator variable 2 for ROW soyoil demand, 1972, 1986, 2005, 2008=1, 2012=-1 all other years=0
DRSOOD3	Indicator variable 3 for ROW soyoil demand, 1971, 1975, 1985, 2003=1, 1979, 1984, 1998=-1 all other years=0
DRWTOAF	Dummy variable for the period from 2001 to 2012 =1, all other years=0
DSRSOYM1	Indicator variable 1 for ROW soybean imports, 1990, 1998, 2007=1, 1979, 1983, 1987, 1997, 2010=-1 all other years=0
DSRSOYM2	Indicator variable 2 for ROW soybean imports, 1981, 1996, 2004=1, 1994, 2002=-1 all other years=0
DSRSOYM3	Indicator variable 3 for ROW soybean imports, 1982, 1998, 2009=1, 1973, 1984, 1985, 1986, 1993=-1 all other years=0
DSRSOYM4	Indicator variable 4 for ROW soybean imports, 1978, 1980=1, 1992=-1 all other years=0
RGDP85	ROW real GDP index, real 1985 prices, annual
RSOMEXPR	ROW stock of international market promotion expenditures for soymeal, real deflated $US
RSOOEXPR	ROW stock of international market promotion expenditures for soyoil, real deflated $US

RSOYEXPR	ROW stock of international market promotion expenditures for soybeans, real deflated $US

Brazil

BGDP85	Brazil real gross domestic product, 1985 prices, annual
BSOMDZC	Brazil other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
BSOMHEC	Brazil soymeal ending stocks, 1,000 mt, end of marketing year
BSOMMMC	Brazil soymeal imports, 1,000 mt, marketing year
BSOMQ	Brazil soymeal extraction rate, mt of soymeal/mt of soybeans
BSOODZC	Brazil other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
BSOOHEC	Brazil soyoil ending stocks, 1,000 mt, end of marketing year
BSOOQ	Brazil soyoil extraction rate, mt of soyoil/mt of soybeans
BSOYDZC	Brazil seed, feed, and other use of soybeans, 1,000 mt, marketing year
BSOYHEC	Brazil soybean ending stocks, 1,000 mt, end of marketing year
BSOYSYC	Brazil soybean yield, mt/hectare, crop year
BWPI85	Brazil whole sale price index, 1985=1, annual
XBZUSA	Exchange rate, Trillion Brazilian Reais/$US, annual

Argentina

DGPREEX	Dummy variable for the period in the absence of soybean exports, from 1960 to 1971 =1, all other years=0
DGREEXB	Dummy variable for the policy to boost soybean crushing, from 2004 to 2006 =1, all other years=0
GGDP85	Argentina real gross domestic product, 1985 prices, annual
GSOMDZC	Argentina other use (statistical discrepancy) of soymeal, 1,000 mt, marketing year
GSOMHEC	Argentina soymeal ending stocks, 1,000 mt, end of marketing year
GSOMMMC	Argentina soymeal imports, 1,000 mt, marketing year
GSOMQ	Argentina soymeal extraction rate, mt of soymeal/mt of soybeans
GSOMTX	Dummy variable for export taxes on soymeal, from 1960 to 1991 =0.035, from 1992 to 2001 =0, from 2002 to 2006 =0.2, from 2007 to 2012 =0.35, all other years=0
GSOODZC	Argentina other use (statistical discrepancy) of soyoil, 1,000 mt, marketing year
GSOOHEC	Argentina soymeal ending stocks, 1,000 mt, end of marketing year
GSOOQ	Argentina soyoil extraction rate, mt of soyoil/mt of soybeans
GSOOTX	Dummy variable for export taxes on soyoil, from 1960 to 1991 =0.035, from 1992 to 2001 =0, from 2002 to 2006 =0.193, from 2007 to 2012 =0.32, all other years=0
GSOYDZC	Argentina seed, feed, and other use of soybeans, 1,000 mt, marketing year
GSOYHEC	Argentina soybean ending stocks, 1,000 mt, end of marketing year
GSOYSYC	Argentina soybean yield, mt/hectare, marketing year
GSOYTX	Dummy variable for export taxes on soybeans, from 1960 to 2001 =0.035, from 2002 to 2006 =0.235, 2007=0.35, 2008=0.45, from 2009 to 2012 =0.35, all other years=0
GWPI85	Argentina wholesale price index, 1985=1, annual
XARUSA	Exchange rate, million Argentina Austral/$US, annual

APPENDIX B

Ex-Post Simulation Validation Statistics, Theil Forecast Error Statistics, 1880/81 to 2012/13

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
ASOYPCC	0.00	0.31	0.69	0.10	0.90	0.09
ASOYPFC	0.05	0.35	0.60	0.15	0.80	0.10
ASOYSHC	0.01	0.01	0.98	0.00	0.98	0.01
ASOYSPC	0.00	0.24	0.76	0.26	0.74	0.01
CSOYPCC	0.00	0.35	0.65	0.14	0.86	0.08
CSOYPFC	0.05	0.35	0.59	0.17	0.78	0.10
CSOYSHC	0.00	0.10	0.90	0.12	0.88	0.00
CSOYSPC	0.00	0.16	0.84	0.18	0.82	0.00
DSOYPCC	0.00	0.45	0.55	0.21	0.79	0.08
DSOYPFC	0.06	0.40	0.54	0.20	0.74	0.10
DSOYSHC	0.04	0.12	0.84	0.10	0.86	0.01
DSOYSPC	0.01	0.06	0.93	0.08	0.91	0.01
LSOYPCC	0.00	0.36	0.63	0.16	0.83	0.08
LSOYPFC	0.06	0.35	0.59	0.17	0.77	0.09
LSOYSHC	0.02	0.09	0.90	0.10	0.88	0.00
LSOYSPC	0.00	0.21	0.78	0.22	0.77	0.00
OSOYPCC	0.00	0.30	0.70	0.10	0.90	0.08
OSOYPFC	0.05	0.35	0.60	0.16	0.79	0.10
OSOYSHC	0.00	0.00	1.00	0.00	1.00	0.00
OSOYSPC	0.00	0.03	0.97	0.03	0.97	0.00
PSOYPCC	0.00	0.38	0.62	0.16	0.83	0.08
PSOYPFC	0.05	0.35	0.60	0.17	0.78	0.10
PSOYSHC	0.01	0.03	0.96	0.04	0.95	0.00
PSOYSPC	0.00	0.10	0.90	0.11	0.89	0.00
SSOYPCC	0.00	0.38	0.61	0.16	0.84	0.08
SSOYPFC	0.06	0.38	0.56	0.19	0.75	0.10
SSOYSHC	0.00	0.05	0.95	0.04	0.96	0.01
SSOYSPC	0.01	0.00	0.99	0.01	0.98	0.01
USOYDCC	0.01	0.04	0.94	0.07	0.91	0.01
USOYHEC	0.20	0.01	0.79	0.01	0.79	0.08
USOYHTC	0.20	0.01	0.79	0.01	0.79	0.08
USOYMEC	0.02	0.00	0.98	0.00	0.98	0.02
USOYPFC	0.05	0.36	0.59	0.18	0.77	0.10
USOYSHC	0.02	0.10	0.89	0.11	0.87	0.00
USOYSPC	0.00	0.25	0.75	0.26	0.74	0.00

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
UCOODPC	0.57	0.01	0.42	0.09	0.34	0.13
UHPMDDC	0.23	0.00	0.77	0.01	0.76	0.01
UHPMPWC	0.01	0.25	0.75	0.14	0.85	0.05
UOLODDC	0.00	0.00	1.00	0.00	1.00	0.01
UOLOPWC	0.02	0.07	0.91	0.01	0.97	0.07
USOMDDC	0.28	0.00	0.71	0.01	0.71	0.01
USOMDPC	0.03	0.12	0.85	0.03	0.94	0.00
USOMHEC	0.01	0.01	0.98	0.04	0.96	0.07
USOMMEC	0.08	0.18	0.74	0.03	0.89	0.07
USOMPWC	0.01	0.26	0.73	0.15	0.84	0.05
USOMSPC	0.01	0.04	0.94	0.07	0.91	0.01
USOODDC	0.15	0.00	0.85	0.00	0.85	0.01
USOODPC	0.57	0.02	0.41	0.10	0.33	0.01
USOOHEC	0.00	0.00	0.99	0.12	0.88	0.09
USOOHTC	0.00	0.00	0.99	0.12	0.88	0.09
USOOMEC	0.03	0.24	0.72	0.06	0.91	0.15
USOOMTC	0.03	0.37	0.59	0.13	0.84	0.13
USOOPWC	0.02	0.08	0.90	0.01	0.97	0.07
USOOSPC	0.01	0.04	0.94	0.07	0.92	0.01
USOYEHR	0.16	0.03	0.81	0.00	0.84	0.08
USOYGCC	0.05	0.50	0.45	0.10	0.86	0.27
USOYPWC	0.05	0.32	0.63	0.14	0.81	0.10
UCOODPC	0.57	0.01	0.42	0.09	0.34	0.13
UHPMDDC	0.23	0.00	0.77	0.01	0.76	0.01
USOMMEC	0.08	0.18	0.74	0.03	0.89	0.07
USOYDCC	0.01	0.04	0.94	0.07	0.91	0.01
UCORSAC	0.18	0.10	0.72	0.00	0.81	0.03
UCORSHC	0.16	0.07	0.77	0.00	0.84	0.03
UCORSPC	0.11	0.01	0.88	0.00	0.89	0.03
UCORDFC	0.18	0.04	0.78	0.00	0.82	0.02
UCORDOC	0.51	0.00	0.49	0.00	0.49	0.04
UCORMEC	0.10	0.10	0.80	0.01	0.89	0.08
UCORHOC	0.26	0.18	0.56	0.04	0.70	0.15
UCORHTC	0.26	0.12	0.62	0.02	0.72	0.13
UCORPFC	0.15	0.45	0.41	0.22	0.63	0.18

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
UCORPWC	0.14	0.44	0.42	0.22	0.64	0.17
UCORPFC	0.15	0.45	0.41	0.22	0.63	0.18
UCORPPC	0.07	0.49	0.44	0.34	0.60	0.08
CCORSAC	0.03	0.10	0.87	0.00	0.97	0.02
DCORSAC	0.34	0.02	0.64	0.06	0.59	0.09
SCORSAC	0.19	0.38	0.43	0.10	0.71	0.06
PCORSAC	0.32	0.00	0.67	0.00	0.67	0.03
LCORSAC	0.03	0.28	0.68	0.06	0.91	0.03
ACORSAC	0.37	0.01	0.61	0.02	0.61	0.08
OCORSAC	0.02	0.16	0.82	0.00	0.98	0.04
TCORSAC	0.16	0.38	0.46	0.13	0.71	0.06
UCORSAC	0.18	0.10	0.72	0.00	0.81	0.03
CCORSHC	0.02	0.08	0.90	0.00	0.98	0.03
DCORSHC	0.33	0.02	0.65	0.06	0.61	0.09
SCORSHC	0.20	0.40	0.40	0.12	0.68	0.07
PCORSHC	0.28	0.00	0.72	0.01	0.71	0.04
LCORSHC	0.02	0.17	0.81	0.01	0.97	0.04
ACORSHC	0.35	0.01	0.64	0.02	0.63	0.09
OCORSHC	0.01	0.10	0.89	0.01	0.98	0.05
TCORSHC	0.14	0.41	0.45	0.09	0.77	0.08
UCORSHC	0.16	0.07	0.77	0.00	0.84	0.03
CCORSPC	0.01	0.00	0.99	0.02	0.97	0.03
DCORSPC	0.24	0.01	0.75	0.03	0.73	0.07
SCORSPC	0.21	0.31	0.49	0.13	0.66	0.07
PCORSPC	0.24	0.00	0.76	0.01	0.75	0.04
LCORSPC	0.02	0.05	0.93	0.01	0.98	0.04
ACORSPC	0.34	0.09	0.57	0.00	0.66	0.10
OCORSPC	0.01	0.07	0.92	0.00	0.99	0.05
TCORSPC	0.15	0.34	0.51	0.09	0.76	0.07
UCORSPC	0.11	0.01	0.88	0.00	0.89	0.03
CCORPFC	0.15	0.45	0.41	0.22	0.64	0.18
DCORPFC	0.15	0.46	0.39	0.23	0.63	0.17
SCORPFC	0.15	0.46	0.39	0.23	0.62	0.17
PCORPFC	0.15	0.44	0.41	0.21	0.64	0.18
LCORPFC	0.14	0.44	0.42	0.21	0.65	0.18

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
ACORPFC	0.16	0.45	0.39	0.23	0.61	0.17
OCORPFC	0.16	0.47	0.37	0.25	0.60	0.18
TCORPFC	0.15	0.46	0.39	0.23	0.62	0.17
CCORPPC	0.07	0.48	0.45	0.33	0.60	0.08
DCORPPC	0.03	0.47	0.49	0.28	0.69	0.08
SCORPPC	0.03	0.50	0.47	0.31	0.66	0.08
PCORPPC	0.07	0.49	0.44	0.34	0.59	0.07
LCORPPC	0.08	0.50	0.42	0.35	0.57	0.07
ACORPPC	0.02	0.47	0.51	0.28	0.70	0.08
OCORPPC	0.02	0.47	0.51	0.30	0.69	0.08
TCORPPC	0.02	0.50	0.48	0.30	0.67	0.08
ESOOSPC	0.03	0.31	0.67	0.13	0.85	0.03
ESOYDCC	0.03	0.31	0.66	0.14	0.84	0.03
ESOYMIC	0.03	0.28	0.70	0.12	0.85	0.03
ECORPIA	0.12	0.43	0.45	0.19	0.70	0.17
ESOYPIA	0.02	0.21	0.77	0.07	0.91	0.08
ESOMPIA	0.00	0.16	0.84	0.05	0.95	0.07
ESOOPXA	0.04	0.08	0.88	0.02	0.95	0.07
ECORPIA	0.12	0.43	0.45	0.19	0.70	0.17
ESOMDDC	0.00	0.00	1.00	0.01	0.99	0.01
ESOMMIC	0.01	0.04	0.95	0.02	0.98	0.03
ESOMSPC	0.03	0.32	0.65	0.14	0.83	0.03
ESOODDC	0.03	0.00	0.97	0.02	0.95	0.02
ESOOMXC	0.00	0.27	0.73	0.15	0.84	0.12
JSOYPUA	0.05	0.28	0.67	0.12	0.82	0.09
JSOMPUA	0.00	0.17	0.83	0.07	0.92	0.06
JSOOPUA	0.01	0.00	0.98	0.01	0.98	0.06
JSOMDDC	0.00	0.01	0.99	0.00	1.00	0.01
JSOMMIC	0.00	0.02	0.98	0.01	0.99	0.04
JSOMSPC	0.00	0.00	0.99	0.00	1.00	0.02
JSOODDC	0.00	0.01	0.98	0.06	0.94	0.02
JSOOMIC	0.00	0.73	0.27	0.36	0.64	0.45
JSOOSPC	0.00	0.01	0.99	0.00	0.99	0.02
JSOYDCC	0.00	0.00	0.99	0.00	0.99	0.02
JSOYMIC	0.00	0.00	1.00	0.01	0.98	0.01

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
HSOYSHC	0.13	0.12	0.75	0.00	0.87	0.04
HSOYSPC	0.14	0.00	0.86	0.02	0.85	0.04
HSOYMIC	0.13	0.00	0.87	0.01	0.87	0.04
HSOYDCC	0.07	0.00	0.93	0.00	0.92	0.02
HSOYPIA	0.04	0.15	0.82	0.04	0.93	0.11
HSOYPFA	0.03	0.14	0.83	0.03	0.94	0.12
HSOMSPC	0.07	0.00	0.93	0.00	0.92	0.02
HSOMDDC	0.00	0.00	1.00	0.00	1.00	0.01
HSOMMXC	0.05	0.07	0.88	0.00	0.95	0.30
HSOMPWA	0.00	0.07	0.92	0.01	0.98	0.05
HSOOSPC	0.07	0.00	0.93	0.00	0.93	0.02
HSOOMIC	0.01	0.33	0.66	0.10	0.89	0.22
HSOODDC	0.00	0.00	1.00	0.00	1.00	0.05
HSOOPWA	0.00	0.00	1.00	0.01	0.98	0.05
RSOMMIN	0.00	0.01	0.99	0.03	0.97	0.03
RSOOSPN	0.04	0.13	0.83	0.03	0.93	0.08
RSOOMIN	0.00	0.00	1.00	0.02	0.98	0.05
RSOMDDN	0.02	0.03	0.96	0.06	0.92	0.03
RSOMSPN	0.04	0.13	0.83	0.03	0.93	0.08
RSOMSPN	0.04	0.13	0.83	0.03	0.93	0.08
RSOODDN	0.03	0.01	0.96	0.04	0.93	0.04
RSOOSPN	0.04	0.13	0.83	0.03	0.93	0.08
RSOYMIN	0.04	0.13	0.83	0.03	0.93	0.08
GSOOPXA	0.01	0.00	0.99	0.02	0.97	0.08
GSOMMEC	0.00	0.00	1.00	0.00	1.00	0.05
GSOMPXA	0.00	0.02	0.98	0.00	0.99	0.06
GSOOMXC	0.00	0.00	1.00	0.00	1.00	0.05
GSOOPXA	0.01	0.00	0.99	0.02	0.97	0.08
GSOYMEC	0.26	0.16	0.58	0.04	0.70	0.17
GSOYPXA	0.01	0.12	0.86	0.03	0.96	0.07
GSOYSPC	0.51	0.00	0.48	0.01	0.48	0.03
GSOYDCC	0.00	0.00	1.00	0.00	1.00	0.04
GSOMSPC	0.00	0.00	1.00	0.00	1.00	0.04
GSOMDDC	0.02	0.01	0.98	0.00	0.98	0.08
GSOOSPC	0.00	0.00	1.00	0.00	1.00	0.04

Variable	Bias (UM)	Reg (UR)	Dist (UD)	Var (US)	Covar (UC)	Theil U
GSOODDC	0.01	0.01	0.98	0.01	0.98	0.01
GSOYSHC	0.52	0.00	0.47	0.01	0.47	0.03
BSOMDDC	0.02	0.04	0.93	0.06	0.91	0.02
BSOMSPC	0.00	0.01	0.99	0.00	1.00	0.02
BSOODDC	0.01	0.03	0.96	0.01	0.97	0.02
BSOOMXC	0.00	0.00	1.00	0.03	0.97	0.08
BSOOSPC	0.00	0.01	0.99	0.00	1.00	0.02
BSOYMXC	0.01	0.08	0.91	0.12	0.87	0.05
BSOYSHC	0.03	0.14	0.83	0.18	0.79	0.02
BSOYSPC	0.01	0.14	0.85	0.16	0.82	0.02
BSOYDCC	0.00	0.01	0.99	0.00	1.00	0.02
BSOMMEC	0.01	0.08	0.91	0.02	0.97	0.03
BSOMPXC	0.00	0.16	0.84	0.06	0.94	0.06
BSOOPXC	0.03	0.06	0.92	0.00	0.97	0.07
BSOYPXC	0.03	0.24	0.73	0.10	0.88	0.08