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# EXPORT DEMAND ESTIMATION FOR U.S. CORN AND SOYBEANS TO MAJOR DESTINATIONS

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EXPORT DEMAND ESTIMATION FOR U.S. CORN AND
SOYBEANS TO MAJOR DESTINATIONS

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THESIS

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A thesis submitted in partial fulfillment of the

requirements for the degree of Master of Agricultural Economics in the

College of Agriculture, Food and Environment

at the University of Kentucky

By

Sayed Yasser Saghaian

Lexington, KY

Director: Michael Reed, Professor of Agricultural Economics

2016

ABSTRACT


EXPORT DEMAND ESTIMATION FOR U.S. CORN AND SOYBEANS TO MAJOR
DESTINATIONS


The United States is the leading producer and exporter of corn and soybeans in
the world. The United States exports 20% of the world's corn and 30% of soybeans in a
typical year (USDA, ERS). The U.S., being the top producer and exporter of these
commodities, is also confronting major rivals such as Argentina, Brazil, and Ukraine,
which are increasing their exports and causing the U.S. to lose some of its market share.
In order to stop this decline in market share, the U.S. can adopt and implement different
policies to manage resources and employ advanced technology more effectively.

In this study, we empirically estimate the export demand function of U.S. corn
and soybeans to the top four export destinations: China, Japan, European Union, and
Mexico in the current context of energy and agriculture linkages and production of
ethanol from corn. A log-linear, panel data equation is used to estimate the U.S. corn and
soybeans export demand function. Own price, cross price, income and exchange rate
elasticities are estimated econometrically. Data for the U.S. and its top four importer
countries were gathered for the 1980-2012 period. A Hausman test implies that a random
effects estimator is better for the estimations.

Elasticity analysis indicates that U.S. corn demand is elastic to own price, cross price, income and poultry inventory, while inelastic to real exchange rate and pig inventory. The positive cross price elasticity reveals that corn and soybeans are substitutes in these countries. Conversely elasticity analysis for the U.S. soybean demand shows elastic cross price, real exchange rate, and pig and poultry inventory effects, while inelastic own price and income effects. Consequently, for the U.S. to gain more international market share, U.S. corn and soybean producers need to take advantage of their advanced technology and high management skills to increase quality and have more competitive pricing compared to rivals. The U.S. can gain more market share by employing better regulation to increase the quality of products, and provide incentives to U.S. farmers and exporters that could help boost their advantages in a highly competitive international environment. Higher quality and more product differentiation could help in this regard. This could help U.S. farmers increase exports to currently existing foreign destinations and access new markets, to expand market shares.

Sayed Yasser Saghaian

04/19/2017

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April 19, 2017

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# CHAPTER ONE: INTRODUCTION

## 1.1. Problem Statement

The U.S. has been a major grain producer in the world since 1970 (FAO, 2012). It has created opportunities for the U.S. farm industry to invest and expand their operations as the world's leading exporter. The U.S. has been and still is a major player in exporting such agricultural crops as corn and soybeans worldwide, followed by countries such as Brazil, Argentina, Ukraine, Romania, South Africa, and European Union. Prices for these crops have spiked in recent years with high fuel prices, climate change and weather supply shocks, new export regulations, the use of corn and soybeans in bio-fuel production, and increased global demand. In return, we have seen a reduction in the U.S. international market shares of corn and soybeans as shown in figure 1, which displays U.S. market share for corn and soybeans from 1983 to 2013. Other factors such as evolving stronger rivals in the international markets and the higher value of the U.S. dollar relative to some other currencies have also caused the loss of U.S. corn and soybean market shares worldwide.

This study tries to explain the reasons behind the decline of U.S. market shares in international markets, and evaluates the effects this decline has on the U.S. grain export industry. Even though the size of the pie is getting larger, especially for soybeans, we still care when other countries' market share increases, because they establish their position in the international market in a way that there is less room for U.S. exporters. Macroeconomic conditions have affected U.S. exports due to exchange rate changes and interest rates. There is decreased international market share, but there is increased domestic use of theses crops. There is concern that it might be hard to take back some of those lost international markets/market shares.
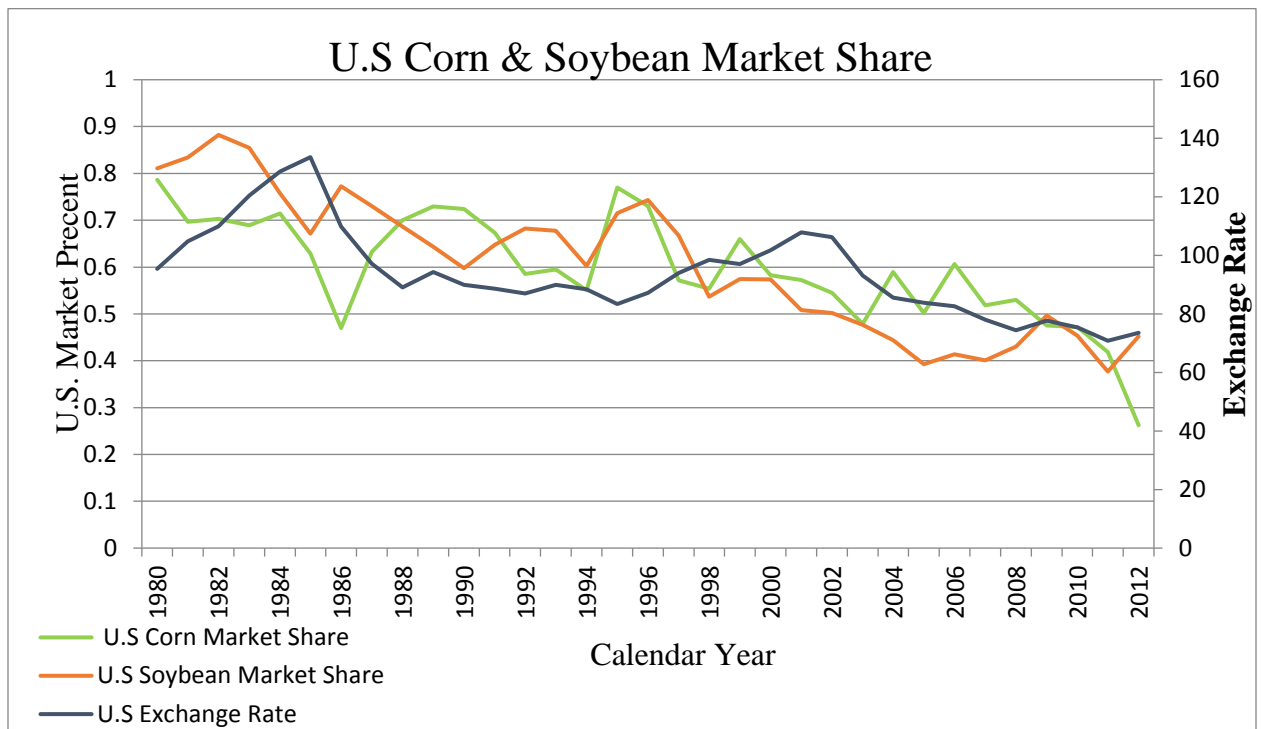
Figure 1 U.S. Corn and Soybean Market Shares, (1980-2011)

Source: FAO Trades STAT

Figure 1 presents the reduction in the U.S. international market shares of corn and soybeans, with the 1980s exhibiting a strong U.S. share of 80%, indicating weak rivals and U.S. profiting from its advanced technology, and likewise displays a decreasing U.S. share through the years up to 2012. In that year the share was 30 to 40 percent worldwide, suggesting the evolution of stronger rivals in the international markets helped by other factors such as a higher valued U.S. dollar relative to some other currencies.

**1.2 Objective**

The objective of this study is to evaluate the role of the U.S. in production and export of corn and soybeans in the world, as well as to identify the most important factors affecting the variations in U.S. exports. There are several factors affecting exports and imports, such as export and import policies of governments (including reductions in export taxes, increases in export quotas, and increases in export subsidies), which encourage or discourage producers and countries to expand their export market. Other factors influencing exports are appreciation or depreciation of the country's currency, where a depreciated currency encourages exports and discourages imports (the reverse is true for an appreciated currency), and dumping, which is exporting goods at prices lower than the home-market prices.

There are several links between corn and soybeans that make these commodities complements or substitute for one another. There are many by-products made from corn and soybeans in different industries, such as bio-fuel, edible oil, and much more. They are major agricultural crops used for human food, and essential sources of livestock feed. Corn and soybeans are good substitutes in production since they use many of the same inputs, but they are also complementary. A corn-soybean rotation is very efficient because corn is a nitrogen-hungry plant, while soybeans are legumes and fix nitrogen from the atmosphere and leave it in the soil. A harvested field of soybeans leaves behind tons of nitrogen that will reduce fertilizer costs if corn is grown in the same field the next season.

Countries like Brazil and Argentina have gained market share at the expense of U.S. exporters by expanding their production and exports. Brazil has nearly matched the U.S. market share for soybeans during the past decade and reached the U.S.'s level in

2012. It has become the major rival for the U.S. This study tries to explain the reasons behind this decline in U.S. market shares in international market, and the effects they can have on the U.S. grain export industry.

## 1.3 Organization

The current chapter presents the problem statement and objectives. The next chapter will present background information on the U.S. corn and soybean markets, including production, exports and major U.S. corn and soybean importing countries, and U.S rivals in the market. Chapter 3 provides a discussion of related literature review on export demand and marketing. Chapter 4 presents a theoretical model to estimate the effects of selected variables on U.S. corn and soybean exports. Chapter 5 includes the empirical results and elasticity analysis. Finally, chapter 6 concludes with a summary, conclusions, agribusiness and marketing implications, limitations and suggestions for future studies.

## 1.4 Our Goals

The primary objective of this study is to estimate export demand functions of U.S. corn and soybean to major destinations. We also evaluate the role of the U.S. in production and trade of corn and soybeans in the world, in addition to identifying the most important factors affecting the variations of U.S. exports. In recent years with highly variability fuel prices, climate change, new export regulations, and new uses of corn and soybeans in bio-fuel production, we have seen a reduction in the U.S.'s international market shares of corn and soybeans as shown in figure1. This study

attempts to explain the reasons behind this decline in U.S. market shares for corn and

soybeans, and the effects they can have on the U.S. grain industry.

**CHAPTER TWO: BACKGROUND**

**2.1 Production**

The United States is the largest producer and exporter of corn and soybeans in the world. According to the Economic Research Service (ERS/USDA) U.S. farmers devote about 80 million acres of land every year planting corn and 77 million acres planting soybeans. The U.S. produces more corn than any other grain and most of this crop is utilized in bio-fuel and livestock feed. Corn is also processed into a multitude of by-products for food and industry such as starch, sweeteners, corn oil, industrial alcohol, and fuel ethanol (USDA, ERS).

Corn is a grain that was first cultivated in North America. In the late 15th century, it was one of the first products to be exported to Europe, and then was introduced to other countries. Varieties of corn are divided into four basic groups: field corn, sweet corn, popcorn, and ornamental corn; each have different uses in our everyday food industry and energy sector. Over time, corn has become a main staple food in different regions of the world.

According to the ERS/USDA, climatic requirements for corn and soybeans are about the same. Thus many areas produce both crops through various rotation schemes. Approximately one-third of the U.S. corn and soybean crops are produced in Iowa and Illinois. Other states producing corn and soybeans include Indiana, eastern portions of South Dakota and Nebraska, western Kentucky and Ohio. These crops generate considerable revenues for the agriculture industry according to food and agricultural organization (FAO) production indices. These regions are required to have a crop rotation among corn, soybeans, wheat, and forage crops due to nutrition needs for crops.

The top four corn producers in 2013/2014 were the U.S. at 351 million metric tons (MMT) (36% of the world's production), China at 218 MMT (22% of the world's production), Brazil at 80 metric tons MMT (8% of the world's production), and EU at 65 MMT (7% of the world's production). Total world production was 990 MMT of corn in 2013/2014.

U.S. soybean production is concentrated in the upper Midwest, which accounts for 80% of production; the rest is mostly planted in the Southeast. Two major products from soybeans are soybean meal and soybean oil. The U.S. produced more than 50 percent of the world soybean production until the 1980s but that share has declined to 37.0% (Masuda and, Goldsmith 2009).

Soybeans were first originated by Chinese farmers around 1100 BC. In the 17th century they were introduced to European countries, and by the 19th century they were in the U.S. Americans farmers discovered that soybeans are a valuable source of protein and oil. Soybeans are the largest source of animal feed and the major U.S. oilseed crop, accounting for 90% of U.S. oilseed production (American Soybean Association). The soybean is the world's main provider of protein and oil. Soybeans are planted in late spring and flower in the summer, similar to maize and sugar beets.

The soybean is the 'king of beans'. It contains 38% protein — twice as much as pork, three times more than eggs, and twelve times more than milk. Soybean meal is the most valuable component obtained from soybeans, ranging from 50 to 75 percent of soybean value and it is the single most important high-protein livestock-feed concentrate used in the U.S. The statistic for U.S. soybean exports aggregates soybeans, soymeal, and soy oil where soymeal and uncrushed beans also accounted for more than fifty percent of

the overall soybean export from the U.S. in the past but it has increased in recent years, livestock feeds account for 98 percent of U.S. soybean meal consumption (USDA, 2015).

The top four soybean producers in 2013/2014 were the U.S at 91 MMT (32%), Brazil at 87 MMT (31%), Argentina at 53 MMT (19% of the world's production), and China at 12 MMT (4% of the world's production). Total world production was 283 MMT of soybeans in 2013/2014.

Back in 2005/2007 there was a cutback in acres planted for soybeans because the demand for corn rose dramatically due to use of corn for producing ethanol, but over the last 30 years U.S. soybean exports increased from 26 million metric tons (MMT) to 48 (MMT). However, due to dramatic increase in soybean production in Brazil and Argentina and the cutback in acres planted, the U.S. share of world exports has fallen from 60 percent to 30 percent (Ray, 2008).

Even though U.S. export value and quantity has been growing in the past thirty-two years, U.S. global trade share has been declining because major foreign corn and soybean producers have increased their output and expanded their exports of these crops. In order to sell their increased output, they have priced their output competitively against U.S. export prices. This particularly impacts U.S. exports to lower income countries that are price sensitive. Consequently, because of the spike in prices in the past few years, other nations have expanded their production and become major competitors for these crops. Houthakker & Magee (1969) stated that while there is special attention focused on price elasticity in international trade, it has been understood that income elasticity is important as well, especially in developing countries.
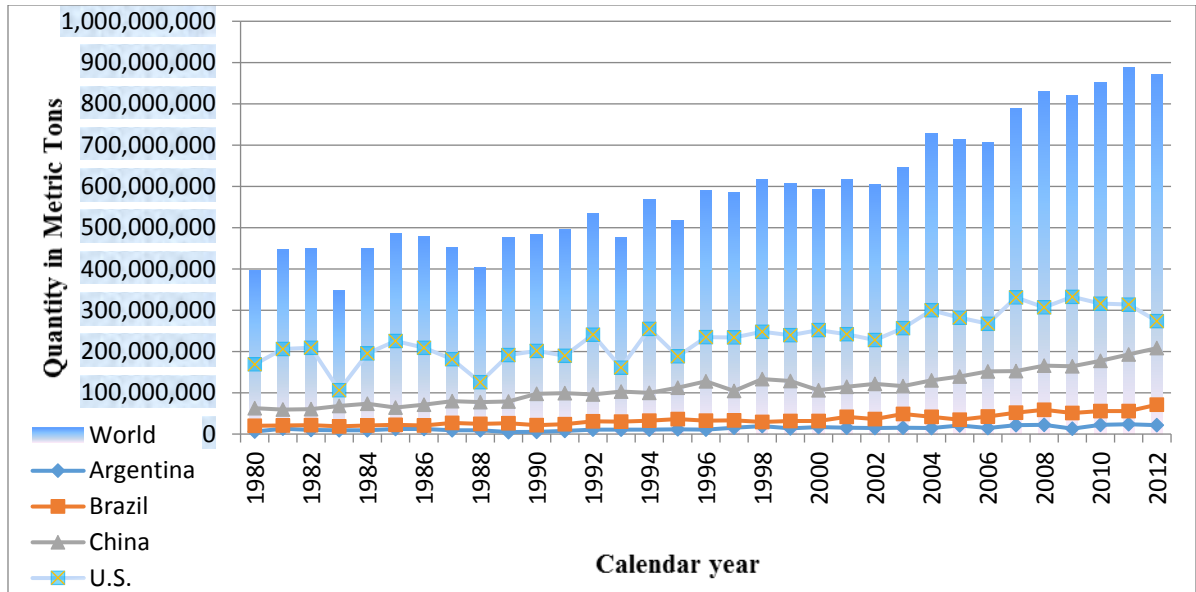
Figure 2 Corn Production by the World and Leading Countries, (1980-2012)

Source: FAO Trade STAT

Figure 2 displays corn production for the past thirty-two years for the world and four major corn producers that were mentioned earlier. The graph shows that China, Brazil, and Argentine are, respectively, the top producers of corn after the U.S. The U.S. reduced corn production in three different periods (1982, 1988, and 1996) mainly because of lower demand that caused lower price, and weather conditions.

Figure 2 also exhibits a jump in China's production from the early 1990s to the present compared to Brazil and Argentina. China being the second largest corn producer after the U.S. is also among the top importers of agricultural goods such as corn, due to its high population and high demand.
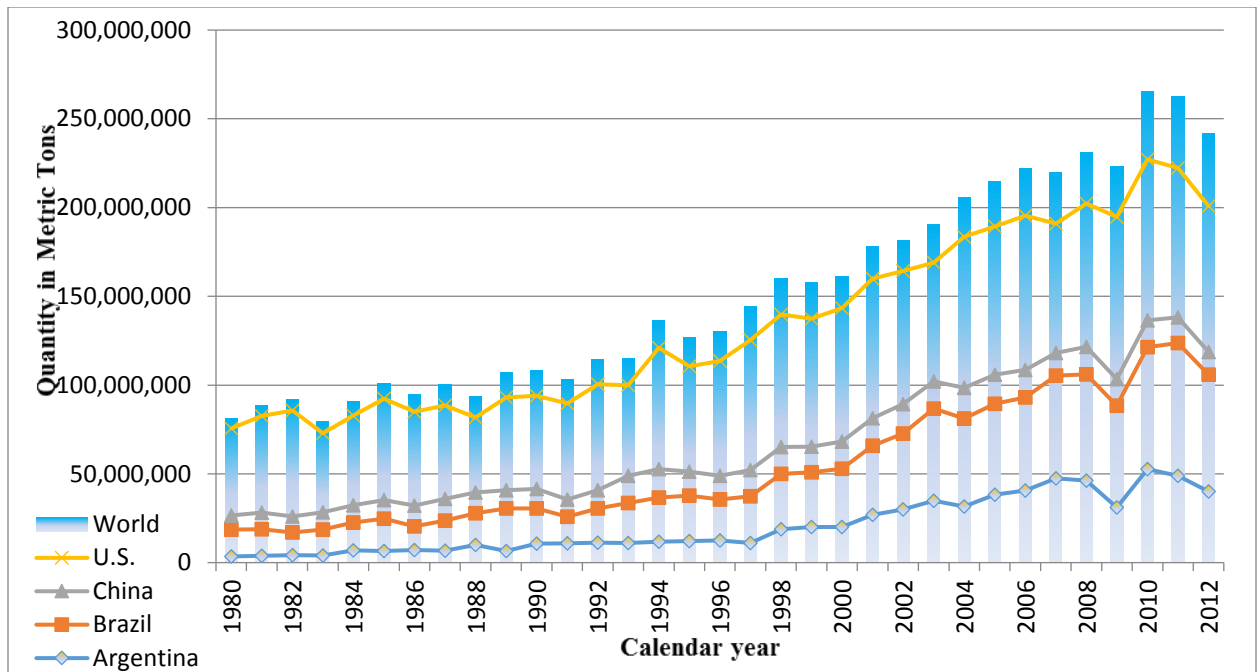
Figure 3 Soybean Production by the World and Leading Countries, (1980-2012)

Source: FAO Trade STAT

Figure 3 shows soybean production for the world and four major producers for the past three decades. This graph also shows the U.S. is the leading producer, following by China, Brazil, and Argentina, respectively. There is a sharp decrease in production for 2008 due to financial crisis that caused the market to crash.

## 2.2 Consumption

According to the National Corn Growers Association, 80% of U.S. corn is consumed domestically and about 20% of the U.S. corn is exported. U.S. corn production is consumed for food products and livestock feed (37%), ethanol production (40%), and export (20%). The lowest U.S. corn export percentage, though, was 11% in 2013/2014.

According to National Soybean Growers Association and USDA, about 51% of U.S. soybean was consumed domestically and the rest was exported in 2013/14. U.S. soybean production is used for soybean meal, soybean oil.

Corn and soybeans are primary inputs of feed for livestock such as pigs and poultry. Nations such as China, Japan, EU, and Mexico have high imports of such grains from the U.S. in order to secure their livestock feed. In 2012, China imported 58.4 million tons of soybeans (roughly 80% of its total consumption). Therefore, its livestock inventory has a direct effect on its imports from the U.S.; and increase in demand on soybean meal can influence prices. Bloomberg 2014 reported soybean buyers in China are increasing imports because demand for animal feed is increasing.
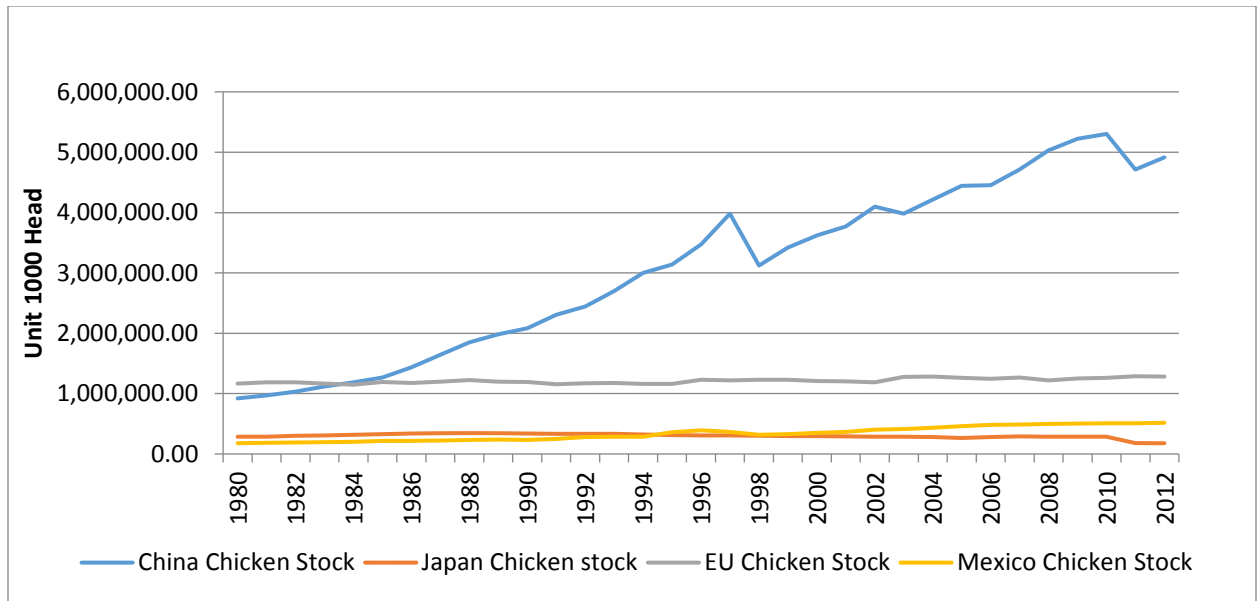


Figure 4 Chicken Stock

Source: FAO Trade STAT

Figure 4 displays the number of chickens in these nations from 1980 to 2012. Japan and Europe kept a steady quantity throughout the years. However, China's chicken numbers increased greatly from 1986 to early 1994, then had a sharp decline in the mid-

1995 to 1996 due to the drought of 1996. Rising demand for corn, soybeans and wheat caused feed prices to spike too. These higher prices for animal feed forced farmers to slaughter some of their animals (Light, and Shevlin 1998).

In early 2000 to 2007 there was a steady increase in Chinese chicken numbers again. The graph shows a relatively small shock in 2007 compared to 1996, due to the financial crisis, and has grown steadily since that time. These shocks did not affect the other two markets (Japan and EU) possibly because they are less dependent on U.S. grain exports and they have enough income to pay higher prices for feed and livestock products.
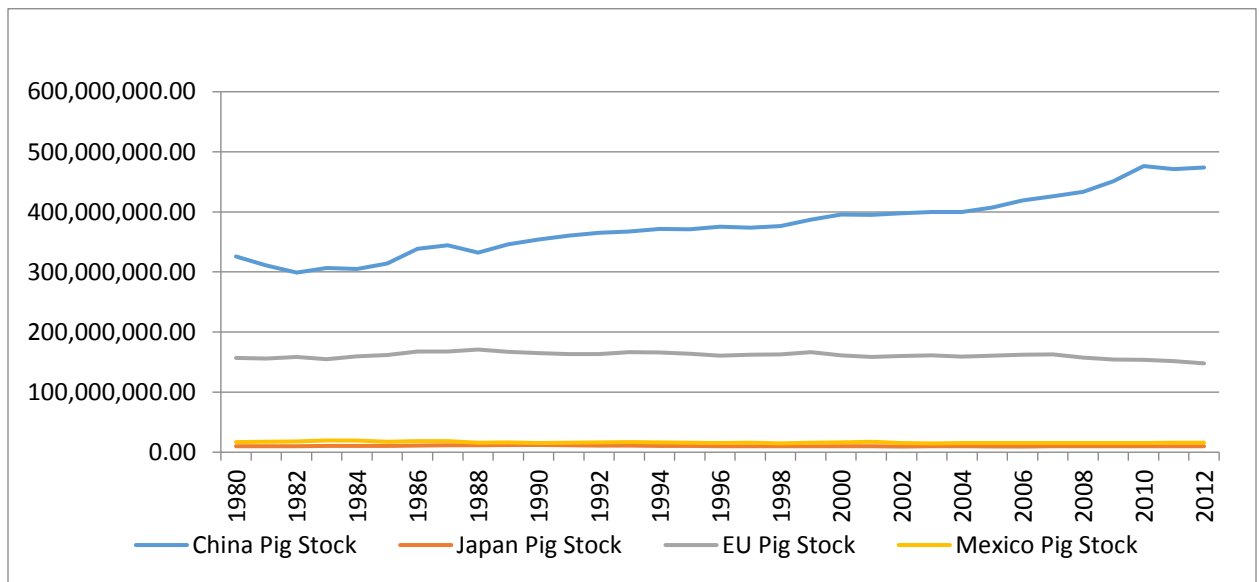


Figure 5 Pig Stock

Source: FAO Trade STAT

Figure 5 displays the quantity of pigs in these nations from 1980 to 2014. Similar to Figure 4 for chickens, Japan and Europe kept a steady quantity of pigs throughout the years, but China exhibits a steady increase in their stock throughout (except for the declines in the same period of 1996 and 2007 due the same reasons as mention above for figure 4).

**2.2.1 Consumption of Corn and Soybeans by the World and Major Countries**

The major consumers of corn and soybeans are the U.S., China, Brazil, Argentina, Mexico, and EU accounting for nearly 72 percent of world consumption (Table 1). Most of the soybeans are crushed to produce meal and soybean oil while most corn is used for ethanol production and livestock feed. In 2011, the U.S. was the leading domestic corn consumer, using about 33 MMT, and second largest soybean consumer after China, using about 49 MMT. China's domestic soybean consumption was about 71 MMT, and it is also the second largest corn consumer at 22 MMT. Other important soybean and corn consumers are: Brazil consuming 40 MMT of soybean and 6 MMT of corn, Argentina consuming 38 MMT of soybeans, India with 18 MMT of corn, and Japan with 15 MMT of corn.

Table 1 Consumption of Corn and Soybeans by Leading Countries, 2011

| Soybean | | | Corn | | |
|---|---|---|---|---|---|
| Rank | Country | Quantity | Rank | Country | Quantity |
| | | MillionTons | | | MillionTons |
| 1 | **China** | **70.8** | 1 | **U.S.** | **320.4** |
| 2 | United States | 48.8 | 2 | China | 210.8 |
| 3 | Brazil | 39.5 | 3 | India | 17.6 |
| 4 | Argentina | 37.8 | 4 | Japan | 15.0 |
| 5 | EU | 12.4 | 5 | Canada | 10.8 |
| 6 | India | 11.2 | 6 | South Africa | 10.7 |
| 7 | Mexico | 3.6 | 7 | Egypt | 10.8 |
| 8 | Japan | 3.0 | 8 | EU | 70.8 |
| 9 | Indonesia | 2.6 | 9 | Brazil | 44.3 |
| 10 | Russia | 2.4 | 10 | Mexico | 25.4 |
| 11 | ROW | 21.9 | 11 | ROW | 72.3 |
| | Total | 253.8 | | Total | 863.8 |

Source: U.S. Department of Agriculture

The U.S., being a leading producer and exporter of corn and soybeans, is also a leading consumer of these crops in the world. According to the National Corn Growers Association, 87% of U.S. corn is consumed domestically, (to break it down (39%) for

feed/residual, (30%) for fuel ethanol, (8%) for DDGs production, (10%) used for food products such as sweetener, starch, corn syrup, cereal, beverage, alcohol, seed) and 13% of U.S. corn is exported, which accounts for a relatively small portion of demand for U.S. corn (USDA, ERS). The three leading exporting countries of soybeans also consume 50% of the world's soybeans. China alone consumed about one third of world soybean consumption.

## 2.3 Export

The U.S. share of world corn exports averaged 60 percent during 2003/04-2007/08 (USDA, ERS). Figure 6 exhibits corn exports worldwide from 1980 to 2011.
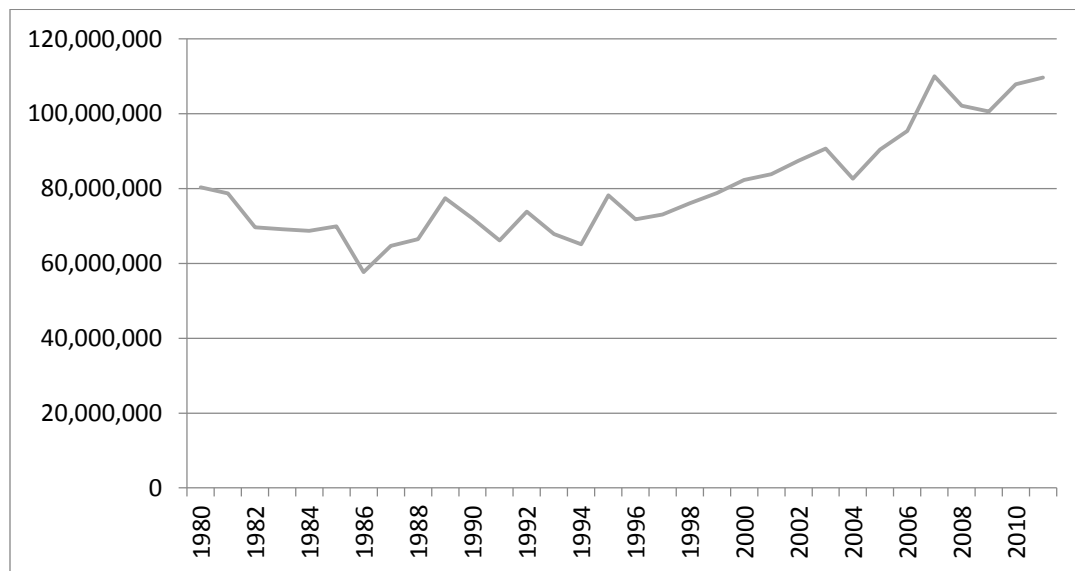


Figure 6 Quantity of World Corn Export from 1980-2011

Source: FAO Trade STAT

There has been steady growth in world corn exports through the years. There were a couple of sharp increases in export growth during the late 1980s and mid 1995s due to increases in food demand, government food policies, the rise in oil price, and the U.S. dollar depreciation worldwide. Corn exports display a steady increase from the late 1990s

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to 2005, and again a sharp increase from 2006-08. The same factors mentioned earlier caused these increases in corn exports.

According to USDA/FAO two major factors determine world corn prices, first is the small percentage of U.S. corn production that is exported (about 15% to 20%), and second is that China is a source of uncertainty in world corn trade -- one year it is the second leading exporter in the world and in another year it is a major importer. Another factor which has impacted corn prices worldwide is the strong demand for ethanol production in recent years (USDA, ERS).

The U.S. share of soybean exports average 45 percent during 2006/07-2010/11 (USDA, ERS). Figure 7 shows soybean exports worldwide from 1980 to 2011.
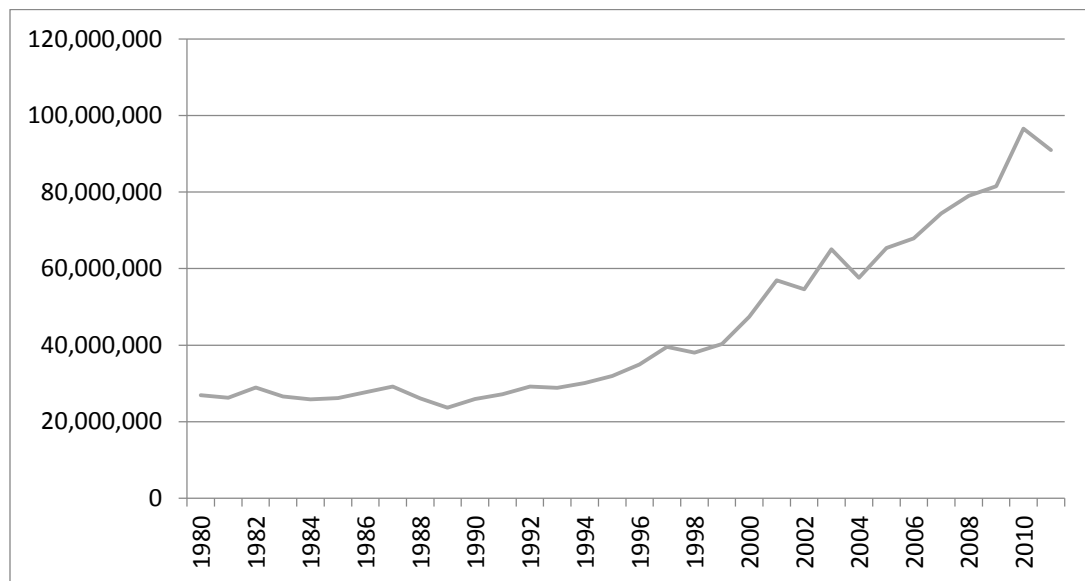


Figure 7 Quantity of World Soybean Export from 1980-2011

Source: FAO Trade STAT

As the graph indicates there was steady export growth from 1980 to early 2000, but there are sharper increases in exports since 2000. There were small export declines in 2003 and 2009 due to drought, government food policies, and the financial crisis.

**2.3.1 Leading Exporting Nations of Corn and Soybean in the World**

The top four corn exporters in 2014 were the U.S. at 46 (MMT (37% of the world's export), Brazil at 22 MMT (18% of the world's export), Argentina at 19 MMT (15% of the world's export), and Ukraine at 19 MMT (15% of the world's export). The rest of the world accounted for 15% of total world export of 125 MMT 2014 (USDA, ERS).

The U.S., Brazil, and Argentina are the leading exporters of soybeans, soybean meal, and soybean oil. Together these three countries account for about 88% of total world export (USDA, ERS). For the past three decades the U.S. has been the leading exporter, but since 2012 Brazil exports have exceeded the U.S. The top three soybean exporters in 2014 were the U.S. at 45 MMT (40% of the world's export), Brazil at 47 MMT (42% of the world's export), and Argentina at 8 MMT (7% of the world's export), The rest of the world accounted for about 12% of total world export of 112 MMT in 2014 (USDA, ERS).
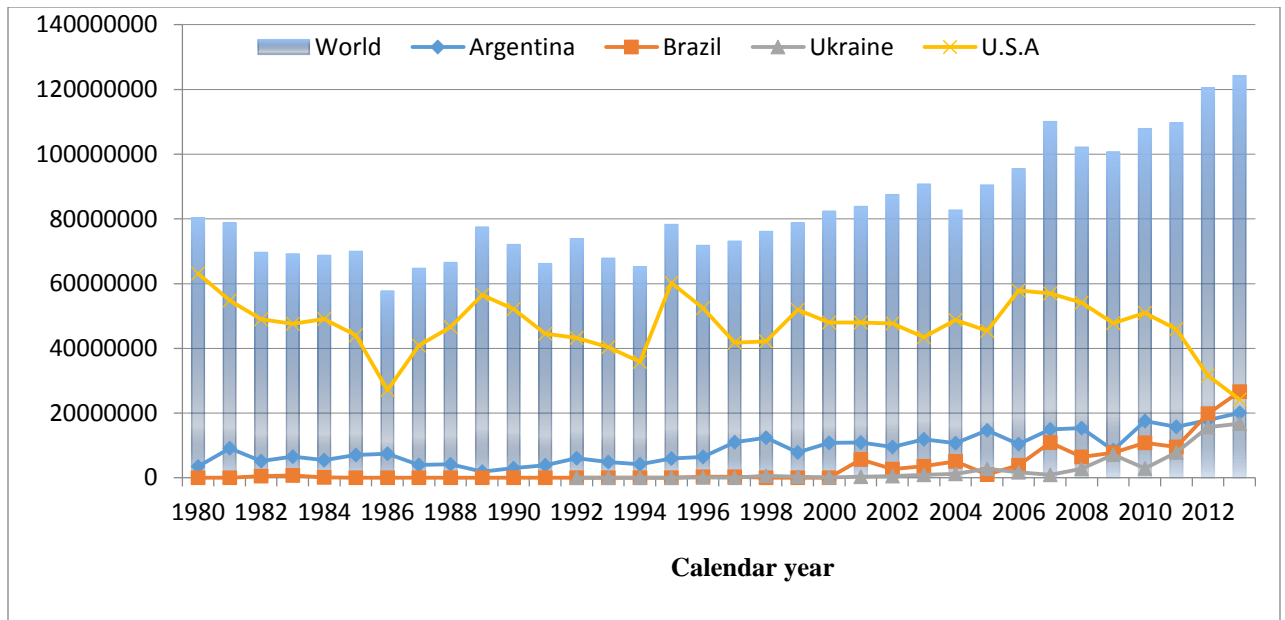
Figure 8 Corn Export by the World and Leading Countries, (1980-2013)

Source: FAO Trade STAT

Figure 8 presents the four top corn exporting nations for the past three decades. These four countries accounted for 93% of world corn exports in 2000-2002 and remaining 7% came from 32 other nations. By 2014 these four nations lost 25 percent of their market share and accounted for only 68 percent of world corn exports (USDA, Farms press, Trade map). Where Brazil, and Argentina only had small increase in their market share, U.S. corn market share declined greatly. Ukraine and France (not shown) increased their export share greatly (Farms press).

The figure displays a gradual increase of corn exports world-wide in these periods. The evaluation of U.S. corn export in three decades indicates the lowest corn export level in 1986, 2013 and the highest corn export level in 1988, 1995 and 2006. These could be due to higher demand because of weather conditions like droughts and floods in some regions of the world, and external and internal factors such as livestock feed demand, change in regulations in these periods.

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Figure 8 shows gradual decreases in total U.S. corn exports from about 600 MMT to about 300 MMT from 1980-2013. The U.S. averaged a 60 percent market share during 2003/04-2007/08, followed by Argentina, Brazil, and Ukraine, respectively. Yet this share dropped to 37 and 34 percent in 2013/14 (USDA, Trade Map, Worlds top export). Argentina's corn exports have increased quite a bit from the mid-1990s to the present compared to other exporting countries.
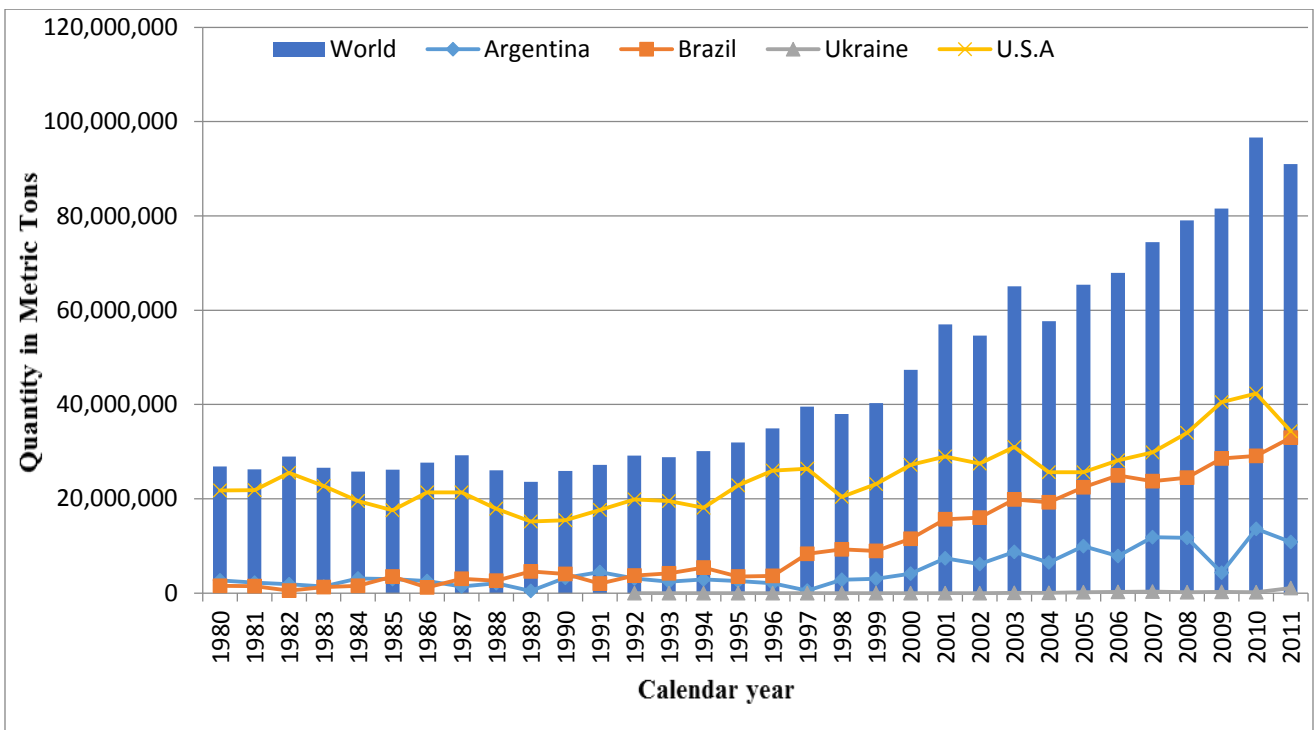


Figure 9 Soybean Export by the World and Leading Countries, (1980-2013)

Source: FAO Trade STAT

Figure 9 displays exports from the top four soybean-exporting countries for the past three decades. Soybean exports have a similar pattern to corn in that exports have increased in these periods. An evaluation of U.S. soybean exports in these three decades shows a gradual increase in U.S. soybean exports from about 200 MMT to about 400

MMT. The U.S. was the leading exporter of soybean up to 2011, following by Brazil, Argentina, and Ukraine. Brazil's soybean exports increased steadily from mid-1990 to 2011, and they exceeded U.S. soybean exports by 2011.

**2.3.2 Players in the Market: U.S. Rivals**

Even though the U.S. is the major producer and exporter of corn and soybeans in the world, the U.S. market share has been declining since the late 1970s and early 1980s. Key U.S. rivals in the corn and soybean markets are Brazil and Argentina. These competitors are thriving nations in production and exports of these crops. Figure 10 presents world corn and soybean export market share in 2011. The U.S., Brazil, and Argentina are the main players in these export markets. The U.S. market share is 42% for corn and 38% for soybeans; Brazil's share is 9% for corn and 36% for soybeans; and Argentina's share is 14% for corn and 12% for soybeans (Figure 10).
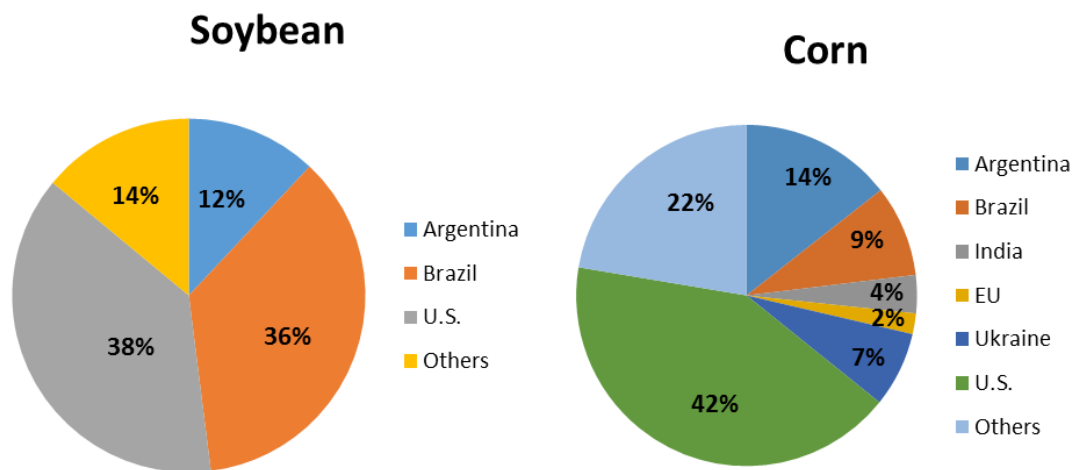


Figure 10 Share of Leading Corn and Soybean Exporting Countries, 2011.

Source: FAO TradeSTAT

As discussed earlier, U.S. market share has declined from 80 percent in 1980 to roughly 40 percent for both crops in 2012. Some of the factors explaining these changes in market shares are policy-related, price factors, exchange rate (positive or negative), demand and supply shocks (positive or negative, this case is negative), huge flood and droughts, food safety regulation, weather condition, and storage policies. For example, the governments in Argentina and Brazil have set up policies that encourage value-added exports that are critical to national food policy, which encourages them to export soybean oil and soybean meal rather than raw soybeans. They gain more value-added by exporting the crushed soybean products instead of raw soybean. These polices have helped these nations to become stronger rivals to the U.S. and gain more market share (USDA). Brazil has gained market share because it will guarantee soybean meal protein levels of 47% to 48% to foreign buyers, while U.S. meal is sold as 44%.

Nearly half of the U.S. soybean meal reaches the 47% protein level but domestic buyers consume nearly all this soybean meal leaving the lower protein soybean meal for the export market (Larson and Rask, 1992). Moreover, Brazil and Argentina have expanded their market share by having vast lands, cheap labor, and strong demand from China. The stronger U.S. dollar offsets the expected U.S. exports of these products, as it will increase the cost for importing nations. Consequently, higher prices give other exporting countries such as Brazil and Argentina the opportunity to expand their production and export of these crops. Poor weather conditions, such as drought and high temperatures, which have short-term impacts on U.S. production and export, cause prices to increase, such as the drought back in 2012 in the U.S. that caused export prices for corn to soar nearly 128 percent above the 20-year historical average, as measured by the Bureau of Labor Statistics (BLS). That

influenced East Asian countries like Japan to start importing large quantities of corn from Brazil and Ukraine, providing opportunity to U.S. rivals to replace U.S. share in the market in the long run.

**2.4 Imports**

### 2.4.1 Leading Importing Nations of Corn and Soybean in the World

According to FAO STAT world corn imports in 2011-12 were 108 MMT. Imports have risen from 78 MMT in 1999-2000 to as high as 108 million metric tons in 2011-12 with an average annual increase of 3 million metric tons since 1999-2000. Over 62% of world corn imports are secured by ten importing countries in the world. The largest corn importing country by far is Japan averaging annual 16.2 MMT, about 15% of world total corn imports, followed by Mexico, 9.4 MMT; South Korea, EU, Egypt around 7.4 MMT; China 5.2 MMT; Taiwan 4.1 MMT; Iran at 3.7 MMT; and Colombia and Malaysia with 2.8 MMT. The U.S. is the leading exporter to Japan, Mexico, and South Korea but it does not export much corn to the EU due to their restrictive GMO product policies. Figure 11 displays the market share of the leading corn-importing nations of the world.
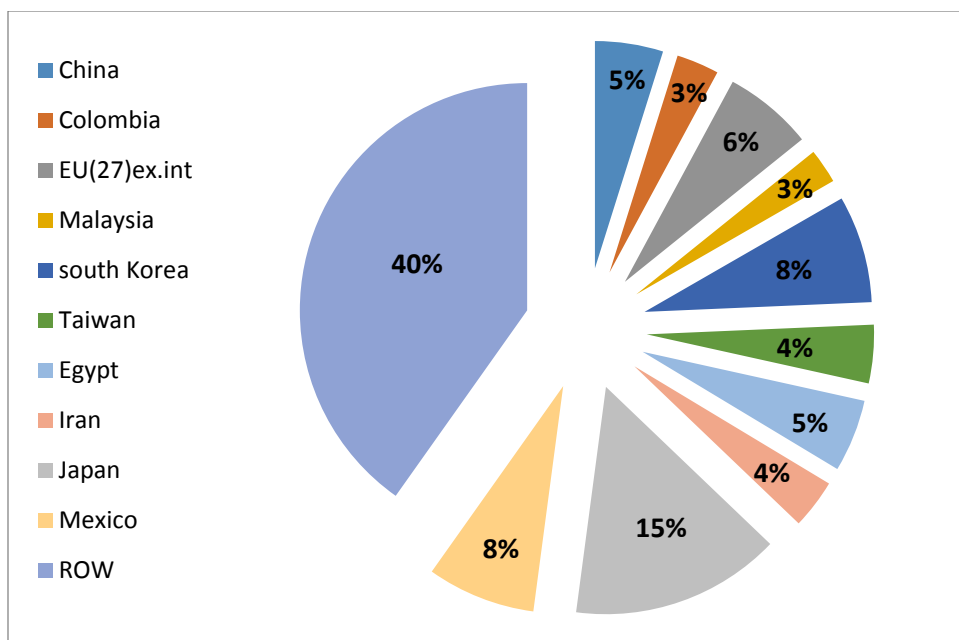
Figure 11 Market Share for Corn Importing Countries for 2007/08 to 2011/12

Source: FAO Trade STAT

According to FAOSTAT world soybean imports in 2011-12 were 90 MMT; imports have more than doubled from 42 MMT in 1999-2000. They were as high as 91 MMT in 2011-12 with an average annual increase of 5 MMT from 1999-2000. Over 70% of world soybean imports are secured by two importing countries, China and the E.U. China is by far the largest soybean importer averaging close to 55 MMT each year from 2007/08 to 2011/12, which accounts for more than 50% of global soybean imports. The EU imported 13.2 MMT in 2011 or about 16% of the world's total.

Figure 12 displays market share for each of the leading soybean importing countries.
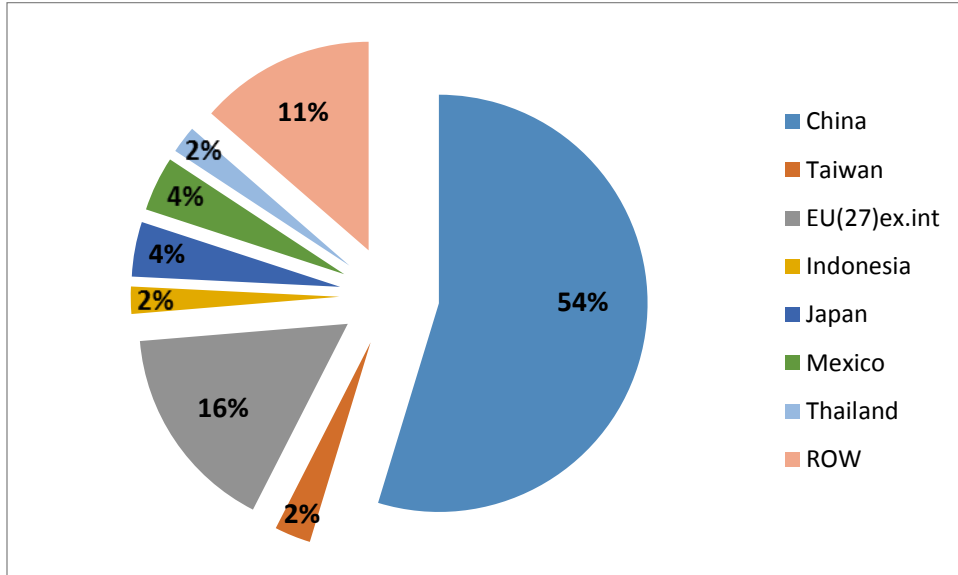


Figure 12 Market Share for Soybean Importing Countries for 2007/08 to 2011/12

Source: FAO Trade STAT

### 2.4.2 Major Importing Countries of U.S. Corn and Soybean

The main import destinations for U.S. corn and soybeans include China, EU, Japan, Mexico, South Korea, and Taiwan. This study focuses on the top three importers of U.S. corn: Japan, Mexico, and China; and the top three importers of U.S. soybeans: Japan, China, and EU.

Japan and Mexico are the top two world corn importers, and are also the top two U.S. corn importers. Japan purchased 80 percent of its corn supply from the United States while Mexico buys almost all of its corn supply from the United States (USDA, U.S Grain Council 2015). China accounts for one of the top producers of corn in the global market, but due to its high population and demand for usage of this grain, has shifted from a net exporter to a net importer. China purchases roughly 75 percent of its corn

imports from the United States (USDA, 2011). Their purchases increased from 1.2 MMT in 2008-10 to 5 MMT from 2011-14 (USDA). The USDA projects that China will need to begin importing significant amounts of corn as early as 2016 and ultimately close to 22 MMT by 2023/24 (USDA).

According to USDA, China accounts for about 54 percent of world trade of soybean, while the U.S. share of China's soybean imports was 38 percent (27.0 MMT) in 2013-14 (it was 50 percent back in 2009/10). China uses most of its imports for meal and oil. The U.S. share of Japanese soybean imports was 62 percent in 2011/12, down from 77 percent in 2006/07. In this year drought in the U.S. caused soybean prices to increase and led some Japanese buyers to shift to Brazilian soybeans. According to the Non GMO Report in 2005, Japan uses most soybeans for oil and meal (74% of total demand); 23% was for food use. The EU-15 accounted for 23 percent of total world soybean imports in 2013/14; the U.S. share in EU soybean export market was only 7 percent in 2013. Figure 13 and 14 display U.S. exports of corn and soybeans to major destinations from 1980-2012.
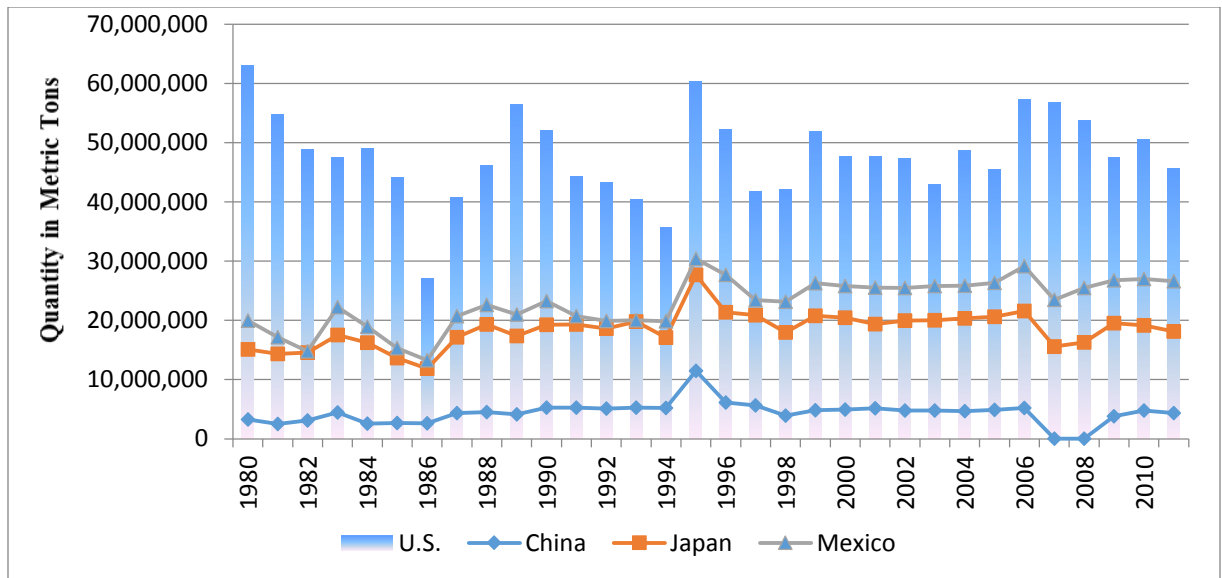
Figure 13 Exports of U.S. Corn to World and Major Destinations, 1980-2012

Source: FAO Trade STAT

Figure 13 shows that exports of U.S corn fluctuated greatly from year to year. Some of the major fluctuations in the past three decades were during 1986 and mid 2007/08 to all three destinations. These were the lowest points for corn exports from the U.S., while their highest levels were in 1995 and 2006 to all three destinations. These fluctuations were due to the same reasons mentioned associated in figure 8. Mexico is the leading importing destination for U.S. corn followed very closely by Japan, and this has been the case throughout the past thirty-two years.
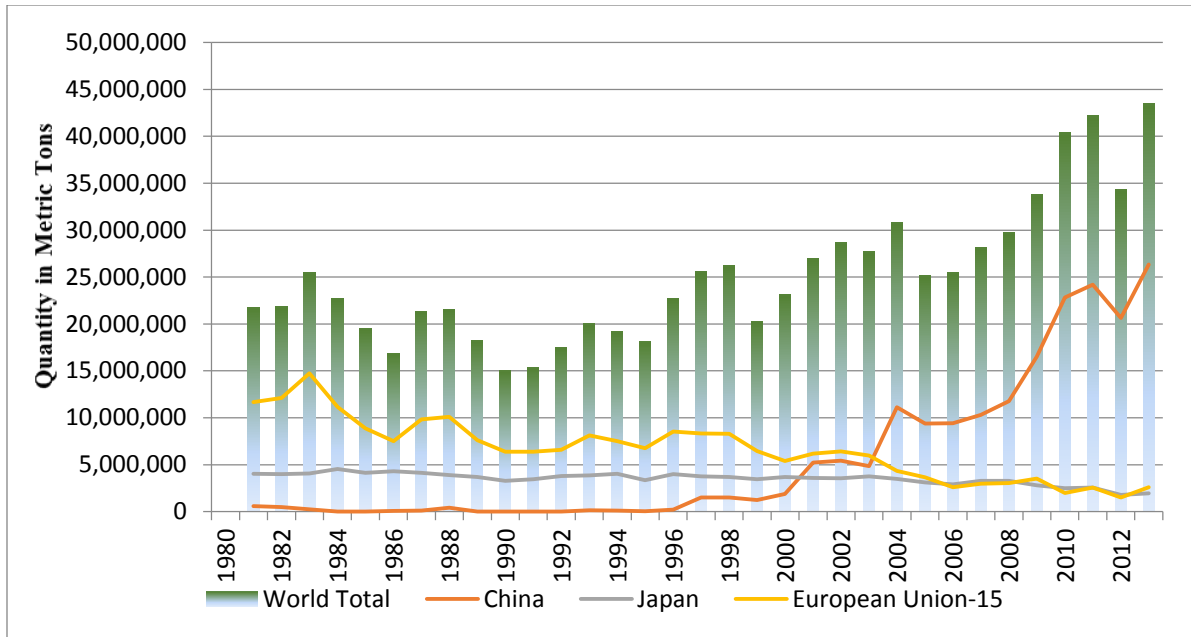
Figure 14 Exports of U.S. Soybean to World and Major Destination, 1980-2012

Source: FAO TradeSTAT

Figure 14 demonstrates that European Union was the leading importer of U.S. soybean in 1980 to the late 1990s but gradually started slowing down its imports in the early 2000s due to their GMOs policies (but they are still among the top importers of U.S. soybeans). The graph shows that China started increasing its imports of soybeans during the mid-1990s and by the mid-2000s had become the largest importer of this crop from the U.S. During the 1995-96 marketing year China imported approximately 18 MMT of soybeans. Since that time Chinese has enhanced its position as an import partner with the U.S. due to their double digit economic growth. Their imports stand at more than a billion bushels of soybeans each marketing year (Figure 14). Its imports alone account for two-thirds of U.S. soybean exports from 2008-12. Japan has been a steady importer of soybeans throughout the three decades.

**Japan:**

Japan is a developed country with limited land resources, yet it is a large producer of meat; so it is a steady buyer of corn due to high demand for meat and dairy products in Japan. Japan is the world's largest corn importer with annual demand of about 16 million tons (USDA, RES). Quality is one of Japan's major concerns, and since the U.S. produces some of the highest quality corn in the world, it satisfies nearly all Japanese demand (normally more than 90 percent of Japanese requirements). Figure 15 displays the major corn suppliers to Japan. (USDA, RES)
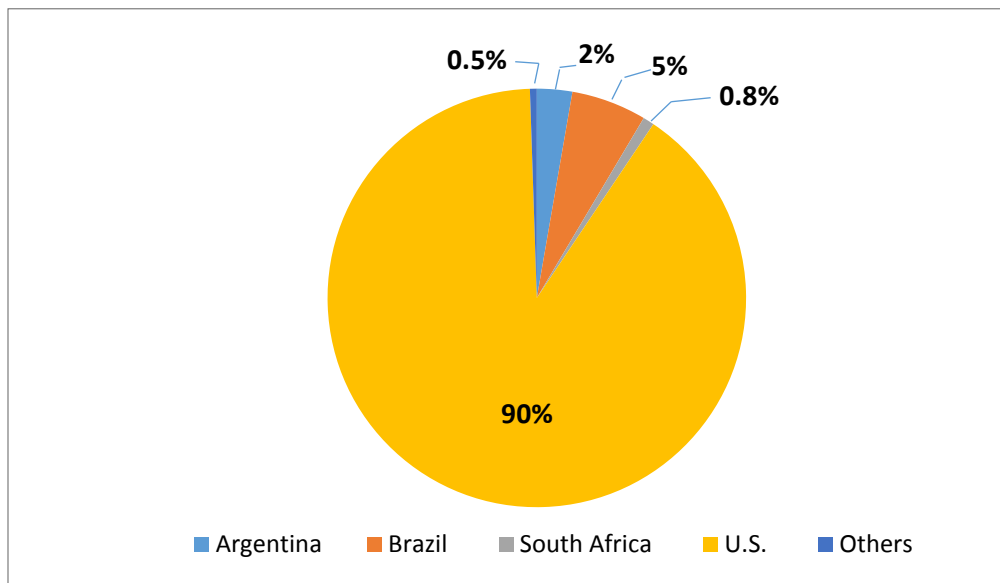


Figure 15 World Export Shares of Corn to Japan, 2011

Source: FAO TradeSTAT

Japan is also the fourth largest importer of soybeans in world; according to USDA over 90% of its soybeans are imported from the U.S., Brazil, and Canada. Japan only produces 3 to 7% of its soybean needs, so imports are important. Japan mainly uses soybeans for food oil, followed by food beans and then feed for livestock. Food beans are

raw materials processed into soy foods such as tofu, natto, miso, soymilk and soy sauce. Soybeans in Japan are used for oil (56 percent, followed by for food (40%), and feed (4%) (USSEC). Japan only imports non-GMO soybeans for its food use. Figure 16 displays the major soybean suppliers to Japan. (USDA, RES)
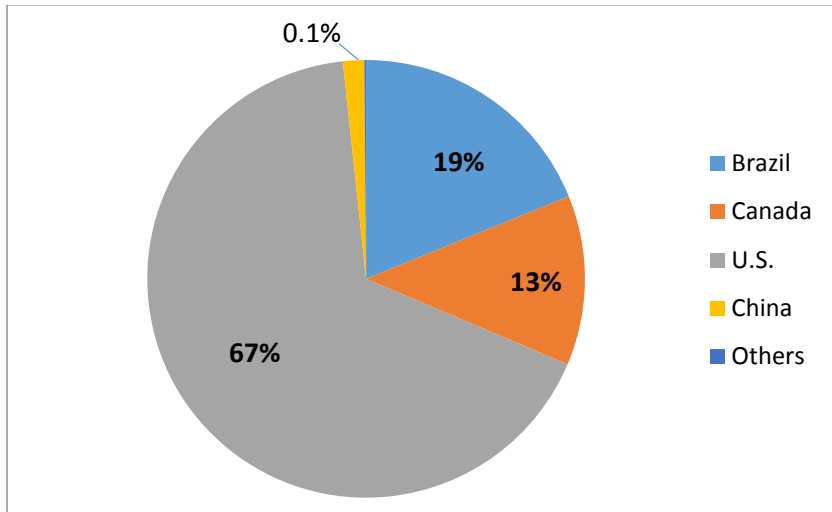


Figure 16 Market Shares for Soybean Suppliers to Japan, 2011.

Source: FAO Trade STAT

**China:**

According to USDA China is the largest consumer of corn and soybeans in the world, it is the second largest producer of corn after the U.S. and one of the top largest importer of corn. It is predicted to surpass Japan's corn imports in the near future. China does not have a stable place in the market for these products. It swings from the second largest corn exporter in one year and the following year becomes one of the largest corn importers (USDA ERS). China is mostly importing its corn from the U.S., its imports reached a peak of 5 MMT in 2014. Since then, U.S. corn exports to China have slowed because of high U.S. corn prices and a dispute about Syngenta product of MIR 162,

which contains a protein that is genetically modified, and more resistant to insects. The corn, also known as Agrisure Viptera, was approved by the U.S. in 2010. Three percent of U.S. acres for the last two seasons of 2013 were planted with MIR 162 and was not confined to any region. But in 2013, China refused to accept American corn with the MIR 162 trait, rejecting imports and causing turmoil in the commodity markets. Recently, though, U.S. corn prices have declined and MIR 162 has been approved, so China can again import U.S. corn to meet their needs. "As early as 2016 USDA projects that China will need to begin importing significant amounts of corn and ultimately close to 22 MMT by 2023/24. This corn deficit will likely be filled by the U.S. and a few other corn exporting countries" (USDA).
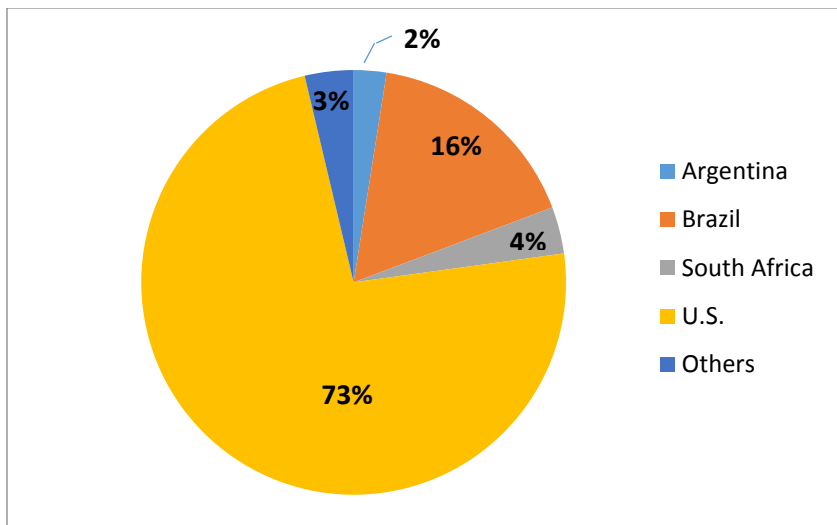


Figure 17 Market Shares for Corn Suppliers to China, 2011

Source: FAO TradeSTAT

China is the world's largest soybean importer, importing close to 55 million metric tons annually, or 54% of total world soybean imports and 64% of total U.S. soybean exports. According to USDA, due to its economic growth, high population and increasing per capita income, the Chinese diet has shifted toward meat, resulting in an

increased use of corn and soybean meal in livestock feed. Brazil exported nearly 33 million tons of soybeans to China in 2013-14, accounting for a 47% market share in that year.
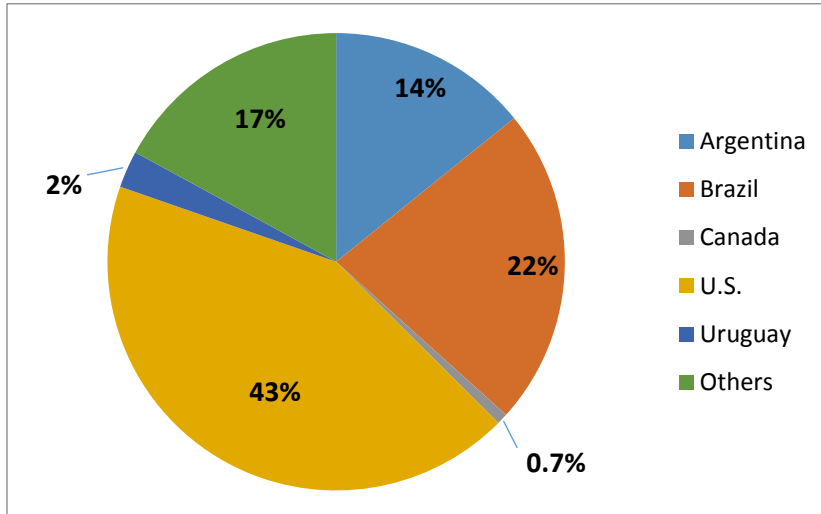


Figure 18 Market Shares for Soybean Suppliers to China, 2011

Source: FAO TradeSTAT

**European Union:**

In the past four decades the EU has been, and still is, among the leading corn and soybean importers in the world. According to the FAS, in 2011 the EU was the third largest importer of soybeans (11 million tons) and the fourth largest importer of corn (6 million tons) in the world. The EU was also among the top five corn producers and consumers in the world for 2011. U.S. agricultural exports to the EU have changed significantly over the last three decades, with some of the biggest changes occurring as a result of trade restrictions on bulk commodities (for instance corn and soybeans), which together accounted for 48% of agricultural exports to the EU in 1980 but were only 15% in 2012.

The immense increase in GMO products for the U.S. has affected EU trade patterns, reducing U.S. corn exports since 1992 from 3 million bushels annually to 500 thousand bushels in 2011 (USDA). EU regulations against GMO products and price increases in the U.S. are major reasons behind this reduction. Thus, the EU has shifted its corn suppliers and most of their corn imports come to Brazil and Argentina, where they grow and produce non-GMO products with better prices (USDA).

The toughest restrictions for the E.U. are on soybean meal that is a source of livestock feeds, where there is a zero tolerance on GMO products. Table 2 indicates that the U.S is in third place after Brazil and Argentine in soybean exports to the EU. Domestically-grown soybeans account for less than 10 percent of total soybeans crushed in the EU, and more than 70 percent of soybean meal used in feed is imported, much of it from South America and 22 percent from North America (USDA). The EU has imported more biodiesel from Argentina and Indonesia, and less soybean oil and palm oil from these countries. Soybean oil produced domestically by crushing imported beans has been exported. Most of the soybean oil produced in the EU is exported to Africa. Since 2012/13, North African countries have accounted for more than 50 percent of EU exports.

Table 2 Major Soybean Importers to the EU-28 by country/region of origin (2013)

| Country / region of origin, Import (1,000 tons) | Soybeans | Soybean meal | Soy oil | Total |
|---|---|---|---|---|
| Brazil | 5800 | 8784 | 24 | 14608 |
| Argentina | 250 | 8083 | 25 | 8358 |
| Paraguay | 2000 | 209 | 25 | 2234 |
| Bolivia | 110 | 22 | 0 | 132 |
| Rest of Latin America | 620 | 0 | 0 | 620 |
| United States | 3300 | 1545 | 7 | 4852 |
| Canada | 1150 | 62 | 0 | 1212 |
| Ukraine | 600 | 17 | 44 | 661 |
| Russia | 0 | 137 | 90 | 227 |
| India | 0 | 477 | 0 | 477 |
| Other countries | 107 | 312 | 107 | 526 |
| Total | 13937 | 19648 | 322 | 33907 |

Source: ISTA Mielke (2014, May), Oil World Annual 2014, Hamburg: ISTA Mielke

**Mexico:**

Mexico is the world's second largest importer of corn and soybeans. It is the sixth largest producer and the sixth largest consumer of corn (USDA 2014). In Mexico, corn is by far the most important agricultural commodity and is the main crop and food staple, both in terms of production and consumption. The Mexican corn market is different than most other corn markets in that corn is considered a food grain rather than a feed grain. So Mexico has developed two distinct corn markets: one for white corn, which is mainly for human consumption, and one for yellow corn, which is mainly for feed (although some goes to the starch industry, World-Grain 2014). Yet the future of the Mexican corn market is for yellow corn and its use in the feed industry. White corn use will wain as a staple as incomes grow.

Figure 19 indicates that 89 percent of Mexico's corn imports came from the U.S. in 2011 and 10 percent from South Africa. Mexican corn imports have become more diversified in more recent years as other markets, such as Brazil, became more

competitive than the U.S. In December 2012, total Mexican corn imports included 63% from the U.S. and 26% and 11% from Brazil and South Africa, respectively (USDA FSA).
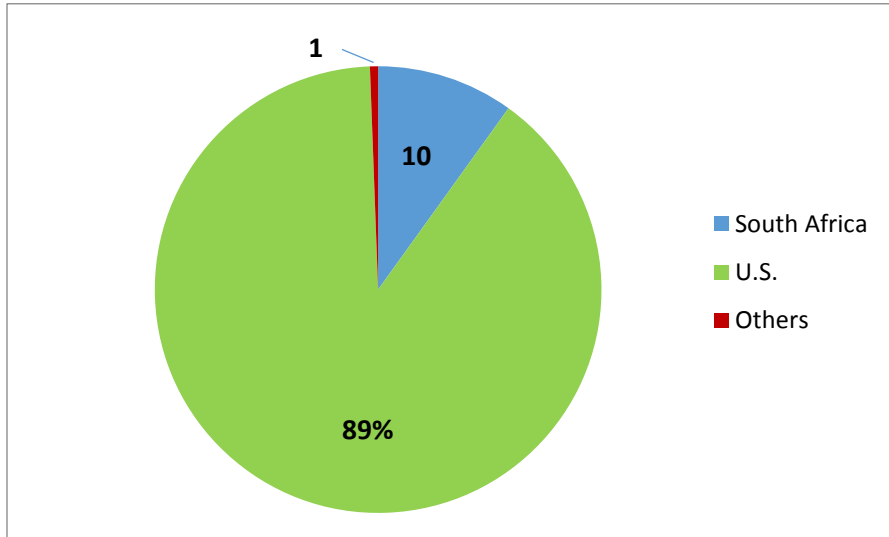


Figure 19 Market Shares for Corn Suppliers to Mexico, 2011

Source: FAO TradeSTAT

　　　Since the North American Free Trade Agreement (NAFTA), Mexico has lifted its tariff policies on soybeans, and imports have mostly displaced domestic soybean production. Figure 20 show that the U.S. is the major exporter of soybean to Mexico, covering 94 percent of imports in 2011.
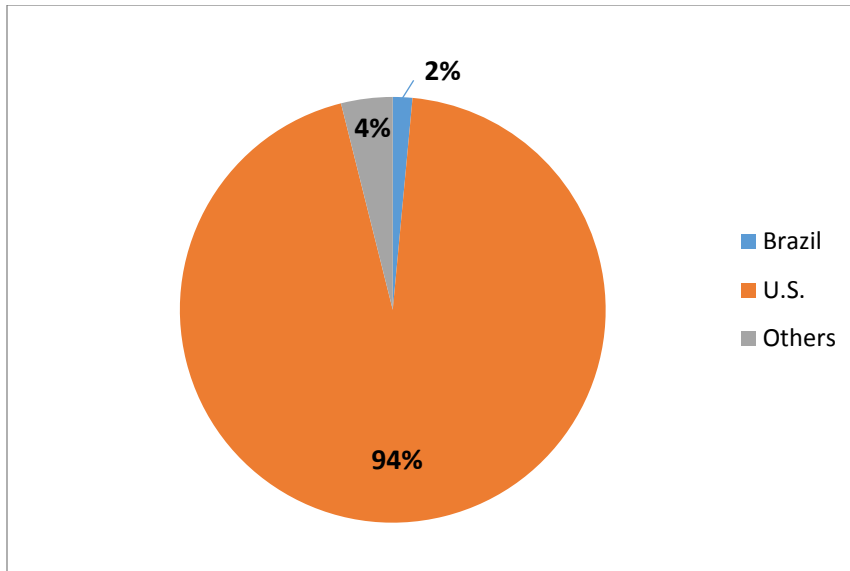
Figure 20 Market Shares for Soybean Suppliers to Mexico, 2011

Source: FAO TradeSTAT

### 2.4.3 Ethanol and Effect of Biofuel Production on Corn and Soybean Prices:

The growth of ethanol production has strengthened the connection between food crops, where ethanol is derived, and the energy sector. Some have argued that volatility in the energy market is likely to be transmitted to the food sector through the ethanol linkage (Muhammad and Kebede, 2009). Now much of U.S. corn production is going into ethanol production. The amount of corn used for ethanol grew from less than 1.4 billion bushels (about 13% of total use) in 2004 to 5.2 billion bushels (about 38% of total use) in 2014 (USDA, 2015). According to USDA the U.S. is the world's largest ethanol producer and currently holds a 57-percent share of global ethanol production. Ethanol is the world's most widely used liquid biofuel in the transportation sector (USDA, ERS).

Condon, Klemick, and Wolverton (2013) argue an increase in ethanol production of one billion gallons increases corn prices by three to four percent. Higher corn prices provide an incentive for farmers to allocate more land and other resources to growing

corn at the expense of growing other crops, mainly soybeans. This causes the quantity of soybeans produced to decrease and increases its price along with the corn price. Because the U.S. law requires that ethanol be used through the renewable fuel standards, there is less corn available for non-ethanol users, including foreign buyers and U.S. livestock producers. The high demand for corn, coupled with the partially regulated market where government controls the forces of supply and demand, has pushed corn prices higher.

Ethanol production increased tremendously, and with the increased production this relation between ethanol production and corn prices strengthened. Agricultural output prices are now linked to energy prices through biofuel production from commodities (Serra and Silberman, 2013; Taheripour and Tyner, 2008). De Gorter et al. (2015) concluded that studying this linkage is important to understanding the changes in food prices (such as corn). The ethanol industry has become the major competition for export: more corn for ethanol production means less corn for exports.

Corn is a major feedstock for domestic ethanol production and 5.5 billion bushels of U.S. corn were used for that purpose in 2011-2012. The energy sector uses ethanol as a substitute for gasoline. In recent years, due to rising gasoline prices, the energy sector has increased production of biofuel products such as ethanol (USDA, ERS). Ethanol production in the U.S. has grown tremendously in the last decade. Production was averaging 1 billion gallons per year in the early 1990s, but grew to 7 billion gallons in 2007, and in 2013 exceeded 13 billion gallons. Ethanol is made by fermenting and distilling crops such as corn.

U.S. government promotion of the ethanol industry through the biofuel mandate, is an important element in the recent spikes in corn (and other commodity) prices, which

in return forced the food industry and farmers to produce and invest more of their resources in growing corn (Elliott, 2013). Ethanol was introduced in the early 1980s as transportation fuel to be blended with gasoline in order to increase its octane level. Later the role of ethanol was shifted to become an 'oxygenate' to help gasoline burn more efficiently through several government mandates. There were only about fifty ethanol plants in the U.S. in the late 1990s, producing about one billion gallons annually. The Renewable Fuels Standard Act, which was passed in 2005, targeted 7.5 billion gallons of ethanol production by the year 2012. Additionally, Congress passed another energy bill in 2007, doubling the Renewable Fuels Standard by 2015 to 15 billion gallons. The maximum amount of ethanol that can currently be blended stands at 10% level. With the current U.S. consumption of gasoline being approximately 140 billion gallons annually, the maximum amount of ethanol blended as E10 is about 14 billion gallons (Taheripour and Tyner).
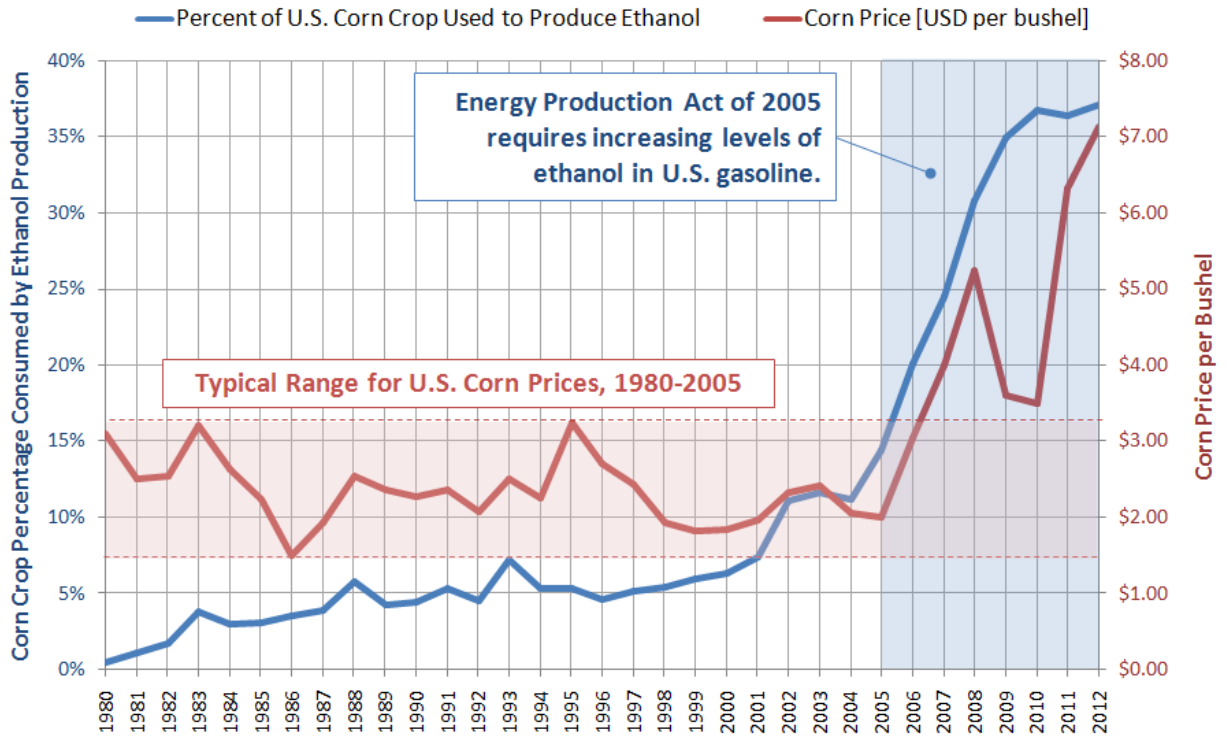
Source: Iowa State University Agricultural Marketing Resource Center, Ethanol Usage Projections & Corn Balance Sheet and U.S.D.A. Agricultural Prices

Figure 21 U.S Corn Consumed by Ethanol production and Corn Price

Figure 21 displays the effect of the Federal Renewable Fuel Standard mandates on corn prices and ethanol production. The 2011-12 the law required oil companies blend 13.2 billion gallons of ethanol with the gasoline they produce. In 2013, the blending requirement increased to 13.8 billion gallons.

**CHAPTER THREE: LITERATURE REVIEW**

The concentration of this study is on the export demand of U.S. corn and soybeans to major foreign destinations. The economic influence of the U.S., as the largest exporter of grains in the world, is considerable on grains export and import markets, job markets in agricultural industry, and price inflation in grain market. According to USDA, U.S. agricultural exports have been larger than U.S. agricultural imports since 1960s, generating a surplus in U.S. agricultural trade. After WWII, as the economies of Europe and Asia recovered and incomes increased, citizens there began eating more meat than they had before the war. The demand for meat, feed grains and protein meals from oilseeds increased, and caused increased agricultural exports by the U.S. and increased importance of export markets to American farmers (The Development of American Agriculture, 1993).

There is an extensive literature on the U.S. agricultural exports. The majority of the previous literature focuses on export demand estimation for U.S. commodities and on how the importing countries' income and exchange rates affected export demand. Some of this research is on U.S. export demand for different commodities in the agricultural sector, such as the research conducted by Konandreas, Bushnell, and Green (1978) on wheat, Jones (1988) on meat, Guci (2008) on grapefruit juice, and Hooy and Choong (2010) on exchange rate effects. However, there is a lack of empirical research exploring the factors that influence export demand for corn and soybeans. This paper expands the export demand function  to integrate new variables into the export demand function.

Konandrea, Bushnei, and Green (1978) studied the relationship between U.S. export demand and exchange rates. Their research focused on estimation of an export

demand function for U.S. wheat. Their results indicated that exchange rate and price changes have a significant impact on export demand for U.S. wheat, and U.S. export demand for wheat is responsive to price and exchange rate changes.

Tassos (1988) used an Armington model to analyze the impact of the European Community enlargement on U.S. corn and soybean exports. His results indicated that the enlargement had a significant and negative impact on U.S. corn exports to new EU members based on the fact that commodity prices are determined through demand, supply and exchange rates.

Reimer, Zheng, and Gehlhar (2012) studied the export demand elastically of the U.S. crops in different periods. Devadoss and Meyers (1990) had done a similar study on variability in the wheat export demand elasticity and its policy implications for the late 1980s. This involved regressing the local price variation with changes in U.S. export prices. The results of the 2012 study indicated that export demand elasticities for corn and wheat were slightly more elastic during 2001–2011 than in the previous studies (Devadoss and Meyers (1990)), and export demand elasticity for soybeans was slightly more inelastic during 2001–2011 than in previous years. Other research on export demand argued that, by contrast, the magnitude of the elasticity of export demand had long been debated and continued to be in need of a firmer empirical foundation (Magee 1975, Gardiner and Dixit 1987, Carter and Gardiner 1988, and Miller and Paarlberg 2001).

Armah and Epperson (1997) did research on export demand for US frozen concentrated orange juice (FCOJ) with special focus on the impacts of export promotion programs based on annual observations from 1984 to 1992. The study was based on exports to France, Germany, Japan, the Netherlands, and the United Kingdom. They use a single

equation model for export demand. Their results indicate that own-price, real exchange rate of the importing country in most cases, and trend had a negative relationship with US FCOJ exports; while the price of Brazilian FCOJ exports, the real income (GNP) of the importing country, and export promotion programs were positively related to US FCOJ exports. This study investigated ways to help increase U.S. export revenue and directly increase market share for FCOJ to its top major importer through governmental agencies involved in export promotion programs and formulation of policy, at a time when U.S is the major importer of this product absorbing 23 percent of world export.

Reimer and Kang 2010 claimed that local prices in many importing countries are constrained from directly following U.S. export prices. This may be the result of transport and transaction costs, market power, exchange rates, domestic policies, and border policies. This means that imports from these countries might not be as responsive to U.S. price changes because local prices do not change. Furthermore, elasticity estimates may be biased unless local prices are used in econometric models.

Haniotis, Baffes, and Ames (1988) did a study on the export elasticity demand and supply for wheat, corn and soybeans using a dynamic adjustments model. Their results indicated differences in the export behavior of each product with U.S. corn exports being elastic, while U.S. soybean exports exhibited an inelastic response, and the wheat elasticity of export had a positive sign. This study investigated the stability of export markets at a time when the U.S. world market share was more than 60%. The adjustment coefficients indicated that exports and export prices did not adjust immediately to their equilibrium levels.

Senhadji and Montenegro (1999) estimated the aggregate agricultural export demand elasticities for 53 developing and industrial countries using time series techniques and found a significant effect of the trading country's income and relative prices on export demand, especially in the long run. Results showed that trade is an important factor in economic growth for all developing countries.

Onunkwo and Epperson (2000) identified the major factors affecting the export demand for U.S. pecans and the impacts of federal promotion programs on the foreign demand for U.S. pecans. Since export markets are essential to the U.S. market, results indicated that the U.S. pecan industry can benefit considerably from increased export promotion to overcome obstacles such as unfair trade practices by other nations. These researchers did a similar study on U.S. export demand for almonds in 2001. The results of this study were very similar to the results of their U.S. pecan study.

Sobolevsky, Moschini, and Lapan (2005) used a partial equilibrium model for the soybean complex with four regions (U.S., Argentina, Brazil, and the Rest of the World (ROW)) where Roundup Ready (RR) products were weakly inferior substitutes to the conventional ones. RR seeds are priced at a premium, and costly segregation is necessary to separate conventional and biotech products. As RR products might be lower priced, results indicated that the U.S., Argentina, Brazil, and the Rest of the ROW, all gain from the introduction of RR soybeans, even when the ROW and Brazil imposed production bans on the RR products.

There are many studies on export demand functions. The following three papers are examples of export demand functions in general.   Susanto (2006) estimated the oligopoly power in the soybean market. Estimates of market power and the hypothesis

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tests of market power suggest that both soybean and soybean meal export markets are deemed competitive rather than behaving as a Cournot or any other form of noncompetitive behavior. Jayasinghe, Beghin, and Moschini (2009), using export demand function and gravity model from data on 48 countries, investigated the determinants of world demand for U.S. corn seeds, and the cost of export trade to different destinations. They conclude all trade costs matter, mostly tariffs, and have a negative impact on U.S. corn seed exports.

Zheng, Saghaian, and Reed (2011) estimated export demand elasticities for U.S. pistachios in 21 markets using panel data from 1989 to 2009. These markets accounted for 78 percent of the total U.S. pistachio exports. They found that U.S. pistachio producers need to take advantage of their advanced technology and reputation to protect themselves from higher food safety standards.

O'Brien (2010) analyzed world corn supply-demand trends for marketing years (MY) 1987-88 through MY 2010-11. He measured the variability of world corn supply-demand in recent history, and projected corn supply-demand balances for MY 2010/11. He concluded that corn prices could rise markedly in the near future because of increased demand for its use in ethanol production. Increased energy use for corn could sharpen price competition between U.S. livestock feeders and foreign export buyers. Consequently, ethanol use causes accelerated acreage shifts toward corn production (in the United States and elsewhere) and away from other less profitable crop enterprises.

**CHAPTER FOUR: MODEL SPECIFICATION**

Export demand function estimation has a significant role in the international trade field and there are several procedures for this estimation. Theoretically, there are three main variables to estimate export demand functions (Guci, 2008 and Hooy and Choong, 2010). First is price of product, which is the main explanatory variable, second foreign income that represents the economic activity and the purchasing power of the importing country, third exchange rate, which is a relative price that is crucial in affecting exports and imports. For our purpose, Ordinary Least Square regression is used for the estimation, using actual data to estimate the effects of these three factors on export demand of U.S. corn and soybeans. Since feed demand is important for these two crops, the quantity of livestock (chickens and hogs) in each importing country is also included in the model.

There are many studies on export demand functions. As was stated in the literature review, Susanto (2006) estimated the oligopoly power in the soybean market. Estimates of market power and the hypothesis tests of market power suggested that both soybean and soybean meal export markets were deemed competitive rather than behaving as a Cournot or any other form of noncompetitive behavior. Jayasinghe, Beghin, and Moschini (2009), using export demand function and gravity model from data on 48 countries, investigated the determinants of world demand for U.S. corn seeds, and the cost of export trade to different destinations.

Zheng (2011) estimated export demand elasticities of U.S. pistachios for 21 markets and conducted panel data analysis with annual data from 1989 to 2009. This research also uses a similar panel data model. There are various benefits for using panel data estimation.

First, the panel data estimation measures variations over both cross sectional and time series dimensions jointly, which provides more information and better coefficient estimates than pure cross sectional or pure time series data. It allows for correction of heterogeneity and increases the power of the tests. Second, panel data incorporates dynamic variations in the data by exploring information from the dynamic reactions of each of the individuals, but not from the lengthy time series (Kennedy, 2003).

## 4.1 Variables

In this thesis the export demand function is specified as a simple linear regression model, relating the U.S. corn and soybean export demand quantity to several independent variables, including corn and soybean export price (a substitute's price), importing countries' GDP, the real exchange rate between the country's currency and the U.S. dollar, and the ending inventory of livestock (pigs and poultry) in the importing country. Therefore, the model combines all the important variables mentioned in the previous literature. The effects of substitutes or complements are also estimated. The estimates cover the time span 1980 to 2012.

The main economic factors affecting export demand are theorized to be own price, cross prices, GDP's, the real exchange rates, and livestock quantity. Equation (4.1) specifies the export demand function for U.S. corn and soybean.

$$\ln q_{i,t} = \alpha_0 + \alpha_1 \ln p_{(i,t)c} + \alpha_2 \ln p_{(i,t)s} + \alpha_3 \ln gdp_{i,t} + \alpha_4 \ln ex_{i,t} + \alpha_5 \ln pigst_{i,t} +$$

$$\alpha_6 \ln poulst_{i,t} + \mu_t + \varepsilon_i \qquad (4.1)$$

Equation 4.1:

$q_{i,t}$ = U.S. export quantities of corn (soybeans) to country i in time t;

$p_{(i,t)c}$ = U.S. corn export prices to country i in time t;

$p_{(i,t)s}$ = U.S. soybean export prices to country i in time t;

$gdp_{i,t}$ = GDP of country i in time t;

$ex_{i,t}$ = The real exchange rates between country i's currency and the U.S. dollar in time t;

$pigst_{i,t}$ = Quantity of pigs in importing country i in time t;

$poulst_{i,t}$ = Quantity of poultry in importing country i in time t;

$\mu_t$ = Year fixed effect

This model utilizes a logarithmic function to make values with different scales become more comparable. The coefficients are in elasticity form, so they are much easier to interpret. For instance, $\alpha_1$ is the own price elasticity coefficient, which is the

percentage change in quantity demanded caused by a 1% change in its own price. $\alpha_2$ is the cross price elasticity of demand measuring the percentage change in the export demand for U.S. corn and soybean caused by a 1% change in the price of complements or substitutes. $\alpha_3$ is the income (GDP) elasticity of demand, which measures the percentage change in export demand caused by a 1% change in GDP in the importing countries. $\alpha_4$ is the real exchange rate elasticity of export demand measuring the percentage change in the variable caused by a 1% change in the real exchange rate between foreign currencies and the U.S. dollar. And finally $\alpha_5$ and $\alpha_6$ are the elasticities for the quantity of livestock for each importing country, measuring the percentage change in their demand for U.S. corn and soybean caused by 1% change their livestock numbers.

The real exchange rate is calculated using this formula:

$$ex = \frac{p_d}{e * p_f} \tag{4.2}$$

Equation 4.2:

$p_d$ = Domestic price in the importing countries;

$p_f$ = U.S. price in foreign countries;

$e$ = the nominal exchange rate.

The subscript i represents the four importing destinations, and the subscript t represents time, from 1980 to 2012. All variables are both time variant and cross sectional variant.

According to economic theory, the effect of the own price of corn and soybeans on quantity demanded is expected to be negative. To account for complementary and substitution relationships, the average export price of U.S. corn/soybeans is used in the appropriate equation. They may impact positively on the variable if the consumption relationship between corn and soybean is substitutional, and negative if complementary.

## 4.2 Data Description

Four major importing countries are selected for this study: Japan, China, EU, and Mexico. Annual time series data for the variables are chosen from 1980 to 2012 for the estimation. Data for export values and quantities of corn and soybeans were collected from Food and Agriculture Organization (FAO) TradeSTAT; data for GDP was acquired from USDA; real exchange rate data came from IMF, Division of Trade Statistics; and data for pig and poultry inventory was collected from the FAO TradeSTAT. Export prices are the average values calculated by dividing the total export values by the total export quantities.

**4.3 Model Validation-Hausman Test (Hausman, 2003)**

There are two types of models to obtain estimates with panel data: the fixed effects model and the random effects model. In order to determine the best model with unbiased, consistent, and hopefully efficient estimators, a Hausman test is performed. The Hausman test determines whether there is a significant difference between the fixed and random effects estimators by testing the null hypothesis that the difference between an efficient estimator and an inefficient estimator is zero. The fixed effects estimator is more efficient than random effects estimator by allowing estimation of coefficients on time-invariant unobservable variables, so their effects are not eliminated and shows a relationship among the years, Additionally, the fixed effects estimator takes degrees of freedom and correcting the composite errors. Yet the above advantages for fixed effects can only be used when the Hausman test supports it. If the Hausman test does not support its assumptions, we will use the random effects estimator (Rorres-Reyna).

In the model of equation 4.1, the Hausman test is a chi-square distributed with 2 degrees of freedom since three countries are used for each test, which is the number of time-varying regressors. The test result generated by Data Analysis and Statistical Software (STATA) for corn is $chi2 (6) = 28.99$ with p-value = 0.0001 and for soybean is $chi2 (6) = 36.69$ with p-value = 0.0000, indicating below the 0.05 significant level and reject the null hypothesis, therefore the fixed effects estimator is chosen.

**4.4 Data Summary**

Tables 3 and 4 summarize the data set for corn and soybeans, respectively. They also show that the range of the data variations is small due to the chosen double log function and the use of indexed values. Table 5 summarizes the data set for corn exports with soybeans as the substitute. The first row is the year, varies from 1980 to 2014, a total of 34 years. The Obs. is the number of total observations, 105. The second row is the quantity of corn exported in million ton (MMT) from the U.S. to three major destinations, with a minimum of 0.2 MMT to Mexico in 1993, a maximum of 16 MMT to Japan in 2006, and a mean of 7 MMT. The third row is the price of corn exported in dollars per MT from the U.S. to the three destinations, with minimum of $80 in 1982 to Mexico, maximum of $307 in 2010 to China, with the mean of $145, The sixth and seventh row are GDP and Exchange rate measured in U.S Dollar. The eighth and ninth row are pig and poultry inventory measured in animal units per million (M).

Table 3 Descriptive Statistics for Corn

| Variable | Mean | S.D | Min | Max | Obs. |
|---|---|---|---|---|---|
| Year | 1997 | 10 | 1980 | 2014 | 105 |
| Quantity of corn export(MMT) | 7 | 5 | 0.2 | 16 | 105 |
| Price of corn export | 145 | 58 | 80 | 307 | 105 |
| Quantity of soy export(MMT) | 6 | 6 | 0.06 | 30 | 105 |
| Price of Soy export | 292 | 108 | 180 | 580 | 105 |
| Importing Countries GDP(BD) | 2190 | 2300 | 129 | 10230 | 105 |
| Exchange Rate | 40 | 48 | 3 | 149 | 105 |
| Pig Livestock(M) | 136 | 178 | 10 | 482 | 105 |
| Poultry Livestock(M) | 1 | 2 | 0.2 | 5 | 105 |

Generated by SAS

Table 3 summarizes the data set for soybean export with corn as the substitute. The fourth row shows the quantity of soybean exported in million tons (MMT) from the U.S. to three major destinations, with a minimum of 0.06 MMT in 1985 to China, a maximum of 26 MMT in 2014 to China, and a mean of 6 MMT. The sixth row is the value of soybean exported in million dollars from the U.S. to the three destination, with minimum of $180 million in 1983 to China, a maximum of $580 million in 2012 to China, and a mean of $292 million.

Table 4 Descriptive Statistics for Soybean

| Variable | Mean | S.D | Min | Max | Obs. |
|---|---|---|---|---|---|
| Year | 1997 | 10 | 1980 | 2014 | 105 |
| Quantity of Soy export(MMT) | 6 | 6 | 0 | 30 | 105 |
| Value of Soy export | 292 | 108 | 180 | 580 | 105 |
| Quantity of Corn export(MMT) | 7 | 5 | 0.2 | 16 | 105 |
| Value of Corn export | 145 | 58 | 80 | 307 | 105 |
| Importing Countries GDP(BD) | 4910 | 4480 | 189 | 18300 | 105 |
| Exchange Rate | 34 | 44 | 0.7 | 133 | 105 |
| Pig Livestock(M) | 184 | 157 | 9 | 482 | 105 |
| Poultry Livestock(M) | 2 | 1 | 0.2 | 5 | 105 |

Generated by SAS

**CHAPTER FIVE: EMPIRICAL RESULTS**

Export demand functions for U.S. corn and soybeans were estimated using a double log linear regression model and the independent variables outlined in Chapter 4. This chapter presents the results using the chosen estimator, which is the fix effects model, following by analysis of elasticities.

**5.1 Parameter Estimates**

Based on the Hausman test statistics for corn model, we concluded that the fixed effects model fits the data better than the random effects model. To confirm that there is no autocorrelation in the model, tests were performed and the resulting F statistic was 2.19, p=0.28; therefore, the H0 was not rejected at the 5% significant level. Thus serial correlation was not a problem and we fail to reject the null and concluded the data does not have first-order autocorrelation. To confirm that there is no presence of heteroscedasticity in the model, tests were performed and the resulting F statistic was 27, p=0.000; therefore, the H0 was rejected and concluded heteroscedasticity, therefore to control for heteroscedasticity the option "robust" was used.   The model results show an $R^2$ of 80%, meaning that 80% of the variation in U.S. corn exports to these markets is explained by the model.  The estimated coefficients for the corn export demand are presented in table 5.

**5.2 Elasticity Analysis:**

Parameter estimates of the U.S. corn price model confirm the anticipated results in terms of signs, significance and elasticity. Given that the functional form used in this study was log-log, each coefficient is an elasticity of export demand. The estimated own price elasticity is statistically significant and has the correct sign, an inverse relationship between

quantity demanded and price. This indicates increasing price of U.S. corn by 1% would

decrease U.S. corn exports by 6%, which is highly elastic.

Table 5 Estimated U.S. Corn Export Demand Function

| variable | Parameter | Expected signs | Coefficient estimate | P>|z| | 95% Conf. Interval | |
|---|---|---|---|---|---|---|
| U.S. Corn Export Price | $\alpha_1$ | - | -5.89 | 0.000 | -8.10 | -2.73 |
| U.S. Soybean Export Price | $\alpha_2$ | + | 3.85 | 0.084 | 0.94 | 8.22 |
| Importing Countries GDP | $\alpha_3$ | + | -0.22 | 0.357 | -0.69 | 0.25 |
| Real Exchange Rate | $\alpha_4$ | - | 0.51 | 0.029 | 0.05 | 0.97 |
| Pig Inventory | $\alpha_5$ | + | -0.73 | 0.013 | -1.32 | -0.15 |
| Poultry Inventory | $\alpha_6$ | + | 1.23 | 0.001 | 0.50 | 1.96 |
| Constant | $\alpha_0$ | N/A | 22.09 | 0.000 | 12.86 | 31.31 |

The result for price of soybeans as a substitute commodity is statistically significant

and has positive sign that confirms the anticipated result showing a direct relationship with

U.S. corn exports. This cross price elasticity shows that a 1% increase in price of soybean

would result in 4% increase in corn demand, which is higher than expected. The income

elasticity is statistically insignificant, though not of the expected sign. The exchange rate

coefficient is statistically significant; with a positive sign.

The size of the importing country's pig inventory is statistically significant, but has

an unexpected negative sign. The poultry inventory coefficient has the expected positive

sign and is statistically significant. A 1% increase in the quantity of poultry would increase

demand for imported corn by 1.23% in these importing countries, which is elastic.

Based on the Hausman test statistics for the soybean model we reject the H0 at the

5% significant level. Therefore, the fixed effects model fits the data better than the random

effects model.    To confirm that there is no presence of heteroscedasticity and

autocorrelation in the model, tests were performed and the resulting F statistic was 0.18,

p=0.98 for heteroscedasticity, and F statistic was 5.51, p=0.14 for autocorrelation; therefore, the H0 was not rejected and concluded data does not have heteroscedasticity nor autocorrelation.

Table 6 Estimated U.S. Export Demand Function for Soybeans

| Variable | Parameter | Expected signs | Coefficient estimate | P>\|z\| | 95% Conf. Interval | |
|----------|-----------|----------------|----------------------|---------|------|------|
| U.S. Soybean Export Price | $\alpha_1$ | - | 4.30 | 0.006 | 1.27 | 7.32 |
| U.S. Corn Export Price | $\alpha_2$ | + | 1.05 | 0.512 | -2.14 | 4.25 |
| Importing Countries GDP | $\alpha_3$ | + | 0.11 | 0.701 | -0.44 | 0.65 |
| Real Exchange Rate | $\alpha_4$ | - | 0.80 | 0.098 | -0.15 | 1.73 |
| Importing Countries Pig Livestock | $\alpha_5$ | + | 6.89 | 0.000 | 3.94 | 9.81 |
| Importing Countries Poultry Livestock | $\alpha_6$ | + | 0.53 | 0.267 | -0.42 | 1.47 |
| Constant | $\alpha_0$ | N/A | -150 | 0.000 | -195 | -105 |

The parameter estimates for the U.S. soybean price model confirm that most of the coefficients have the anticipated signs with the exception of price of soybeans and exchange rate. The coefficients for price of corn, foreign GDP, and poultry are not statistically different from zero. Similar to the corn model, the functional form that was used was log-log so coefficients are elasticities. The estimated coefficient for soybean price, own price, is statistically significant but does not have the expected sign. The result for the price of corn as a substitute commodity is statistically insignificant, and has a positive sign that confirms expectations.

The GDP coefficient is statistically insignificant. The exchange rate coefficient is significant, but has an unexpected sign.

The pig inventory in the importing country has an expected positive sign and it is statistically significant. A 1% increase in the pig stock increases demand for imported

soybean by 7% in the importing countries. However, the poultry coefficient is statistically

insignificant.

**CHAPTER 6: CONCLUSIONS AND IMPLICATIONS**

This chapter starts with a summary of the study, followed by a discussion of the general conclusions from the estimation results presented in Chapter 5. The general conclusions lead to the implications, including economic and agribusiness implications. In agribusiness implications, issues regarding policies and promotion programs for corn, soybean and ethanol production, and marketing strategies are addressed. Last, suggested future research areas are listed as extensions or modifications to overcome limitations of the current study.

**6.1. Summary:**

In this study, we empirically estimated the export demand function of U.S. corn and soybeans to the top four export destinations: China, Japan, European Union, and Mexico. A log-linear, panel data equation was used to estimate the U.S. corn and soybeans export demand function. Data for the U.S. and its top four importer countries were gathered for the 1980-2012 period. A Hausman test showed that a fix effects estimator is better for the estimations.

During the last thirty-two years, world corn and soybean trade patterns have experienced a dramatic change. The U.S. went from holding 80 percent of world export market now down to 30 percent due to increased competition from Brazil and Argentina as major rivals in the market, increase domestic use particularly in ethanol production. This study explores the underlying factors behind these changing export levels. The objective was to evaluate the role of the U.S. in production and export of corn and soybeans in the world, as well as to identify the most important factors affecting the variations in U.S. exports by establishing an export demand function in the studied period, and exploring the

U.S. market share and drawing reliable conclusions and implications based on the model for future policy making, marketing strategies, and agribusiness applications. Given the above objective, the evolution of the U.S. corn and soybean industry was reviewed, in contrast with Brazil and Argentina and other important producers. Then the export market situation was discussed by illustrations of loss and gain of market share for the U.S.

**6.2 Conclusion:**

Own price, cross price, income and exchange rate elasticities were estimated econometrically. Elasticity analysis indicates that the U.S. corn demand is highly elastic to own price, cross price, and poultry inventory, and these coefficients had the correct sign. The positive cross price elasticity revealed that corn and soybeans were substitutes in these countries. Estimation results in table 5 show that corn's own-price has a negative effect on the amount demanded by international markets, and it is estimated as -5.4. While cross-price, foreign GDP's and foreign poultry inventory are affecting the quantity demanded positively, and their elasticities are estimated as 3.85, 0.51, and 1.23, respectively. These results answer the first objective.

Estimation results for soybean demand were not consistent with expectations. The elasticity analysis for the U.S. soybean export demand showed elastic own price, cross price, real exchange rate and pig inventory, while inelastic in foreign income, and poultry inventory. Estimation results in table 6 show that most of the coefficients have the anticipated signs with the exception of soybeans' own price, and real exchange rate.

**6.3. Implications:**

This section describes the implications of the thesis based on the conclusions drawn from the model and the research done. It is separated into two sections, which are

economic and agribusiness. It tells the readers how these results may be used in future policy making and agribusiness applications.

### 6.3.1. Economic Implications:

As shown in table 5 and 6, U.S. corn and soybean export demand own-price, cross price, poultry inventory in case of the corn, and pig inventory in case of soybean are highly elastic. A one percent change in own price, and cross price will cause the export demand quantity to change more than one percent. This could provide policy makers and economists a base to design future corn and soybean policies to stimulate demand in both domestic and international markets.

### 6.3.2. Implications:

From this thesis, especially because corn price shows it is highly elastic then by capacity utilization that is, increase supply and lowering the price a little bit, by increasing grain production U.S. exporter can increase export market share and take business from rivals. The export demand elasticity is elastic, so increasing U.S. production will increase total export revenue. There are suggestions on ways to increase U.S. grain sales. For example, imposing better regulation to increase the quality of corn and soybeans, such as increasing the protein level of soybeans. In this case a benefit-position strategy, that is, offering products with a higher quality to benefit consumers, would be the preferred choice. Or controlling the use of corn in the production of ethanol by reducing mandates that encourage corn use in ethanol.

In addition, the U.S. can use its higher technology and productivity and better managerial skills to produce corn and soybeans with a lower per unit cost, or provide export subsidies to farmers and exporters, to be more competitive with respect to its

rivals in regards to price. In this case, corn and soybeans producers and exporters can choose a cost-position strategy and provide corn and soybeans cheaper to international markets. These factors would help the U.S. increase market share among the top leading nations in international markets, and could help keep the U.S. as the major player in the international markets as in the past several decades.

Corn use in ethanol production is a short-term phenomenon because in the long run there will likely be more efficient ingredients for biofuels. Currently ethanol use is drawing U.S. corn away from international markets. Yet there are faster growing grain markets outside of the U.S. in the next 10 to 20 years that come from economic development and consequent higher income of the rural populations moving to cities, and the growing middle-class families worldwide, where there will be a higher demand for corn and soybeans. Therefore, the U.S., as the major producer of corn and soybeans, needs to prepare itself to reach these international markets; that is to raise its market share and earn higher profits for farmers in the future.

Increasing market share is the key to having concentration and market power, and exercising favorable pricing policies through higher concentration and product differentiation that allows the U.S. to raise barriers to entry for new entrants. This will provide the U.S. with price policy strategic options in times of changes in demand conditions and market fluctuations.

Corn and soybeans markets and applications change over time. This research is not only beneficial for economists, researchers, and long-run policy makers but also for producers in that they can adjust their production in order to maximize their profit level using the above results. Overall, for better prosperity of U.S. farmers and exporters, and

in order to increase market share in international markets, U.S. corn and soybean producers need to take advantage of the advanced technology and higher managerial skills for greater food quality standards and more competitive prices, compared to rivals in the international markets. The U.S. can achieve this by implementing the required regulations and standards for higher quality of products and better organization of post-harvest activities, along with probably considering export-tax subsidies, and making the processes and transactions smoother.

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