WORLD MARKETS OF VERTICALLY DIFFERENTIATED AGRICULTURAL
COMMODITIES:
A CASE OF SOYBEAN MARKETS

by

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B.A., Toyo University, 2004
M.S., Kansas State University, 2008

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
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Abstract

This dissertation presents the development of a new approach to include the interaction of vertically differentiated products, a subject that has been largely ignored in previous studies, to analyze the market power of exporters and importers in the world markets of agricultural commodities. Three theoretical models, a residual demand elasticity (RDE) model, a residual supply elasticity (RSE) model, and a two-country partial equilibrium trade model, are developed, and the corresponding empirical models are specified for U.S.-Japan soybean trade. Genetically modified (GM) and non-genetically modified (non-GM) soybeans are vertically differentiated products in the sense that GM soybeans are largely defined as an inferior substitute to non-GM soybeans. I compare two versions of these models: a new approach in which the interaction between non-GM and GM soybeans is taken into account and the traditional approach in which the interaction is ignored.

In each of the three models (the RDE model, the RSE model, and the partial equilibrium trade model), the traditional approach overestimates the market margin of U.S. non-GM soybean exporters and that of Japanese non-GM soybean importers. By considering the interaction between non-GM and GM soybeans, the new approach greatly reduces the estimates of the corresponding market margins of U.S. exporters and Japanese importers to improve the accuracy of such estimates. The statistical significance of the coefficient estimate of the interaction term, the U.S. GM soybean price or the Japanese GM soybean price, in all three models suggests that the new approach, which includes the interaction between non-GM and GM soybeans, is necessary and preferred.

The partial equilibrium trade model includes both an RDE equation and an RSE equation in a system to address the possible contemporaneous cross-equation correlation. Thus, the

estimation results of the partial equilibrium trade model are further improved, compared to those of the RDE model and the RSE model. Using the traditional approach to estimate the partial equilibrium trade model, I find that the U.S. non-GM soybean exporters' market margin is 56.5% and the Japanese non-GM soybean importers' market margin is 16.1%. However, the results obtained by using the new approach show that the market margins of U.S. exporters and Japanese importers are 33.2% and 6%, respectively. By taking into account the interaction between non-GM and GM soybeans, the new approach improves the accuracy of the estimates of market margins of soybean exporters and importers. U.S. non-GM soybean exporters do have a significant market margin in international markets, but it is not as large as the one suggested by the traditional approach. Although Japanese non-GM soybean importers enjoy some market margin, it is relatively small.

The theoretical and empirical models and results in this dissertation provide new and more accurate estimates of residual demand and supply elasticities and market power and improve the understanding on world soybean markets. These results can be useful for industry participants in international soybean markets, academic researchers, and policy makers.

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Dedication

Dedicated to my parents,

Hideo and Harue Yamaura.

Chapter 1 - INTRODUCTION

1.1 Problem Identification

World agricultural commodity trade flows have changed dramatically during the last decade. On the production side, major agricultural commodity producing countries such as the United States (U.S.), Brazil, and China started and expanded the production of genetically modified (GM) crops. On the consumption side, world demand for agricultural commodities has been increasing significantly, mostly due to higher incomes in developing countries and world population growth. The production and trade of GM crops may help meet the increasing world demand, but some consumers are concerned about the potential risks associated with GM crops. A number of countries have imposed various restrictions on the imports of GM products. The European Union (EU) is one of the world's largest agricultural commodity importers, but it places very tight regulations on the imports of GM agricultural commodities. EU consumers are very sensitive about the use of genetically modified organisms (GMOs) in agricultural and food products. For instance, "the average premium for non-genetically modified (non-GM) soybeans and meal is a tolerance of 1% presence of GM material in 2002-03" (Brookes 2004, p.4). Another major importing country with strict policies for GMOs is Japan. Japan has very strict labeling rules and a tolerance of a maximum 5% presence of GM material for soybeans imports. Japan also limits the use of GMOs for direct human consumption, except for vegetable oils.

Market power may exist in the world markets of agricultural commodities due to high market concentration, barriers to entry, product differentiation, or state trading behaviors. The existence and degree of the market power have important implications for world agricultural producers, consumers, and governments. Numerous studies have examined and measured the

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degree of market power in the markets of commodities and other agricultural/food products[1]. However, the interaction between two vertically differentiated goods − traditional non-GM commodities and GM commodities − was not taken into account in previous studies. For any type of agricultural commodity, the non-GM commodity and the GM commodity are vertically differentiated in the sense that, if the prices of the two goods are the same, all consumers will generally prefer the non-GM commodity. The demand for one good depends on not only its own price, but also the price of the other vertically differentiated good. If a trader or an agricultural producer supplies both the non-GM and the GM commodity, he or she will set the pricing strategies for the two commodities jointly rather than independently. Failing to include the interaction between the two vertically differentiated goods can result in incorrect measures of exporters' or importers' market power in world commodity markets and misleading policy and welfare implications.

1.2 Objectives

This dissertation addresses this gap in the literature by explicitly including the interaction between non-GM soybeans and GM soybeans in an analysis of the market power of exporters and importers in world soybean markets. I first develop a conceptual model that extends the Goldberg and Knetter (1999) approach to incorporate the interaction between non-GM and GM soybeans in the world demand and supply functions of the two goods. Then, I conduct an empirical estimation on U.S.-Japan soybean trade based on the conceptual model.

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[1] Carter et al. (1999), Yang and Lee (2001), Cho et al. (2002), Saghaian and Reed (2004), Poosiripinyo and Reed (2005), Song et al. (2006), Andersen et al. (2008), Felt et al. (2010), Mulik and Crespi (2011), and Yamaura (2011) measure the degree of market power in the trade of agricultural and food products.

The U.S. residual demand function and Japan's residual supply function are specified and estimated to obtain the corresponding residual demand and supply elasticities for non-GM soybeans. The estimation results are then used to calculate the market power of U.S. exporters or Japanese importers in international soybean markets. For purposes of comparison, the same data set will be used to conduct a second estimation based on a traditional model that does not include the interaction of non-GM and GM soybeans. The results from the two models are compared to determine how a lack of consideration for the interaction between two vertically differentiated products (non-GM and GM soybeans) affects the elasticity estimates and the measures of market power in world soybean markets.

1.3 Organization of Chapters

The remaining chapters are organized as follows. Chapter 2 provides background information on product differentiation and the structure of non-GM and GM crop industry. Chapter 3 outlines studies of imperfect competition in international markets. The methodology and data are described in Chapter 4 and 5, respectively. Chapter 6 discusses the results of the empirical analysis. Finally, conclusions are presented in Chapter 7.

Chapter 2 - PRODUCT DIFFERENTIATION AND THE INDUSTRY STRUCTURE

This chapter provides background information on product differentiation and the industry structure of non-GM and GM crops. The first part of the section defines product differentiation, and the second part of the section provides an overview of the relevant literature in empirical studies of vertically differentiated products. The third part of the section provides overviews of producing and consuming countries' attitudes toward biotechnology. Lastly, an overview of studies for non-GM and GM crops is provided.

2.1 Definition

There are three types of product differentiation: 1) vertical differentiation, 2) horizontal differentiation, and 3) mixed differentiation. Vertical differentiation "occurs in a market where the several goods that are present can be ordered according to their objective quality from the highest to the lowest. It's possible to say in this case that one good is 'better' than another" (Piana 2003, p.3). Horizontal product differentiation is defined as products that differ by features which cannot be ordered in an objective way. Features for horizontally differentiated products are often based on colors, styles, or tastes (Piana 2003). Hotteling-type location[2] models illustrate the idea of horizontal differentiation.

Mixed differentiation is characterized by both vertical and horizontal differentiation. Thus, products of mixed differentiation have different quality levels as with vertical differentiation and also have different characteristics such as shapes, taste, style, or color, as with

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[2] Hotteling (1929) developed a location model that demonstrates the relationship between location and firm's pricing behavior.

horizontal differentiation. In this case, consumers consider both quality levels and characteristics

of goods when making their purchasing decision.

For sources of product differentiation, Tirole (1988, p.306) indicated that "incumbents

may have patented product innovations, or they may have cornered the right niches in the

product space, or they may enjoy consumer loyalty." Carlton and Perloff (2005) listed two

approaches that are frequently used for the estimation on markets of differentiated products: a

demand system and a choice experience model. The first approach involves estimating a system

of demand functions with possible restrictions on model parameters. In a choice experience

model, each product's market share is specified as a function of product characteristics and

prices. The estimation is conducted using a traditional logit or the more general random

parameter logit model (Carlton and Perloff, 2005).

2.2 Empirical Studies on Agricultural Commodities

Lavoie (2005) developed theoretical and empirical models to examine price

discrimination in the wheat industry based on the Mussa and Rosen (1978) model. In the study,

wheat is a vertically differentiated intermediate good, and international wheat trade is

characterized by the presence of state-trading enterprises. Lavoie (2005) showed that price

differences are not fully explained by elements under perfect competition in any two markets.

Those elements are a difference in grade or protein content, a difference in handling and shipping

cost in each Canadian port or a difference in scarcity rent. Lavoie concluded that "the Canadian

Wheat Board pricing strategy is more complex and dynamic than the prescription for static

optimization derived in this study" (Lavoie 2005, p.851).

A study by Eales and Binkley (2003) examined consumer demand in a baking mix

market, which bears a strong resemblance to a theoretical model of a vertically differentiated

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product using a linear approximate almost ideal demand system (LA/AIDS). There is no price competition in the theoretical model of vertical differentiation. The authors discovered that there is price competition in an empirical analysis, but it is not strong. They pointed out that two major baking mix firms have used different marketing strategies to occupy widely different points on the quality scale. This behavior has led to market equilibria with very little price competition. They concluded that the empirical evidence of the baking mix market validates the conclusions of the theoretical models.

2.3 History of Non-GM and GM Products

Since 6 countries (Argentina, Australia, Canada, China, Mexico, and the U.S.) first planted biotech crops in 1996, the number of such biotech-crop-producing countries has increased to 29 in 2011. Figure 2.1 shows the global area of biotech crops from 1996 to 2011. The global area of biotech crops has been increasing since 1996, and it reached 160 million hectares (Mha) in 2011. Table 2.1 shows a planted area of biotech crops in 2011 by country. The top 10 countries with more than one million hectares in 2011 are the U.S. (69 Mha), Brazil (30.3 Mha), Argentina (23.7 Mha), India (10.6 Mha), Canada (10.4 Mha), China (3.9 Mha), Paraguay (2.8 Mha), Pakistan (2.6 Mha), South Africa (2.3 Mha), and Uruguay (1.3 Mha) (James 2011). However, the planted areas in the other 19 countries[3] in 2011 were smaller than before (James 2011).

James (2009) summarized the shares of biotech-herbicide-tolerant crops in 2009. GM soybeans were the most planted biotech crop in the world and accounted for approximately 52%

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[3] The 19 countries that plant GM crops are Bolivia, Australia, Philippines, Burkina Faso, Myanmar, Spain, Mexico, Colombia, Chile, Honduras, Portugal, Czech Republic, Poland, Egypt, Slovakia, Costa Rica, Romania, Sweden, and Germany.

of the global biotech crop area. GM maize was the second most planted crop, with 31% of the

global biotech crop area, followed by GM cotton (12%) and GM canola (5%).

Figure 2.2 shows the GM soybean cultivation area by acreage globally and for the top

three producing countries. In 1997, around five million hectares of globally planted soybeans

were categorized as GM soybeans. Over a five-year period, GM soybean technology was

quickly adopted by many soybean farms, and by 2003, more than 40 Mha was designated for

GM soybeans. By 2009, the acreage of GM soybeans was close to 70 Mha. The U.S. is the

largest GM soybean-producing country, and about 30 Mha of GM soybeans were produced in

the U.S. in 2009. Argentina is the second largest GM soybean-producing country, with about 20

Mha planted in 2009. Since 2005, Brazil has been the third largest GM soybean-producing

country and planted approximately 15 Mha in 2009. Therefore, approximately 60% of the global

GM soybeans were produced in the U.S., Argentina, and Brazil in 2009.

2.3.1 Attitudes toward Biotechnology − The Production Side

In this section, I discuss the biotech policies and the history of major GMO-producing

countries. The U.S., Brazil, Argentina, and China are the top four GMO-producing countries.

Song (2006) summarized the biotech policies of top GMO-producing countries in 2004 to

analyze soybean markets. The U.S. Department of Agriculture − Economics Research Service

(USDA-ERS) is a good information source of biotech policies.

U.S.

Since it adopted GMO technology in 1996, the U.S. has led world agricultural

biotechnology in product, adoption, commercialization, and exports (Song 2006). In 2011, U.S.

biotech varieties included soybean, maize, cotton, canola, sugar beet, alfalfa, papaya, and squash

(Table 2.1). The USDA-ERS reported that U.S. farmers expected lower production costs,

expected higher yields, reduced herbicide use from planting GM crops, and adopted biotech

commodities immediately after they were available in 1996 (USDA-ERS 2004). As the U.S.

GM commodities expanded, so did the variety of U.S. biotech agricultural products and

genetically engineered (GE) traits for herbicide tolerance (HT) and insect resistance (Bt). Some

examples of U.S. biotech commodities shares are 93% of HT soybeans, 78% of HT cotton, 73%

of Bt cotton, 70% of HT corn, and 63% of Bt corn (USDA-ERS 2011). In 2010, the U.S. was

the largest producer of biotech crops, and it accounted for over 48% of world production (James

2010). China, Japan, and Mexico were major importing countries of U.S. soybeans.

Brazil

Although the Brazilian government did not allow the adoption and commercialization of

biotech commodities before 2003, biotech commodities, mainly soybeans, were illegally planted

on a large scale. In 2003, the government officially approved the planting of GM soybeans in

Brazil (James 2005). Bt cotton was first planted in 2006, and biotech maize was planted in 2007.

In 2011, Brazilian biotech varieties included soybean, maize, and cotton (Table 2.1). Brazil was

the second largest soybean producing country in 2011. The major destination for soybean grain

was China, Europe for soybean meal, and Iran and India for soybean oil and vegetable oil (James

2009). James (2010) reported that Brazil has retained the second largest grower position of GM

crops in the world and had the largest absolute increase in production from 2009 to 2010. Brazil

plants approximately 17% of all the GM crops in the world (James 2010).

Argentina

Argentina had one of the earliest biotech soybean field trials in 1986. Argentina has

grown GM soybeans and has had the highest GM soybean adoption rate since 1996. Bt cotton

and maize were first planted in 1998. Almost all (99%) of the soybeans planted in 2005 were

GM varieties (James 2005), and an estimated 83% of the maize and 95% of the cotton planted were GM varieties in 2009. Argentina is a major competitor in the international soybean market (Figure 2.2). In 2011, Argentinean biotech varieties included soybean, maize, and cotton (Table 2.1). In 2010, Argentina had 22.9 Mha of biotech crops and 19.5 Mha were planted for GM soybeans and 3 Mha were planted for GM maize. Argentina had the highest GM crop adoptions in 2010. GM soybean adoption rate is 100%, and the rate of GM maize is 86%.

China

In China, Bt cotton was the dominant GM commodity in 1997, and no other food GM commodities were approved for production before 2001 (Marchant et al. 2002). The national adoption rate for Bt cotton was 68% in 2009. In addition to cotton, the other biotech varieties produced in China are papaya, poplar, tomato, and sweet pepper (Table 2.1). In 2009, China approved biotech rice and maize. This approval in China is "the most important biotech development" (James 2010, p.96) for China, Asia, and the world, because "rice is the most important food crop and maize is the most important feed crop in the world" (James 2010, p.96).

Canada

Canada is one of six biotech crop founding countries. GM canola was first planted in 1996, and the national adoption rate for GM canola was 94% in 2010 (James 2010). Only 1% of planted canola in 2010 was conventional canola, and the remaining (5%) was planted to become mutation-derived GM canola. Since 2008, Canada has planted GM sugarbeets. Ninety-five percent of the total plantings of sugar beets were biotech sugarbeets in 2010 (James 2010). Two other major biotech crops, soybeans and maize, represented over 60% of total plantings in 2006. Canadian biotech varieties include canola, sugarbeets, maize, and soybeans (Table 2.1). Canada retained its position as the fifth largest biotech crop-planting country in the world in 2010.

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India

In India, Bt cotton was the first planted a GM commodity in 2002. James (2010) reported that India had been the second largest cotton-producing country since 2006, and adoption of Bt cotton resulted in a representation of 86% of the total cotton planted in India in 2010. The acreage of Bt cotton has increased by 188 times in 9 years so that "Bt cotton had transformed cotton production in India by increasing yield, decreasing insecticide applications, and, through welfare benefits, contributed to the alleviation of poverty for more than 6 million small resource-poor farmers in 2010" (James 2010, p. 45). Indian biotech varieties were cotton and rice in 2011 (Table 2.1).

2.3.2 Attitudes toward Biotechnology − The Consumer Side

The U.S., the leading biotech producing country, does not require any mandatory labeling for its biotech food products. However, the top three soybean importing countries, China, EU, and Japan, require that all food products containing biotech contents must be labeled (Marchant et al. 2002).

China

When China joined the World Trade Organization (WTO) in 2001, the Chinese government implemented several regulations for biotech crops such as biosafety administration, biosafety evaluation, import safety, and labeling administration for agricultural biotech products. The specific rules on importing biotech products based on the regulations include the following: 1) Test results from in-country field experiments in the exporting country are required for imported biotech products for human consumption, 2) Identity Preserved (IP) handling certificates are required for imported biotech commodities, and 3) all biotech products must be labeled.

The approval of biosafety for biotech rice and maize in 2009 would greatly affect the interests of not only global agriculture-producing countries but also Chinese consumers. The potential benefits of these crops for China are also enormous (James 2009).

EU

The EU has strict labeling rules for biotech products. However, some countries in the EU have planted GM crops. In 2011, eight EU countries planted biotech crops. Six EU countries − Spain, Portugal, Czech Republic, Poland, Slovakia, and Romania − planted Bt maize, and three EU countries − Czech Republic, Sweden, and Germany − planted GM potatoes. However, no country planted GM soybeans.

On the import side, EU regulations on GM food and feed[4] provide a general framework for GMO regulations. The EU initially imported only soybeans with a zero tolerance for traces of biotech varieties. After encountering many difficulties, EU now accepts soybean imports with up to 0.9% of approved GM material (Aramyan et al. 2009). This regulation provides rules for the labeling of GM products and "a threshold for the presence of GM material that is adventitious or technically unavoidable" (European Commission[5]). Austria, France, Greece, Hungary, Germany, and Luxembourg are currently applying safeguard clauses on GMO events (European Commission).

Japan

Seven biotech crops (alfalfa, corn, cotton, potato, rapeseed, soybean, and sugarbeets) and six food additives (α-amylase, chymosin, glucoamylase, lipase, pullulanase, and riboflavin) are

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[4] The Regulation 1829/2003 on genetically modified food and feed.

[5] For more detailed information on GMO policy in EU, see Food and Feed Safety, European Commission. http://ec.europa.eu/food/food/biotechnology/evaluation/gmo_nutshell_en.htm.

permissible for food consumption in Japan (Ministry of Health, Labour and Welfare 2011). The main characteristic of these GM crops is resistance to herbicides, and these GM food additives are used to produce processed foods. Since 2001, Japan's Ministry of Agriculture, Forestry and Fisheries (MAFF) has required labeling of GM crops and products, including seven crops and 32 groups of processed food products in Japan (Ministry of Health, Labour and Welfare 2011).

Yamaura (2011) summarized the Japanese soybean consumption and non-GM soybean trade. In the 1990s, GM soybean consumption became a widely debated topic in Japan. Then Japanese consumers drove the debate by purchasing more non-GMO products (Yamaura 2011). These Japanese consumer behaviors were influenced by the Japanese food culture, in which soybeans are a staple in many Japanese foods and dishes. Tofu and natto, ethnic Japanese foods of fermented whole soybeans, are examples of typical soybean foods. In 2000, all manufacturers of soy products completed the shift to using only non-GM soybeans for tofu and natto production in Japan. Japan imports soybeans using two major shipping methods: bulk shipments and container shipments. Container shipments have become more popular in 2010 for shipping specialty soybeans[6] from the U.S. to Japan and are particularly useful in shipping IP-handled soybeans. These containers enable Japanese importers to keep their shipments of GM soybeans for oils and livestock feeds separated from non-GM soybeans for human consumption (Yamaura 2011).

Non-GM and GM are vertically differentiated products. If the prices of both type of product are the same, worldwide consumers prefer non-GM soybeans to GM soybeans because of quality concerns. However, due to the lower prices of GM soybeans, most countries[7] choose

[6] Specialty soybeans are all non-GM soybeans.

[7] These countries include China, the largest soybean importing country, and Mexico, the fourth largest soybean importing country.

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to import and consume GM soybeans. This is not the case for either EU or Japan. Given the current price difference between non-GM and GM soybeans, EU and Japanese consumers strongly prefer non-GM soybeans and are willing to pay premium prices for these commodities (James 2010).

2.4 GM Soybean Share in Producing Countries

Figure 2.3 shows GM soybean shares of total soybean acreage of the world and three countries. In 1996, the world GM soybean share was less than 20%; since then, however, there has been rapid adoption of GM soybeans around the world. The world GM soybean share reached 50%, 60%, and 70% in 1998, 2001, and 2008, respectively. In 2009, the world GM soybean share was close to 80% of total soybean production. Only three years after the introduction of GM soybeans in the U.S., the GM soybean share in the total U.S. soybean production was over 50%. Argentina is one of the countries with the largest and most rapid GM soybean adoption rate. In 1997, more than 40% of Argentina's total soybeans were GM soybeans. At present, Argentina soybeans are almost all GM soybeans. Brazil started the commercial production of GM soybeans in 2003. GM soybeans represented more than 70% of all soybeans in 2008.

Table 2.2 shows GM soybean acreages and GM soybean ratios of many countries and the world. In the world, the acreage of GM soybeans accounted for only 7.6% of total soybean acreage in 1997. After 12 years, the world GM soybean percentage became 77%. In the U.S., the GM soybean ratio increased from 4% in 1997 to 91% in 2009. A similar increase in the share of GM soybean acreage occurred in many other countries.

2.5 Studies for GM and Non-GM Crops

Researchers have focused on the welfare effects of GM product labeling. Fulton and Giannakas (2004) investigated the effect of a ban on GM products in markets with heterogeneous producers and consumers. Giannakas and Yiannaka (2006) extended the analysis to include organic, GMO, and conventional food products to analyze the effects of the labeling of organic products on consumer welfare. Veyssiere and Giannakas (2006) found GM labeling regimes in countries depended on five issues: the distribution of consumer preferences, the size of the segregation and labeling costs, the relative productive efficiency, the market power of companies, and the strength of intellectual property rights. Giannakas and Yiannaka (2008) analyzed the case of consumer-oriented GM products as second-generation GM products to determine the corresponding welfare effects on consumers. Lassoued and Giannakas (2010) examined the implications of a mandatory labeling regime.

Moschini et al. (2000) developed a world trade model with three regions, the U.S., South America, and the rest of the world, to evaluate the welfare effects of the adoption of GMO, especially Roundup Ready (RR) soybeans, in the soybean complex using calibration techniques with assumed parameter values of soybean trade, such as supply and demand elasticities and RR seed price mark-up. They focused on a GM soybean innovator-monopolist case with a large number of competitors, both in the home country and importing countries. Sobolevsky et al. (2005) extended the Moschini et al. (2000) study by separating two South American countries: Argentina, which is an early adopter and had the world's highest adoption rates of RR soybeans in 2003, and Brazil, which has not permanently authorized the use of GM soybeans[8].

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[8] Brazil did not permit production of GMO at the time of the Sobolevsky et al. (2005) study.

Lapan and Moschini (2001, 2004) built a two-country partial equilibrium model (the U.S. as the home country and Europe as the importer) to analyze the implications of the introduction of GM products. The U.S. has a monopolist seed supplier, and U.S. consumers are indifferent toward the difference between non-GM and GM products, while EU consumers treat GM products as inferior substitutes for non-GM products.

Saunders and Cagatay (2003) simulated various scenarios for the impact of GM food production on producers, consumers, and trade in New Zealand. They used the Lincoln trade and environment model to quantify both global and regional effects on farmers who adopt GM biotech and consumers who change their preferences related to GM products. Saunders and Cagatay (2003) summarized eight studies that focus on trade impacts of GM products and use partial equilibrium or general equilibrium models with calibration problems[9]. Saunders and Cagatay (2003) found that the estimation results of various scenarios are consistent with these findings, such as a rise in GM-free imports into Japan or EU and a fall of GM imports from the U.S. They concluded that the results that markets in Japan and EU have such an influence on world and New Zealand trade are not surprising. The results also indicated that Japanese and EU consumers are very sensitive to GM products and prefer to consume GM-free products.

Konduru et al. (2009) focused on the separation of non-GM and GM products. IP systems are used to separate non-GM and GM crops through relevant supply chains and export markets. Analysis of GMO testing is widely used for IP systems analysis. GMO testing is used in the field to detect the presence or confirm the absence of certain GM crops (Konduru et al. 2009). The authors examined the implications of measurement uncertainty in GMO testing on

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[9] Saunders and Cagatay (2003) argued that calibration problems arise as one of the main issues at this level of disaggregation in the general equilibrium analysis.

the behavior of importers and exporters. They concluded that the direct impacts on the behavior of importers and exporters come from 1) relative size of IP costs and testing and rejection costs, 2) premium prices offered in the non-GM markets, and 3) measurement uncertainty.

Gryson et al. (2008) examined the segregation costs and benefits for non-GM and GM compound feed production in Belgian livestock products. The authors focused on the IP production costs of non-GM products and examined three different cost scenarios. They found that the extra costs for non-GM production are substantial. Gryson et al. (2008) concluded that consumers will choose the cheapest products if confronted with a price difference for non-GM and GM products.

Choi (2010) theoretically investigated the competition in markets of GM and GMO-free products to analyze the current GM restriction policies in Europe. Focusing on import quota and a ban on GM products, Choi considered two scenarios: Cournot-Nash equilibrium and Stackelberg equilibrium under free trade between the U.S. and Europe. According to Choi (2010), consumers cannot recognize GM products by visual inspection, and non-GM can only be distinguished from GM products by DNA analysis. Therefore, Choi (2010) treated these two products as perfect substitutes in the absence of labels, but close substitutes with labels. Choi's research showed that the GMO-free product price will be increased, and consumer welfare will be reduced by import quotas on GM products. In the long run, only landowners in countries importing GM products will benefit from import bans on GM products, and there are no benefits for producers of traditional non-GM products.

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Table 2.1: Harvested Biotech Crops in 2011 by Country

Rank	Country	Area	Maize	Soybean	Cotton	Canola	Sugar beet	Alfalfa	Papaya	Squash	Poplar	Tomato	Sweet Pepper	Potato
			Biotech Crops											
1	U.S.	69.0	X	X	X	X	X	X	X	X				
2	Brazil	30.3	X	X	X									
3	Argentina	23.7	X	X	X									
4	India	10.6			X									
5	Canada	10.4	X	X		X	X							
6	China	3.9			X				X		X	X	X	
7	Paraguay	2.8		X										
8	Pakistan	2.6			X									
9	South Africa	2.3	X	X	X									
10	Uruguay	1.3	X	X										
11	Bolivia	0.9		X										
12	Australia	0.7			X	X								
13	Philippines	0.6	X											
14	Myanmar	0.3			X									
15	Burkina Faso	0.3			X									
16	Mexico	0.2		X	X									
17	Spain	0.1	X											
18	Colombia	<0.1				X								
19	Chile	<0.1	X	X		X								
20	Honduras	<0.1	X											
21	Portugal	<0.1	X											
22	Czech Republic	<0.1	X											X
23	Poland	<0.1	X											
24	Egypt	<0.1	X											
25	Slovakia	<0.1	X											
26	Romania	<0.1	X											
27	Sweden	<0.1												X
28	Costa Rica	<0.1		X	X									
29	Germany	<0.1												X

Harvested area is million hectares.

Top 17 countries with harvested biotech crops more than or equal to 50,000 hectares.

Source: Modified James (2011) Table 1.

Table 2.2: GM Soybean Acreage and Ratio by Country

	Year	Cultivation Area in Million Hectares		GM Ratio %
		Total Soybean	GM Soybean	
World	1997	67	5.1	7.6
	2009	90	69	77
U.S.	1997	25.7	3.6	4
	2009	31	28.6	91
Argentina	1997	6.2	1.4	22.6
	2009	17.5	17.4	99
Brazil	1999	13	1.4*	10
	2009	23	16.2	71
Canada	1997	0.9	0.0001	0.01
	2007	1.1	0.7	62.5
Mexico	2000	0.12	0.0005	0.4
	2006	0.1	0.005	4.5
Paraguay	2004	2	1.2	60
	2009	2.6	2.2	85
Romania	1999	0.097	0.016	16
	2006	0.14	0.1	70
South Africa	2001	-	0.008	-
	2009	0.24	0.2	85
Uruguay	2002	-	0.02	-
	2007	0.47	0.47	100
Bolivia	2009	0.9	0.8	89

* 1999-2002 illegal cultivation of GM soybeans, data estimated
Source: Modified GMO Compass http://www.gmo-compass.org/

Figure 2.1: Global Area of Biotech Crops from 1996 to 2011
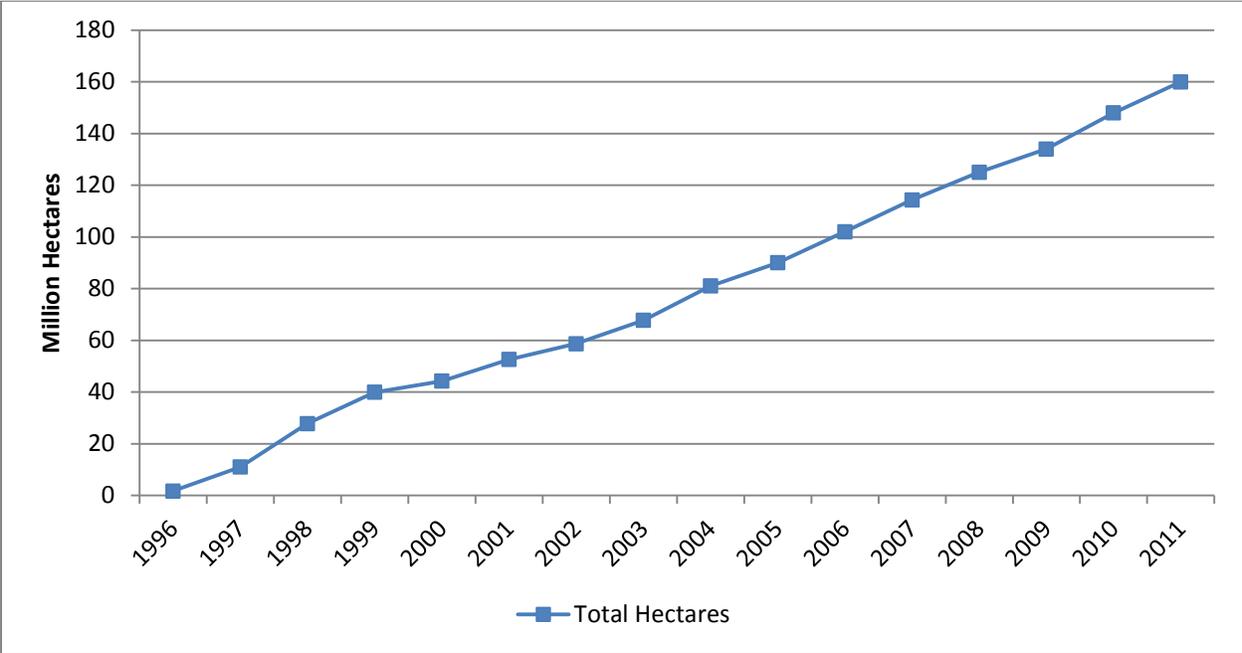
Source: Modified James (2011) Figure 1.

Figure 2.2: Global GM Soybean Cultivation Acreage in Million Hectares
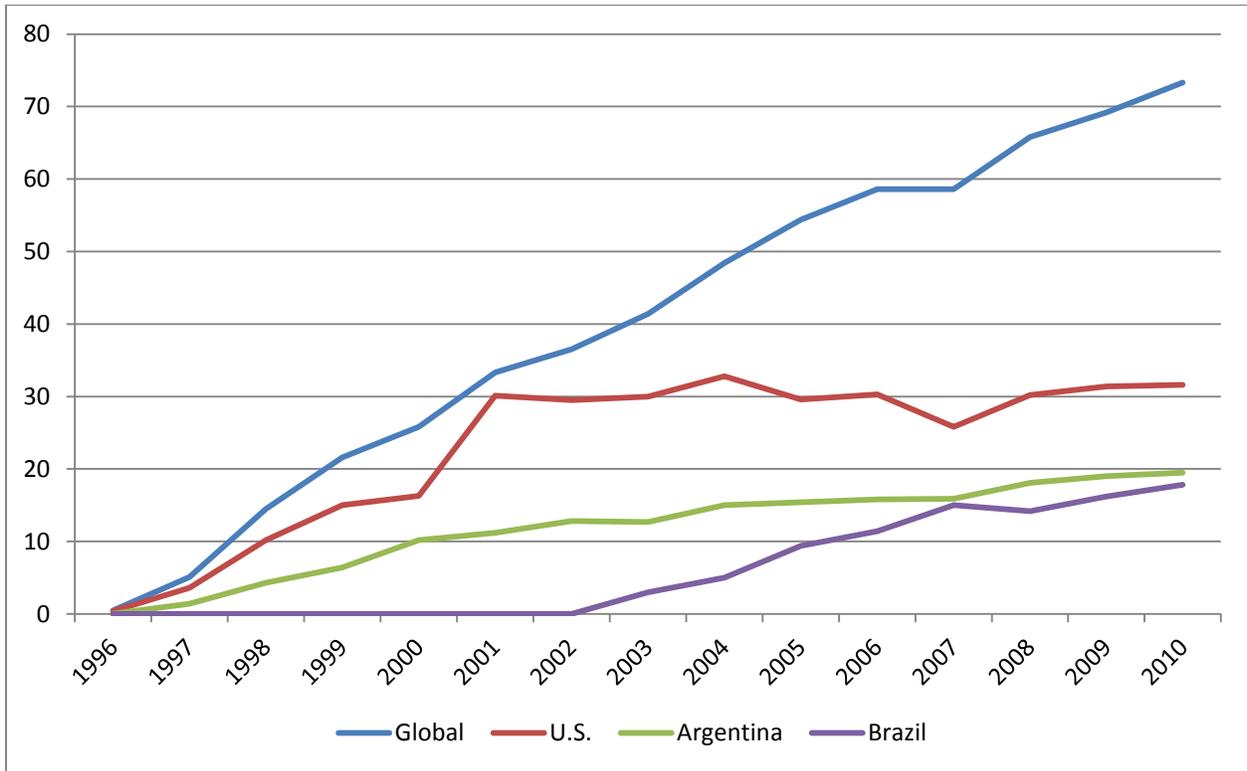
Source: James (1996-2010)

Figure 2.3: GM Soybean Share in the Total Soybean Acreage for Each Country
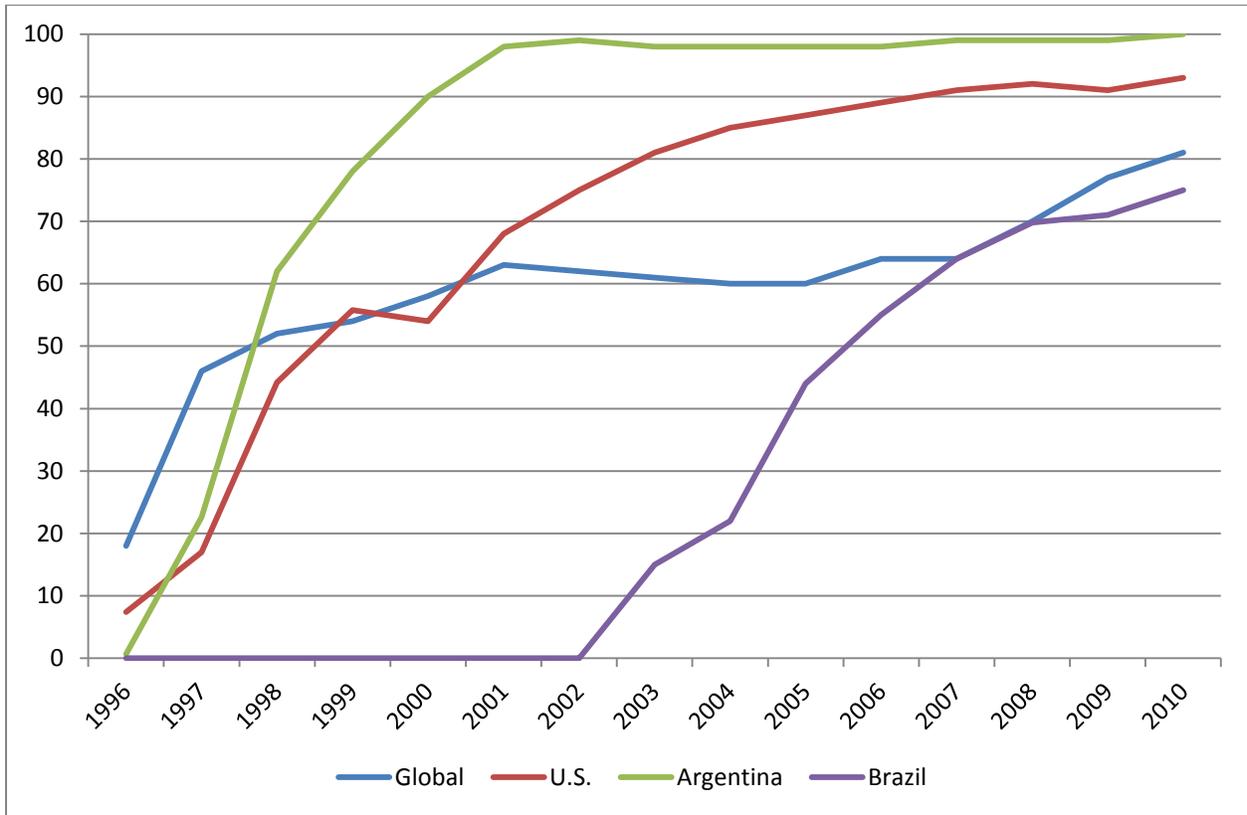
Source: James (1996-2010)

Chapter 3 - IMPERFECT COMPETITION IN INTERNATIONAL MARKETS

The first part of the chapter provides an overview of the relationship between price transmission and exchange rates in international trade. Then exporters' and importers' market power and the associated economic models are discussed. Finally, a partial equilibrium trade model is examined.

3.1 Price Transmission and Exchange Rate

Paudel et al. (2004) argued that the market mechanism and structure of international markets were affected by price transmission and exchange rate elasticities. Therefore, the authors suggested that it is important to define the relationship between international prices and domestic prices to analyze traders' responses to international price changes. Previous studies presented conflicting views on the magnitude of price transmission and the elasticity of exchange rates. Johnson (1977) assumed that there is perfect price transmission, and Bredahl et al. (1979) assumed that the price transmission elasticity for the rest of world is zero as a restricted trade minimum for the elasticity of export demand and is one as internal prices are not insulated by government policies (Bredahl et al. 1979). Pick and Carter (1994) showed an imperfect transmission process; i.e., the pass-through rate is less than one. Paudel et al. (2004) examined a consistent model using the stepwise selection criteria and concluded that "international price transmission elasticities and exchange rate elasticities for soybeans are less than one in both the short run and the long run" (Paudel et al. 2004, p.11) for U.S. soybeans sold in Japan. The authors found that the effect of transportation cost was not significant, and as a result, the

omission of transportation cost did not significantly influence the estimated price transmission elasticities and exchange rate elasticities.

3.2 Exporters' Market Power-Export Supply Function

Kang et al. (2009a) examined market power using a two-stage least squares regression (2SLS) for the world rice market. They also evaluated the effect of a four-firm concentration ratio (CR4) on rice exporters' market power. Estimation results indicated that the major rice-exporting countries had market power in international rice markets. Interestingly, the elasticity of rice export price with respect to CR4 was statistically insignificant; this implied that the market power of rice exporting countries was not significantly increasing in the market concentration.

A study conducted by Kang and Kennedy (2009) examined the effect of market power on coffee prices. They extended Bahmani-Oskooee and Ltaifa's (1992) research on the effect of the real exchange rate on export volume. Export supply functions were estimated using the instrumental variable (IV) and seemingly unrelated regression (SUR) methods. They concluded that IV and SUR yield similar results, and coffee exporting countries have some market power in international coffee markets.

3.2.1 Pricing-To-Market Model

Krugman (1986) originally developed the concept of the pricing-to-market (PTM) models to address the relationship between exchange rates and import prices. He defined the PTM model as "import prices fall 'too little' when a currency appreciates" (Krugman 1986, p. 3). After examining static and dynamic models with demand and supply functions for monopolistic price discrimination and oligopolistic cases, Krugman (1986) concluded the following:

"[E]xplaining PTM model is not as simple as one might hope. It seems clear that a perfectly competitive model will not do the trick... the best hope of understanding pricing to market therefore seems to come from dynamic models of imperfect competition..." (Krugman 1986, p.32).

Although Krugman did not provide more detailed explanations for the PTM model, he did bring the PTM model to the attention of other researchers.

Knetter (1989) contributed to the development of a specific functional PTM model associated with exchange rate fluctuation. Knetter built a PTM model based on exporters' profit maximization as:

$$lnP_{it} = \theta_t + \lambda_i + \beta_i lns_{it} + u_{it},$$

where P_{it} is the export price to destination market i at period t, s_{it} is the exchange rate in terms of the number of a destination market currency per unit of exporter currency, θ_t is the time effect, λ_i is the country effect, β_i is the elasticity of the export price with respect to the exchange rate, and u_{it} is the disturbance. Knetter's PTM model can distinguish among three different market conditions: a competitive market, an imperfectly competitive market, and an integrated market. The estimated coefficients of λ_i and β_i are used for the market conditions. In a competitive market, price equals marginal cost, and the Lerner index is zero. This means that the time effect measures the common price, no variation in the data is related to the country effect or the exchange rate, and the estimates of λ_i and β_i are zero. If the market is imperfectly competitive, then price does not equal marginal cost, the Lerner Index is positive, and the estimates of λ_i and β_i are not zero. The author stated that "U.S. export prices are rather insensitive to exchange rate fluctuations…. German export prices appear to be much more sensitive to exchange rate fluctuations" (Knetter 1989, p.209).

3.2.2 Residual Demand Elasticity Model

Baker and Bresnahan (1988) originally developed the residual demand elasticity (RDE) model to measure the market power of a single firm in an imperfectly competitive market. In a perfectly competitive market, if a firm reduces its production, other firms would increase their production to offset the shortage by the first firm's contraction. Therefore, a single firm's residual demand is infinitely elastic. The residual demand curve of a single firm is downward sloping when the market is imperfectly competitive or has product differentiation. Baker and Bresnahan specified the inverse demand function for a single firm (firm 1) as:

$$P^1 = R(Q^1, Y, W, W^1; \alpha^i, \beta^i, \theta^i),$$

where $R(\cdot)$ is the inverse residual demand function for firm 1, Y is a vector of exogenous demand shifters, W is the industry-wide factor prices, W^1 is firm 1's firm-specific factor prices, α^i and β^i are parameters, and θ^i is a vector of indexes of the oligopoly solution component for all firms. The quantities of other firms' products are represented by

$$Q^i = E^i(Q^1, Y, W, W^1; \alpha^i, \beta^i, \theta^i).$$

Goldberg and Knetter (1999) measured the market power of German beer exporters and U.S. linerboard exporters in specific destination markets based on the model of Baker and Bresnahan (1988). They estimated residual demand elasticities to derive measurements of the market power of German beer exporters and U.S. linerboard exporters in each destination country without firm-specific data. They used the exchange rate as an ideal cost shifter to investigate the market power of exporters in a specific foreign market without detailed cost shifters of their competitors. Based on a theoretical model for the general case of exporter i in a single destination, Goldberg and Knetter obtained an export price function as:

$$P^{ex} = D^{res,ex}(Q^{ex}, W^N, Z, \theta^N),$$

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where P^{ex} is the export price, $D^{res,ex}(.)$ is the inverse residual demand curve, Q^{ex} is the quantity

of exported good, W^N is a vector of all firm-specific cost shifters excluding the exporter group of

interest, Z is the vector of demand shifters in the destination market, and θ^N is the union of all

the conduct parameters (Goldberg and Knetter, 1999). Goldberg and Knetter estimated the

market margins of German beer exporters in various destination markets and found that "the

higher (in absolute value) the elasticity is, the weaker the competition German exporters face"

(Goldberg and Knetter 1999, p.51). The authors concluded that "the extent of exchange rate

variation provides a strong natural experiment for the purpose of identifying the residual demand

elasticity in each destination" (Goldberg and Knetter 1999, p.58).

Poosiripinyo and Reed (2005) discussed the advantages and disadvantages of a RDE

model. The advantages of an RDE model are thus: 1) it can measure market power with modest

data requirements, 2) it can directly estimate the elasticities using a double-log form, and 3) it

incorporates an exchange rate variable in the model as an indicator of marginal cost change. On

the other hand, it is difficult to interpret the estimated coefficients without the parameter of the

residual demand elasticity.

Carter et al. (1999) assumed that each country is a single firm, and the model parameters

could be interpreted as the share-weighted industry averages for all firms within one country.

Carter et al. analyzed the world wheat market by using an RDE model. Using the double-log

form of inverse residual demand function, Carter et al. estimated the price flexibility for the U.S.

wheat exports to Japan directly. They applied likelihood ratio tests for model selection. There

are three alternative market structure models: the competitive model, the monopsony model, and

the U.S. price leadership model. Carter et al. (1999) found that the Japanese wheat import

market was imperfectly competitive and show that U.S. exporters had a 93% market margin in Japan.

Yang and Lee (2001) compared two methods, using an RDE model as in Goldberg and Knetter (1999) to estimate price flexibilities and using a system of multinomial logit (ML) model as in Nevo (1996), to measure the price-cost markup in a study on exporters' market power in South Korean wheat and corn import markets. The results indicated that exporters had market power in the wheat import market. The market margins of U.S., Canadian, and Australian exporters were 38.4%, 14.6%, and 14.2%, respectively. However, there is no market power in the corn import market. The two approaches (the RDE model and the ML model) yielded similar results in each market.

Glauben and Loy (2003) compared the RDE model with another approach, the PTM model by Krugman (1987), in estimating the market power of German food and beverage exporters in international markets. They concluded that the two approaches produced inconsistent results: the PTM model indicates that the German food and beverage exporters have market power, while the RDE model does not. Glauben and Loy (2003) argued that this conflict is probably due to fixed contracts, which are often used in the food and beverage export market. Another study by Zhang et al. (2007) compared the PTM model and the RDE model by examining the U.S. and Brazilian soybean exporters' market power in 10 destination markets.

Cho et al. (2002) extended the RDE model by using a real exchange rate, which is obtained by deflating a nominal exchange rate using the inflation rates of exporting and importing countries. Goldberg and Knetter (1999) used a nominal exchange rate as a cost shifter. However, Cho et al. argued against the use of nominal exchange rates by stating that the "monetary authority of each country determines money supply independently, and a country

could experience a higher inflation rate than the other, which causes appreciation of the values of exchange rates" (Cho et al. 2002, p.2). Cho et al. used the real exchange rate and found that U.S. wheat exporters had large market margins in some Asian countries: 61.4% in South Korea and 83.8% in the Philippines.

Felt et al. (2010) used an RDE model to evaluate the effects of the Taiwanese pork import ban on exporters' market power in Japanese pork imports. The authors developed a duopoly case based on Goldberg and Knetter's (1999) model. Using the generalized method of moments, Felt et al. confirmed that Canadian, Danish, and U.S. exporters had market power in the Japanese pork import market. In particular, it is found that U.S. pork exporters had more market power than exporters in other exporting countries.

A study by Saghaian and Reed (2004) measured the market power beef exporters in the Japanese import markets using an RDE model. Based on the model of Goldberg and Knetter (1999), Saghaian and Reed added a time trend to their model and examined four equations, representing the four main beef exporters to Japan. Although U.S. exporters in the frozen-ribs category receive the highest market margin, Australian and New Zealand exporters also have some market power in five of the six chilled-beef categories.

Mulik and Crespi (2011) further extended the RDE model in examining the effects of the entry of GM rice for Indian and Pakistan rice exporters. They captured the impact of the entry of GM rice by including a dummy variable for entry and its interaction term. The market margins of Indian exporters in U.K. and Kuwait were 27.3% and 13.8%, respectively, before the entry of GM rice. However, the market margins dropped to 19.1% and 5.6% in the U.K. and Kuwait, respectively, after the entry of GM rice.

Conjectural Variations

      The RDE models in Goldberg and Knetter (1999) and many other studies use conjectural variations. A conjectural variations approach incorporates a firm's belief about how rivals will react to its output choice within a static framework. Mathematically, "for all firm *i* we are concerned with the assumed value of the derivative $\frac{\partial q_j}{\partial q_i}$ for all firms *j* other than firm *i* itself" (Nicholson 2005, p.419). There has been some criticism against the use of conjectural variations. Carlton and Perloff (2005, p.159) summarized the two main criticisms. First, the conjectures that firms hold are arbitrary. To address the conjectures' arbitrariness, Stigler (1964) developed a cartel theory analysis of oligopoly behavior. Many other models have been developed based on game theory. Second, multi-period interpretations of conjectural variations models are implausible. Dynamic conjectural variations models are based on inconsistent firm beliefs and actions. However, the models based on game theory are also subject to criticism. One statement against those models is that they also use many arbitrary assumptions (e.g., firms have particular beliefs about other firms' behavior, firms choose output levels rather than prices, or they choose prices rather than output levels, etc.). In the existing literature, models based on game theory are used in some studies, while models using conjectural variations are used in other studies. In spite of these criticisms, many empirical works used a conjectural variations model for assessing market power, since a conjectural variations model has strong advantages such as the ability to measure market power with modest data requirements. Especially focusing on measuring market power in international agricultural trade, a conjectural variations approach is widely used in empirical studies such as using a RDE model in Goldberg and Knetter (1999), Carter et al. (1999), and Mulik and Crespi (2011).

3.3 Importer's Market Power-Import Demand Function

Few studies have examined importers' market power in international markets of agricultural commodities. This is probably due to the fact that producers or exporters are usually perceived to have some market power, and there are difficulties in gathering importers' data. Kang et al. (2009c) examined the price and income elasticity in the world rice market using the double log form of an import demand function. The results indicated that there were inelastic price and income elasticities in the world rice market.

Based on the RDE model in Goldberg and Knetter (1999), the residual supply elasticity (RSE) model can be applied to estimate the market margins of importers in international markets. Song (2006) developed an import price function to analyze the inverse of residual supply elasticity in the Chinese soybean import market.

3.4 Partial Equilibrium Trade Model

The residual demand elasticity model and the residual supply elasticity model can be used together to construct a partial equilibrium trade model. Andersen et al. (2008) examined oligopoly and oligopsony market power in the European dried salted cod market. The authors modeled the interaction between sellers and buyers with potential market power by using the RDE and RSE models. They developed an RSE model based on the work of Durham and Sexton (1992). As Andersen et al. discussed, there has been greater attention paid to the potential for buyers in international markets to exercise market power, and both sellers and buyers can exercise market power in the supply chains along which large producing and wholesaling firms sell products to large retailers (Andersen et al. 2008). Their three-stage least squares (3SLS) regression results showed that Norwegian exporters had a 17.3% market margin and Portuguese importers also enjoyed a 10.5% market margin. Therefore, the authors found that both sellers

and buyers enjoy some market power in international markets of dried salted cod. The authors concluded that the "oligopolist's negative influence on quantity traded will be reinforced if the oligopsonist reduces the market price of the good by reducing the quantity it purchases" (Andersen et al. 2008, p.19) in markets in which both sellers and buyers have market power.

Song (2006) examined the Chinese soybean import market using a two-country partial equilibrium trade model. The partial equilibrium trade model was developed based on the RDE model, a special inverse residual supply model, equilibrium condition as the quantity of imports is equal to the quantity of exports, and price relationship. Song compared who has more market power − U.S. exporters or Chinese importers − in the Chinese soybean import market. This approach measures the market margins of both soybean importers and exporters in the Chinese soybean import market and has more restrictive conditions compared to the usual RDE model because it includes an equilibrium condition. The author examined only U.S exporters in the Chinese soybean import market and found that "the market power of Chinese soybean importers is stronger than that of U.S. soybean exporters" (Song 2006, p.91). Because of data limitations, Song (2006) did not include the imports from South American countries, which account for approximately 40% of total Chinese soybean imports. This limitation indicates that readers need to be cautious in interpreting the empirical results of the study.

Chapter 4 - METHODOLOGY

4.1 Theoretical Model

I adopt and extend Goldberg and Knetter's approach to examine market power in international agricultural commodity markets. I use three models in the analysis. First, I apply Goldberg and Knetter's residual demand model to study international markets of non-GM and GM soybeans. Second, I develop a residual supply model based on Goldberg and Knetter's inverse residual demand function and Song's inverse residual supply function. Third, I build a two-country partial equilibrium trade model using inverse residual demand and inverse residual supply functions. For each of the three models, I specify and estimate two versions of the model: one version with the interaction between non-GM and GM soybeans and another version without the interaction.

4.1.1 Residual Demand Curve

The demand curve that a firm faces is called a residual demand curve. This curve represents the market demand that is not met by other firms at any given price. The left panel of Figure 4.1 depicts the market demand for non-GM soybeans in importing country 2's market, and the supply curve of other suppliers, S_{other}, represents the sum of domestic supply, imports from other exporting countries, and the net change of stocks of non-GM soybeans in importing country 2. In the right panel, the residual demand curve faced by exporting country 1, $D_{Res,1}$, is derived as the difference between the market demand for non-GM soybeans in importing country 2 and the supply curve of other suppliers. A marginal revenue curve is drawn based on the residual demand curve. The equilibrium is determined by the intersection of the marginal revenue curve and the marginal cost curve.

4.1.2 Residual Demand Elasticity Model

Goldberg and Knetter (1999) built a general residual demand function of a homogeneous product in a particular market structure with a dominant firm and a competitive fringe. They focused on multiple exporters in a single destination market. The demand functions faced by a specific exporting country (*ex*) and its competitors in other countries are:

$$P^{ex} = D^{ex}(Q^{ex}, P^1, \dots, P^n, \mathbf{Z}),$$

$$P^k = D^k(Q^k, P^j, P^{ex}, \mathbf{Z}) \quad for \; j = 1, \dots, n \; and \; j \neq k,$$

where P^{ex} is the price of the export good in units of the destination market currency and Q^{ex} is the total quantity of exports from the source country to the destination market. $P^1, \dots, P^n$ are the prices of *n* competing homogeneous products produced in other countries, and $\mathbf{Z}$ is a vector of destination market demand shifters. P^k is the price of exporters from the competing country k (k =1, 2, …, *n*) in units of the destination market currency. Q^k is the total quantity of exports from competitors from country k to the destination market. Solving the first-order conditions of the profit maximization problems, they obtained the export price function:

$$P^{ex} = D^{res,ex}(Q^{ex}, \mathbf{W}^N, \mathbf{Z}, \theta^N),$$

where $\mathbf{W}^N$ denote the union of all firm-specific cost shifters, excluding the exporter group of interest, and θ^N is the union of all the conduct parameters (Goldberg and Knetter, 1999).

4.1.3 Residual Demand Elasticity Model with Vertically Differentiated Products

Next, I lay out the theoretical model for exporters with vertical differential products in a single destination. The inverse residual demand functions are specified as:

$$P^{ex} = D^{ex}(Q^{ex}, P^1, \dots, P^n, P^G, \mathbf{Z}), \tag{1}$$

$$P^k = D^k(Q^k, P^j, P^{ex}, P^G, \mathbf{Z}) \quad for \; j = 1, \dots, n \; and \; j \neq k,$$

$$P^G = D^G(Q^G, P^j, P^{ex}, \mathbf{Z}), \quad for \; j = 1, \dots, n,$$

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where P^G is the price of GM commodity, which is the vertically differentiated variety compared to non-GM commodity in units of the destination market currency, and Q^G is the corresponding total quantity of exports from the source country to the destination market. For this specific exporting country, the profit maximization problem for one exporter, exporter i, can be written as:

$$\max_{q_i^{ex}} \pi_i^{ex} = P^{ex} q_i^{ex} - e^{ex} C_i^{ex}(q_i^{ex}),$$

where e^{ex} is the exchange rate between the destination market and the exporting country and C_i^{ex} is the total cost function of exporter i. Strategic interactions among firms are assumed to be represented by $\frac{\partial q_m^{ex}}{\partial q_i^{ex}} \neq 0$ with $m \neq i$ (conjectural variations). Based on the first-order condition, the following is obtained:

$$P^{ex} = e^{ex} MC_i^{ex} - q_i^{ex} D_1^{ex} \theta_i (\varphi + \xi),$$

where MC_i^{ex} is the marginal cost for exporter i, $\theta_i = \left(1 + \sum_{m \neq i} \frac{\partial q_m^{ex}}{\partial q_i^{ex}}\right)$ captures the competitive behavior among exporters within the source country, $\varphi = \left(1 + \sum_k \frac{\partial D^{ex}}{\partial P^k} \frac{\partial D^k}{\partial P^{ex}}\right)$ captures the competitive interaction between source country firms and foreign producers, $\xi = \frac{\partial D^{ex}}{\partial P^G} \frac{\partial D^G}{\partial P^{ex}}$ captures the interaction term of non-GM and GM commodities from the source country, and D_1 denotes the partial derivative of a demand function with respect to its first argument.

Following Goldberg and Knetter (1999), this study applies parameters that are interpreted as industry averages that are share-weighted means for all firms in the source country rather than using implausible aggregation assumptions such as symmetry of firms (Goldberg and Knetter, 1999).

Therefore, multiplying the first-order condition for exporter i with its market share, s_i, and summing the products yield:

$$\sum_i s_i P^{ex} = \sum_i s_i e^{ex} M C_i^{ex} - \sum_i s_i q_i^{ex} D_1^{ex} \theta_i (\varphi + \xi).$$

The result is a transformed version of the first-order condition for profit maximization that can be estimated using market-level data (Goldberg and Knetter, 1999) as:

$$P^{ex} = e^{ex} M C^{ex} - Q^{ex} D_1^{ex} \theta (\varphi + \xi),$$

where $MC^{ex} = \sum_i s_i M C_i$, and $\theta = \sum_i s_i^2 \theta_i$.

Similarly, for n competing exporting countries, the first-order conditions are used to obtain

$$P^k = e^k M C^k (Q^k, \boldsymbol{W}^k) - Q^k D_1^k (Q^k, P^j, P^{ex}, P^G, \boldsymbol{Z}) \theta^k,$$

where Q^k is the quantity of the export good, $\boldsymbol{W}^k$ is a vector of cost shifters, θ^k is the union of all of the conduct parameters of country k, and $k = 1, 2, \ldots, n$. Let $\boldsymbol{W}^N$ denote the union of all firm-specific cost shifters. Therefore, an export price function for exporters of country k is:

$$P^k = P^{k'} (Q^{ex}, \boldsymbol{W}^N, \boldsymbol{Z}, \theta^k). \tag{2}$$

For the vertically differentiated variety, GM commodity, I use the first-order conditions to obtain thus:

$$P^G = e^{ex} M C^G (Q^G, \boldsymbol{W}^G) - Q^G D_1^G (Q^G, P^j, P^{ex}, \boldsymbol{Z}) \mu^G,$$

where Q^G is the quantity, $\boldsymbol{W}^G$ is a vector of cost shifters, and μ^G is the union of all the conduct parameters of GM commodity. Therefore, an export price function for the vertically differentiated variety, GM commodity, is:

$$P^G = P^{G'} (Q^{ex}, \boldsymbol{W}^G, \boldsymbol{Z}, \mu^G). \tag{3}$$

4.1.4 Calculation of Exporters' Market Power

Substituting equations (2) and (3) into (1) and assuming that the marginal cost of firms is conditioned by the level of output and a vector of input prices denoted $\boldsymbol{W}$, the following export price function is obtained:

$$P^{ex} = D^{ex}\left(Q^{ex}, P^{1^*}, \dots, P^{n^*}, P^{G^*}, \boldsymbol{Z}\right)$$

$$\rightarrow P^{ex} = D^{ex}_{res}(Q^{ex}, \boldsymbol{W}^N, \boldsymbol{W}^G, \boldsymbol{Z}, \theta^N, \mu^G;\ \varphi, \xi),$$

where θ^N is the union of all of the within-country conduct parameters of all exporting countries.

Exporters' market power is calculated by finding the inverse of the residual demand elasticity. It is straightforward to show that the Lerner index for exporters of a source country, which measures the market power, is equal to the negative inverse of the residual demand elasticity:

$$
\begin{aligned}
LI^{ex} &= \frac{P - MC}{P} = \frac{P - MR}{P} = \frac{P - \partial TR/\partial Q}{P} \\[2mm]
&= \frac{P - \left(P + Q(\partial P/\partial Q)\right)}{P} = \frac{-1}{(\partial Q/\partial P)(P/Q)} \\[2mm]
&= -\frac{1}{\varepsilon_d},
\end{aligned}
$$

where ε_d is the residual demand elasticity.

Following Goldberg and Knetter (1999), I find that the residual demand elasticity is:

$$\varepsilon_d = \frac{1}{\partial ln D^{ex}_{res}/\partial ln Q^{ex}}.$$

Thus, exporters' market power in the destination market, which is measured by the Lerner Index, is

$$LI^{ex} = -\partial \ln D_{res}^{ex} / \partial \ln Q^{ex}.$$

4.1.5 Residual Supply Curve

The supply curve that a single buyer faces is called a residual supply curve. This curve represents the market supply that is not purchased by other buyers at any given price. The right panel of Figure 4.2 depicts the market supply for non-GM soybeans of exporting country 1, and the demand curve for other buyers, D_{other}, represents the sum of domestic demand, exports to other importing countries, and the net change of stocks of non-GM soybeans of exporting country 1. The residual supply curve faced by exporting country 1 in the market of importing country 2, $S_{Res,2}$, the corresponding marginal expenditure curve, and the equilibrium are presented in the left panel.

4.1.6 Residual Supply Elasticity Model

Based on Goldberg and Knetter (1999) and Song (2006), I develop the theoretical model for multiple importers that import from a specific exporting country. The inverse supply faced by a specific importing country (*im*) and its competitors in other countries are specified as:

$$P^{im} = S^{im}(Q^{im}, P^{1,oi}, ..., P^{L,oi}, \boldsymbol{H}),$$

$$P^{l,oi} = S^{l,oi}(Q^{l,oi}, P^{h,oi}, P^{im}, \boldsymbol{H}) \quad for\ h = 1, ..., L\ and\ h \neq l,$$

where P^{im} and Q^{im} are the price and quantity of the imported good in the specific importing country, $P^{1,oi}$, …, and $P^{L,oi}$ are the prices of the imported good in L other importing countries, $Q^{l,oi}$ is the total quantity of imports by competitors in importing country l (l = 1, 2, …, L) from the exporting country, and $\boldsymbol{H}$ is a vector of supply shifters of the exporters. The profit maximization problem for an importer j in the specific importing country can be written as:

$$\max_{q_j^{im}} \pi_j^{im} = TV_j^{im} - \frac{P^{im}}{e^{im}} q_j^{im},$$

where π_j^{im}, TV_j^{im}, and q_j^{im} are the profit, total value function, and quantity of the importer j, respectively. Rearranging the first-order condition yields:

$$P^{im} = e^{im}MV_j^{im} - q_j^{im}S_1^{im}\theta_j^{im}\varphi^{im},$$

where MV_j^{im} is the marginal value for importer j, $\theta_j^{im} = \left(1 + \sum_{m \neq j}\frac{\partial q_m^{im}}{\partial q_j^{im}}\right)$ is the sum of the

competitive behavior among importers within the specific importing country, and $\varphi^{im} =$

$\left(1 + \sum_l \frac{\partial S^{im}}{\partial P^{l,oi}}\frac{\partial S^{l,oi}}{\partial P^{im}}\right)$ is the sum of the conjectural variation parameter that is the competitive

interaction between the importers of the specific importing country and importers in other

importing countries. Similar to an RDE model, the parameters are industry averages that are

share-weighted means for all firms in the specific importing country rather than using

implausible aggregation assumptions. Therefore, multiplying the first-order condition for

importer j with its market share, s_j^{im}, and summing the products yield:

$$\sum_j s_j^{im}P^{im} = \sum_j s_j^{im}e^{im}MV_j^{im} - \sum_j s_j^{im}q_j^{im}S_1^{im}\theta_j^{im}\varphi^{im}.$$

Then I get a transformed version of the first-order condition for profit maximization for the

market level data of the specific importing country:

$$P^{im} = e^{im}MV^{im} - Q^{im}S_1^{im}\theta^{im}\varphi^{im},$$

where $MV^{im} = \sum_j s_j^{im}MV_j^{im}$, and $\theta^{im} = \sum_j s_j^2\theta_j^{im}$.

4.1.7 Residual Supply Elasticity Model with Vertically Differentiated Products

Next, I extend the theoretical model of residual supply to include the interaction among

vertically differential products; i.e., the non-GM product and the GM product. The supply

functions of the non-GM product for the specific importing country and the other importing

country and the supply function of the GM product for the importing country are:

$$P^{im} = S^{im}(Q^{im}, P^{1,oi}, \dots, P^{L,oi}, P^{im,G}, \boldsymbol{H}), \tag{4}$$

$$P^{l,oi} = S^{l,oi}(Q^{l,oi}, P^{h,oi}, P^{im}, P^{im,G}, \boldsymbol{H}) \quad for \ h = 1, \dots, L \ and \ h \neq l,$$

$$P^{im,G} = S^G(Q^{im,G}, P^{h,oi}, P^{im}, \boldsymbol{H}), \quad for \ h = 1, \dots, L.$$

Then, I derive and rearrange the first-order conditions to obtain the following condition for the specific importing country:

$$P^{im} = e^{im} MV^{im} - Q^{im} S_1^{im} \theta^{im}(\varphi^{im} + \xi^{im}),$$

where $\xi^{im} = \frac{\partial S^{im}}{\partial P^{im,G}} \frac{\partial S^G}{\partial P^{im}}$ captures the interaction between two vertically differentiated products in the importing country.

For the competing importers in other importing countries, rearranging the first-order conditions yields

$$P^{l,oi} = e^{l,oi} MV^{l,oi}(Q^{l,oi}, \boldsymbol{R}^l) - Q^{l,oi} S_1^{l,oi}(Q^{l,oi}, P^{h,oi}, P^{im}, P^{im,G}, \boldsymbol{H}) \theta^{l,oi},$$

where $Q^{l,oi}$ is the quantity of import good, $\boldsymbol{R}^l$ is a vector of country l's cost shifters, $\theta^{l,oi}$ is the union of all of the conduct parameters of country l, and $l = 1, 2, \dots, L$. Let $\boldsymbol{R}^L$ denote the union of all firm-specific cost shifters. Thus, an import price function for importers of country l is:

$$P^{l,oi} = P^{l,oi\prime}(Q^{im}, \boldsymbol{R}^L, \boldsymbol{H}, \theta^{l,oi}). \tag{5}$$

For the vertically differentiated variety, the GM commodity, I also use the first-order conditions to obtain

$$P^{im,G} = e^{im} MV^G(Q^{im,G}, \boldsymbol{R}^G) - Q^{im,G} S_1^G(Q^{im,G}, P^{h,oi}, P^{im}, \boldsymbol{H}) \mu^{im,G},$$

where $Q^{im,G}$ is the quantity, $\boldsymbol{R}^G$ is a vector of cost shifters, and $\mu^{im,G}$ is the union of all of the conduct parameters of the GM commodity. Then, the export price function for the vertically differentiated variety, the GM commodity, is:

$$P^{im,G} = P^{im,G\prime}(Q^{im}, \boldsymbol{R}^G, \boldsymbol{H}, \mu^{im,G}). \tag{6}$$

4.1.8 Calculation of Importers' Market Power

Substituting equations (5) and (6) into (4) and assuming that the marginal cost of firms is conditioned by the level of output and a vector of input prices, I can express the import price of the specific importing country as a function of the import quantity and all exogenous variables:

$$P^{im} = S^{im}\left(Q^{im}, P^{1,oi^*}, \dots, P^{L,oi^*}, P^{im,G^*}, \mathbf{H}\right)$$

$$\rightarrow P^{im} = S_{res}^{im}\left(Q^{im}, \mathbf{R}^L, \mathbf{R}^G, \mathbf{H}, \theta^{im,L}, \mu^{im,G}; \varphi^{im}, \xi^{im}\right),$$

where $\theta^{im,L}$ is the union of all the within-country conduct parameters of all importing countries.

I can use the residual supply elasticity to calculate importers' market power. It is straightforward to show that the Lerner index for importers of a destination country, which measures their market power, is equal to the inverse of the residual supply elasticity:

$$LI^{im} = \frac{ME - P}{P} = \frac{\partial TE/\partial Q - P}{P} = \frac{(P + Q(\partial P/\partial Q)) - P}{P}$$

$$= \frac{Q(\partial P/\partial Q)}{P}$$

$$= \frac{1}{\varepsilon_s},$$

where ε_s is the residual supply elasticity. For comparison to the Lerner index for exporters of a source country, the adjusted Lerner index for importers of a destination country is needed:

$$Adjusted\ LI^{im} = \frac{ME - P}{ME} = \frac{\partial TE/\partial Q - P}{\partial TE/\partial Q} = \frac{(P + Q(\partial P/\partial Q)) - P}{P + Q(\partial P/\partial Q)}$$

$$= \frac{Q(\partial P/\partial Q)}{P + Q(\partial P/\partial Q)}$$

$$= \frac{1}{1 + \varepsilon_s}.$$

Then, I find the residual supply elasticity is:

$$\varepsilon_s \ = \frac{1}{\partial ln S_{res}^{im}/\partial ln Q^{im}}.$$

Thus, importers' market power in the destination market, which is measured by the adjusted

Lerner Index, is:

$$Adjusted\ LI^{im} \ = \frac{\partial ln S_{res}^{im}/\partial ln Q^{im}}{1 + \partial ln S_{res}^{im}/\partial ln Q^{im}}.$$

4.1.9 Inflation Rate and Nominal Exchange Rate

Many previous studies use nominal exchange rates by assuming that there are no

substantial differences of inflation rates among exporters and importers. Cho et al. (2002)

indicated that using only nominal exchange rates to adjust prices and costs across countries to

make them comparable may not be adequate so that both nominal exchange rates and inflation

rates are needed in the adjustments and comparison. In this dissertation, I first deflate the

nominal exchange rates by using the inflation rates, and then I use the deflated exchange rates to

make all prices and cost shifters comparable across countries.

4.1.10 Partial Equilibrium Trade Model

In addition to a single residual demand model for the specific exporting country and a

single residual supply model for the specific importing country, I examine a two-country partial

equilibrium trade model, which includes both the residual demand function and the residual

supply function in order to take possible contemporaneous cross-equation correlations into

account.

I specify the two-country partial equilibrium trade model as

$$\begin{cases} P^{ex} = D^{ex}_{res}(Q^{ex}, \boldsymbol{W}^N, \boldsymbol{W}^G, \boldsymbol{Z}, \theta^N, \mu^G; \; \varphi, \xi) \\ P^{im} = S^{im}_{res}(Q^{im}, \boldsymbol{R}^L, \boldsymbol{R}^G, \boldsymbol{H}, \theta^{im,L}, \mu^{im,G}; \; \varphi^{im}, \xi^{im}), \end{cases}$$

where $Q^{ex} = Q^{im}$ to recognize that the quantity imported by an importing country from an

exporting country is equal to the corresponding quantity exported by the exporting country to the

importing country. The first equation is the residual demand function of the specific exporting

country (*ex*), and the second equation is the residual supply function of the specific importing

country (*im*).

4.2 Empirical Models

Based on the three theoretical models above, I develop corresponding empirical models

in this section. I apply the empirical models to U.S.-Japan soybean trade, which is an important

part of international soybean markets. Given that over 70% of Japanese soybean imports are

from the U.S., the empirical results should also be useful for the corresponding industries and

policy makers in the two countries. Carter et al. (1999) assumed that each country is a single

firm and that the model parameters could be interpreted as the share-weighted industry averages

for all firms within one country. For both the U.S. and Japan, where there is more than one firm

exporting to Japan and importing from the U.S., I interpret "the parameters as share-weighted

industry averages for all firms" (Carter et al. 1999 p.5) in the U.S. and in Japan, respectively. I

follow Carter et al. (1999) and treat each exporting and importing country as a single firm; i.e.,

the U.S. is a single exporter and Japan is a single importer of soybeans in the empirical models.

Therefore, this study is able "to transform the first-order conditions as estimated with market

level data without using implausible aggregation assumption" (Carter et al. 1999 p.5).

4.2.1 Empirical RDE Model

Following Goldberg and Knetter (1999), I use a logarithm functional form in the empirical specification so that it is straightforward to express elasticities in simple forms of model parameters. Two versions of the residual demand elasticity (RDE) model for the exporting country, the U.S., are specified as:

$$lnP^{ex} = \alpha_0 + \alpha_1 lnQ^{ex} + \mathbf{\Gamma} ln\mathbf{Z} + \mathbf{\Phi} ln\mathbf{W}^N + \epsilon^{ex}, \qquad (The\ Traditional\ Approach)$$
$$lnP^{ex} = \alpha_0 + \alpha_1 lnQ^{ex} + \alpha_2 lnP^{GM,US} + \mathbf{\Gamma} ln\mathbf{Z} + \mathbf{\Phi} ln\mathbf{W}^N + \epsilon^{ex}, (The\ New\ Approach)$$

where P^{ex} and Q^{ex} are the U.S. non-GM soybean export price and quantity to Japan, respectively, $P^{GM,US}$ is the U.S. GM soybean export price to Japan, $\mathbf{Z}$ is a vector of demand shifters of the Japanese market such as Japanese real income and a time trend, $\mathbf{W}^N$ is a vector of the cost shifters for n competing non-GM soybean exporting countries including exchange rates between Japan and other non-GM soybean exporting countries such as Canada and China, and ϵ^{ex} is the error term. The traditional approach ignores the interaction between two vertically differentiated goods, non-GM and GM soybeans, while the second case includes the interaction in the residual demand elasticity model of U.S. non-GM soybean exports to Japan.

The parameters of interest in the RDE model are α_1 and α_2. The α_1 is the inverse of the residual demand elasticity of U.S. non-GM soybean exports to Japan. When the estimate of α_1 is zero, U.S. non-GM soybean exporters do not have market power in Japanese import markets. In this situation, U.S. non-GM soybean exporters face a perfectly elastic demand curve so that they are price takers in the market. On the other hand, when the estimate of α_1 is negative and significant, U.S. non-GM soybean exporters have some market power in Japanese import markets (i.e., they can influence the soybean export price). A larger absolute value of $\hat{\alpha}_1$ indicates greater market power on the part of U.S. exporters. The α_2 is the coefficient of the GM

soybean price, and a statistically significant estimate of α_2 implies that the model with the interaction between two vertically differentiated products (non-GM and GM soybeans) is preferred.

4.2.2 Empirical RSE Model

I also specify two versions of the residual supply elasticity model for the importing country, Japan:

$$lnP^{im} = \beta_0 + \beta_1 lnQ^{im} + \boldsymbol{\Upsilon} ln\boldsymbol{H} + \boldsymbol{\Psi} ln\boldsymbol{R}^L + \epsilon^{im}, \qquad (The\ Traditional\ Approach)$$
$$lnP^{im} = \beta_0 + \beta_1 lnQ^{im} + \beta_2 lnP^{GM,JP} + \boldsymbol{\Upsilon} ln\boldsymbol{H} + \boldsymbol{\Psi} ln\boldsymbol{R}^L + \epsilon^{im}, (The\ New\ Approach)$$

where P^{im} and Q^{im} are the Japanese non-GM soybean import price and quantity from the U.S., $P^{GM,JP}$ is the Japanese GM soybean import price from the U.S., $\boldsymbol{H}$ is a vector of supply shifters in the U.S. such as energy price, labor cost, soybean-corn price ratio futures prices, and a time trend, $\boldsymbol{R}^L$ is a vector of the cost shifters for L competing non-GM soybean importing countries which includes the exchange rates between the U.S. and other non-GM soybean importing countries such as the EU, China, and South Korea, and ϵ^{im} is the error term.

The parameters of interest in the RSE model are β_1 and β_2. The β_1 is the inverse of the residual supply elasticity faced by Japanese importers. Japanese non-GM soybean importers do not have any market power and face a perfectly elastic supply curve when the estimate of β_1 is zero. Japanese importers have some market power when $\hat{\beta}_1$ is positive and significant, and their power is greater when the absolute value of $\hat{\beta}_1$ is larger. If the parameter estimate ($\hat{\beta}_2$) of the GM soybean price is statistically significant, the model with the interaction between two vertically differentiated products (non-GM and GM soybeans) is preferred.

4.2.3 Empirical Partial Equilibrium Trade Model

Two versions of the two-country partial equilibrium trade model are specified thus:

$$\textit{The Traditional Approach} \quad \begin{cases} lnP^{ex} = \alpha_0 + \alpha_1 lnQ^{ex} + \mathbf{\Gamma}ln\mathbf{Z} + \mathbf{\Phi}ln\mathbf{W}^N + \epsilon^{ex} \\ lnP^{im} = \beta_0 + \beta_1 lnQ^{im} + \mathbf{Y}ln\mathbf{H} + \mathbf{\Psi}ln\mathbf{R}^L + \epsilon^{im} \end{cases} \quad and$$

$$\textit{The New Approach} \quad \begin{cases} lnP^{ex} = \alpha_0 + \alpha_1 lnQ^{ex} + \alpha_2 lnP^{GM,US} + \mathbf{\Gamma}ln\mathbf{Z} + \mathbf{\Phi}ln\mathbf{W}^N + \epsilon^{ex} \\ lnP^{im} = \beta_0 + \beta_1 lnQ^{im} + \beta_2 lnP^{GM,JP} + \mathbf{Y}ln\mathbf{H} + \mathbf{\Psi}ln\mathbf{R}^L + \epsilon^{im}. \end{cases}$$

As noted above, the partial equilibrium trade model system is adapted to take possible

contemporaneous cross-equation correlations into account. There is an endogeneity problem

because the quantity variables, Q^{ex} and Q^{im}, are both right-hand-side endogenous variables.

Therefore, I use the 3SLS method for the estimation to address both the endogeneity issue and

contemporaneous cross-equation correlations in the system.

The parameters of interest are α_1, α_2, β_1, and β_2. The estimates of α_1 and β_1 indicate the

existence and magnitude of U.S. exporters' and Japanese importers' market power in the

corresponding market, respectively. The estimates of α_2 and β_2 can show whether the

interaction between two vertically differentiated products (non-GM and GM soybeans) should be

included in the estimation of exporters' and importers' market power.

Figure 4.1: Residual Demand for Exporting Country 1's Non-GM Soybeans in Importing Country 2's Market.

Importing Country 2's market for Non-GM Soybeans

Residual Demand

S_{Other}

P^{ex}

D_2

MC_1

$D_{Res,1}$

$MR_{Res,1}$

Q^{ex}
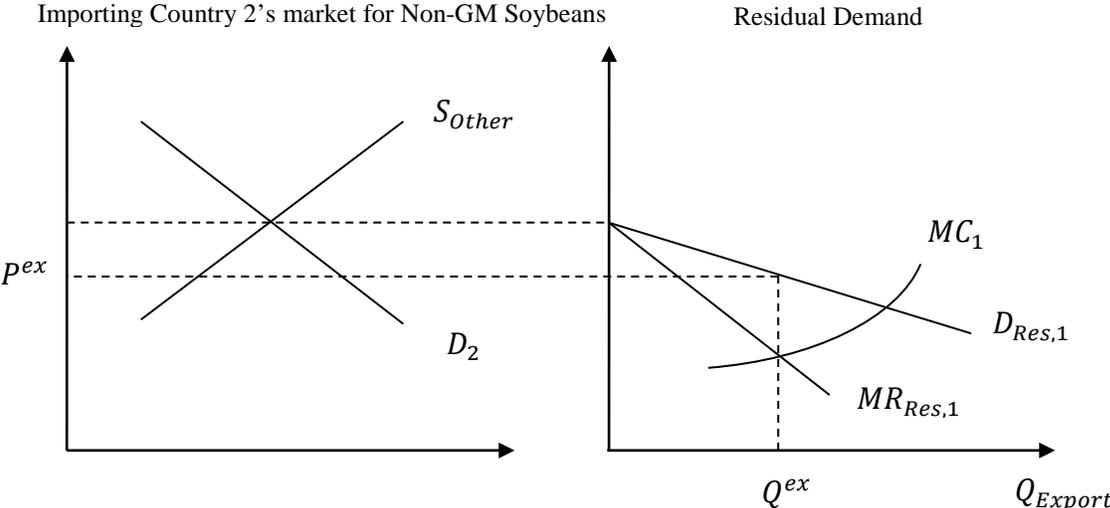
Q_{Export}

Figure 4.2: Residual Supply faced by Importing Country 2 in Exporting Country 1's Non-GM Soybean Market.

Residual Supply   Exporting Country 1's market for Non-GM Soybeans

$ME_{Res,2}$

$S_{Res,2}$

MV_2

S_1

P^{im}

D_{Other}

Q^{im} Q_{Import}
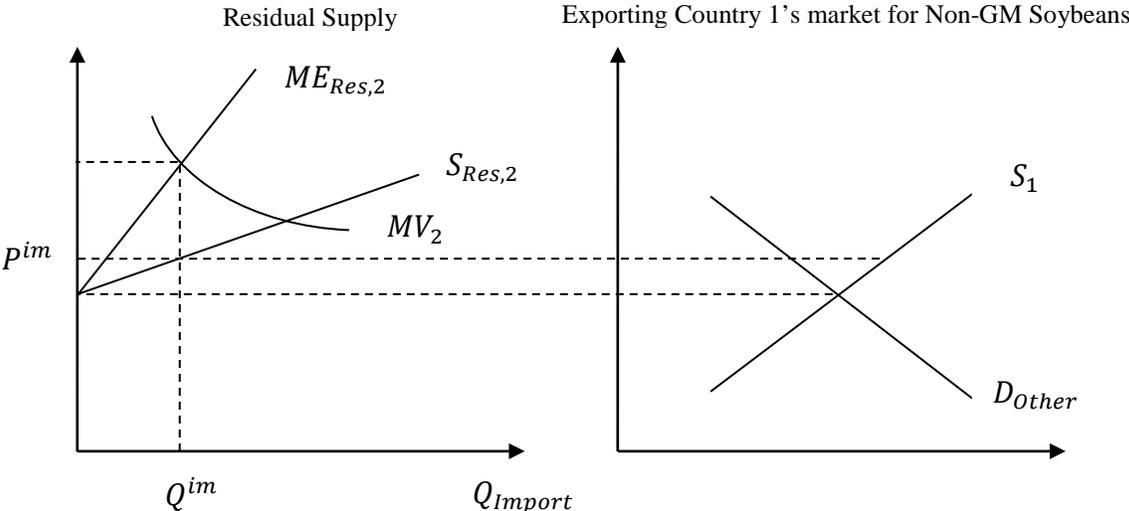
Chapter 5 - DATA DESCRIPTION

5.1 Trade Prices and Quantities

Weekly data from January 2000 to December 2011 are used in the estimation. I first discuss the export/import prices and quantities. The weekly export price data for U.S. GM soybeans were obtained from Chicago Board of Trade (CBOT) and are shown in Figure 5.1. The weekly price and quantity of Japanese non-GM soybean imports and the weekly price of Japanese GM soybean imports from the U.S. were obtained from Tokyo Grain Exchange (TGE). Those data are illustrated in Figures 5.2 and 5.3.

I need U.S. non-GM soybean prices for the estimation, but these data are not directly available. Through contacting representatives of Cargill[10] and Huron Commodities, Inc.[11], I obtain the data of non-GM soybean premiums paid to U.S. farmers and know that the non-GM soybean premiums are greatly affected by the demand of non-GM soybeans. Thus, I calculate U.S. non-GM soybean prices as the sum of U.S. GM soybean prices from CBOT and the (high-protein) non-GM soybean premiums. Since Japanese soybean wholesalers[12] import non-GM soybeans to make food products such as tofu, miso, and natto (Japan Tofu Association[13]; Japan Natto Cooperative Society Federation[14]; Miso Online[15]), I use the high protein non-GM soybean premium price to calculate U.S. non-GM soybean prices.

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[10] Mr. Jeff Duckworth, Cargill, Bloomington, IL. http://www.cargillag.com.

[11] Mr. Jim Traub, Huron Commodities USA, Monticello, IL. http://www.huron.com/.

[12] Major soybean wholesalers are Marubeni Corporation http://www.marubeni.com/index.html, Mitsui & CO., LTD. http://www.mitsui.com/jp/en/index.html, and Sojitz Corporation http://www.sojitz.com/en/index.html.

[13] Japan Tofu Association is available at: http://www.tofu-as.jp/english/index.html.

[14] Japan Natto Cooperative Society Federation is available at: http://www.710.or.jp/ (in Japanese).

[15] Miso online is available at: http://www.miso.or.jp/en/index.html .

Because the GM soybean price from the CBOT is quoted in cents per bushel and the non-GM soybean premiums are quoted in dollars per bushel, I use Metric Conversions (1 Metric Ton = 36.7437 bushels for soybeans) from the Ag Decision Maker at Iowa State University to convert the data from dollar per bushel to dollar per metric ton. The calculated U.S. non-GM soybean prices are shown in Figure 5.1.

I use real export and import prices in the estimation. In an RDE model, I transform U.S. non-GM and GM soybean export prices to the real terms by using the consumer price index (CPI) in Japan. Data on the monthly CPI in Japan were obtained from the portal site of Official Statistics of Japan, e-Stat. In a RSE model, Japanese non-GM and GM soybean import prices are converted into real terms by using the producer price index (PPI) in the U.S. The data on the monthly PPI in the U.S. were obtained from the U.S. Bureau of Labor Statistics. Table 5.1 shows the summary statistics of quantity, real prices for U.S. non-GM and GM soybean exports and Japanese non-GM and GM soybean imports, demand shifters, supply shifters, and cost shifters.

5.2 Demand, Supply, and Cost Shifters

For the RDE model, I use the Japanese personal disposable income (PDI) as the destination market demand shifters.[16] Data on the monthly PDI were obtained from the portal site of Official Statistics of Japan, e-Stat. The PDI data are converted into real terms by using the CPI in Japan. Weekly exchange rates between Japan and competing exporting countries including Canada and China were obtained from PACIFIC Exchange Rate Service, the University of British Columbia. These exchange rates for the RDE model are expressed as the

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[16] Mulik and Crespi (2011) use destination countries' wage index, wholesale price index, or producer price index (PPI) as the cost shifters in an RDE model for Indian and Pakistan Basmati rice exports analysis.

number of competing exporting countries' currencies per Japanese yen. For instance, the exchange rate between Japan and Canada on December 30, 2011, is 0.013157 Canadian dollars per Japanese yen.

Cho et al. (2002) emphasized the importance of using real exchange rates, while most previous studies used nominal exchange rates in the estimation of RDE and RSE models. In this study, I use real exchange rates, which are obtained by multiplying nominal exchange rates with the ratios of price levels in the two corresponding countries (Krugman and Obstfeld 2002). The real exchange rate measures the purchasing power of a currency relative to another, which is known as purchasing power parity (PPP). Following Krugman and Obstfeld (2002), a real exchange rate is calculated as:

$$r_{ppp} = e_{1,2} \frac{P_1}{P_2},$$

where r_{ppp} can be interpreted as the real exchange rate, $e_{1,2}$ is the nominal exchange rate between country 1 and country 2, and P_1 and P_2 are the price levels in countries 1 and 2, respectively. Figures 5.5-5.9 show real exchange rates between Canada and Japan, China and Japan, the EU and the U.S., China and the U.S., and South Korea and the U.S.

For the RSE model, I use the labor cost (LC) and the energy cost (EC) as the producers' supply shifters. Data on the monthly labor cost were obtained from the OECD iLibrary (http://www.oecd-ilibrary.org), and a monthly commodity fuel index was obtained from the International Monetary Fund as the energy cost. The LC and EC data are converted to the real terms by using the PPI in the U.S. I also use the soybean-corn price ratio (SCR) that is synthetically generated using soybean and corn futures prices. The SCR is not a tradable futures contract and is being distributed for information purposes only (CME Group). The November soybean futures over December corn futures is a key index for the present U.S. soybean farmers
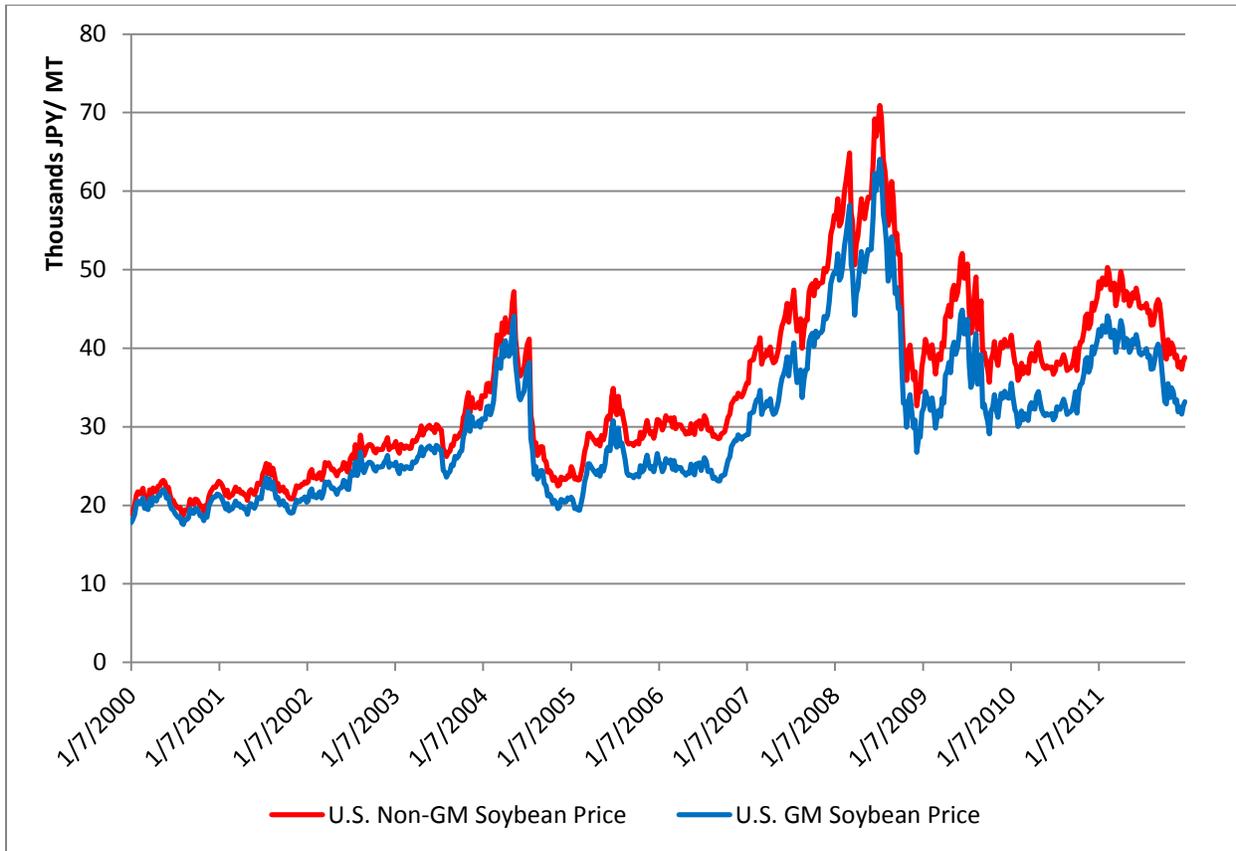
50

to help them decide whether they will continue planting soybeans or shift to corn during the next year. Data on the SCR (Figure 5.4) were obtained from CBOT. After 2010, the SCR has been decreasing, and the SCR was below 2.0 in 2011. Higher corn prices due to the increasing ethanol production have affected U.S. soybean production and supply functions in a cross or competitive commodity manner. U.S. farmers have been willing to provide or produce fewer soybeans than corn in recent years because of the greater expected profitability for corn. Thus, the soybean-corn price ratio is a factor in the crop decisions of U.S. farmers[17]. Lin and Riley (1998) discussed whether the SCR is a reliable indicator for planting decisions. They concluded that the SCR will provide a part of the explanation for farmers' acreage choices between corn and soybeans. The EU, China, and South Korea are other importing countries of U.S. non-GM soybeans. Weekly exchange rates between the U.S. and the other destination countries including the EU, China, and South Korea were obtained from the PACIFIC Exchange Rate Service, the University of British Columbia. These exchange rates in the RSE model are expressed as the number of other destination countries' currency per U.S. dollar. For instance, the exchange rate between the EU and the U.S. was 0.772201 euros per U.S. dollar on December 30, 2011.

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[17] This information is based on an interview with Dr. Daniel O'Brien, Extension Agricultural Economist-Northwest Research Extension Center, K-State Research and Extension.

Table 5.1: Summary Statistics of Non-GM soybean Analysis

Variable	Mean	Std. Dev.	Minimum	Maximum
P^{US} (JPY/MT)	44723.64	40329.7	18231.49	202487.4
P^{JP} (USD/MT)	305.4874	72.00234	193.5037	534.8425
$P^{GM,US}$ (JPY/MT)	39053.34	34960.02	17062.81	177763.7
$P^{GM,JP}$ (USD/MT)	268.2251	52.66697	179.6687	423.5965
Q^{non-GM} (MT)	17.07659	4.886468	5.851398	33.45151
$ER^{JP,CA}$ (CAD/JPY)	0.011653	0.001429	0.008209	0.014318
$ER^{JP,CH}$ (CHY/JPY)	0.072154	0.005594	0.061614	0.083787
$ER^{US,EU}$ (EUR/USD)	0.847115	0.153871	0.629723	1.199544
$ER^{US,CH}$ (CHY/USD)	7.681722	0.693274	6.310741	8.280202
$ER^{US,KO}$ (KOW/USD)	1129.104	127.1173	906.38	1558.1
$Income^{JP}$ (JPY)	10390.1	434.0878	9560.059	11228.95
SCR^{US}	2.470471	0.377396	1.719088	3.978125
LC^{US}	101.8193	4.644074	94.725	109.602
EC^{US}	129.2759	26.7644	94.3	192.6
$Time\ Trend$	313	180.5662	1	625

Figure 5.1: Non-GM and GM Soybean Prices in U.S. from January 2000 to December 2011

Figure 5.2: Non-GM and GM Soybean Prices in Japan from January 2000 to December 2011

Source: Tokyo Grain Exchange http://www.tge.or.jp/english/index.shtml.
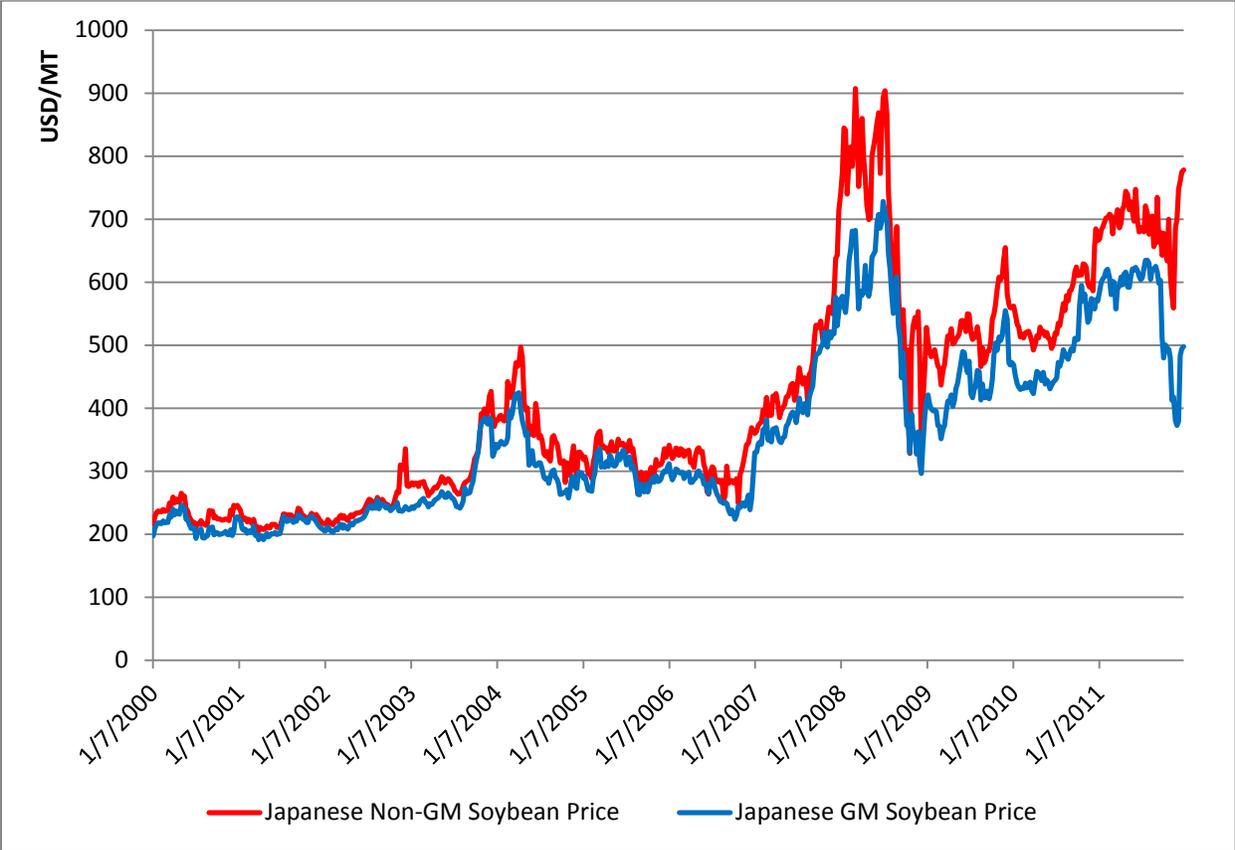
Figure 5.3: Non-GM Soybean Trading Volumes between U.S. and Japan from January 2000 to December 2011

Source: Tokyo Grain Exchange http://www.tge.or.jp/english/index.shtml.
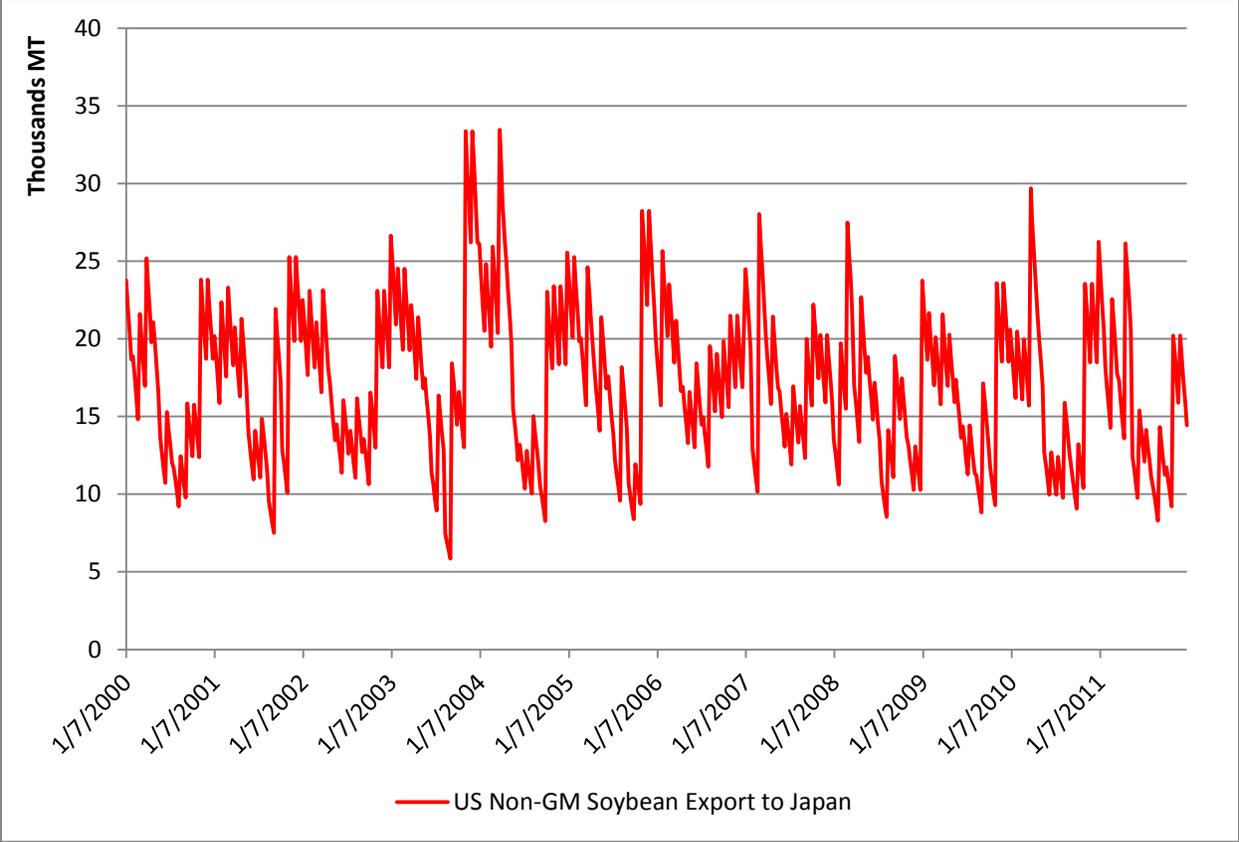
Figure 5.4: The Soybean-Corn Price Ratio from January 2000 to December 2011
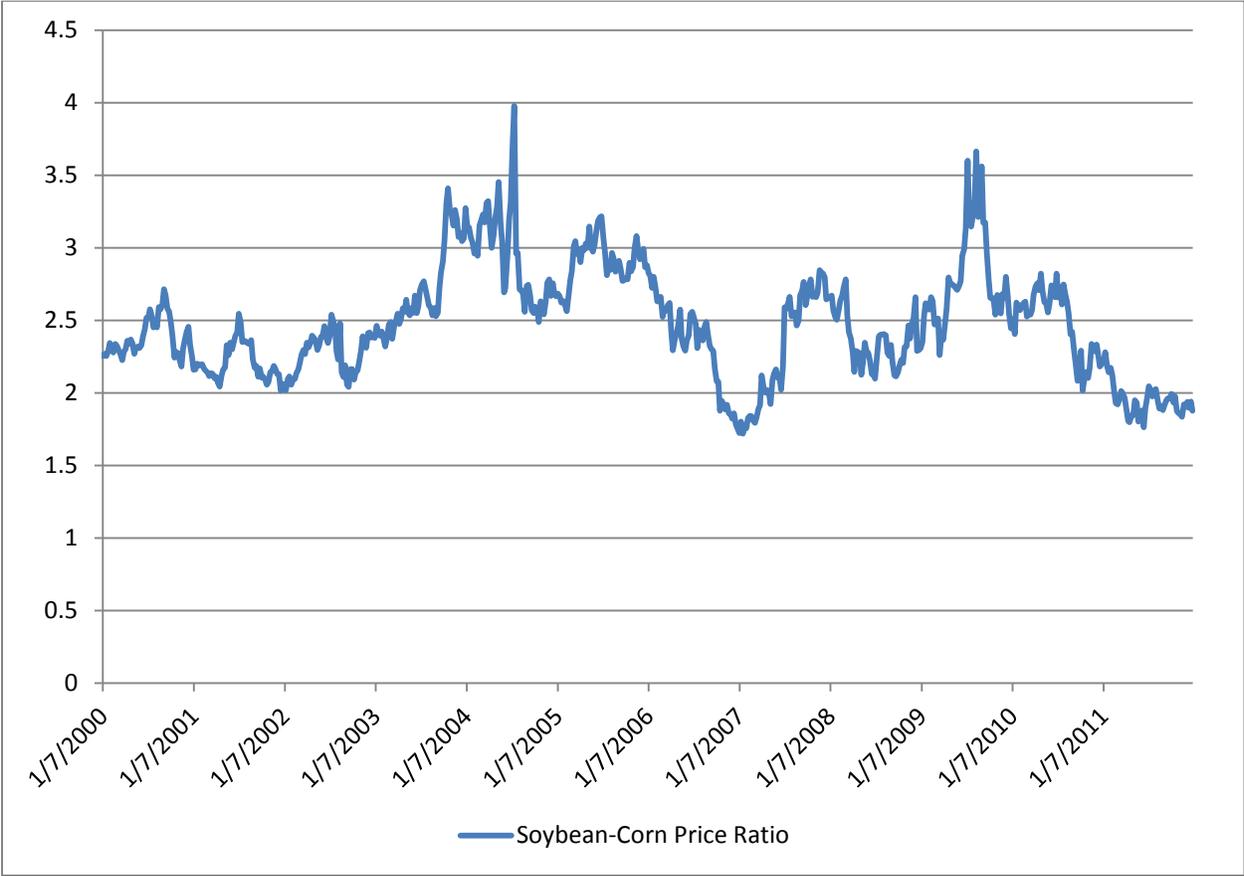
Source: Chicago Board of Trade http://www.cmegroup.com/company/cbot.html.

Figure 5.5: Exchange Rate between Canada and Japan from January 2000 to December 2011
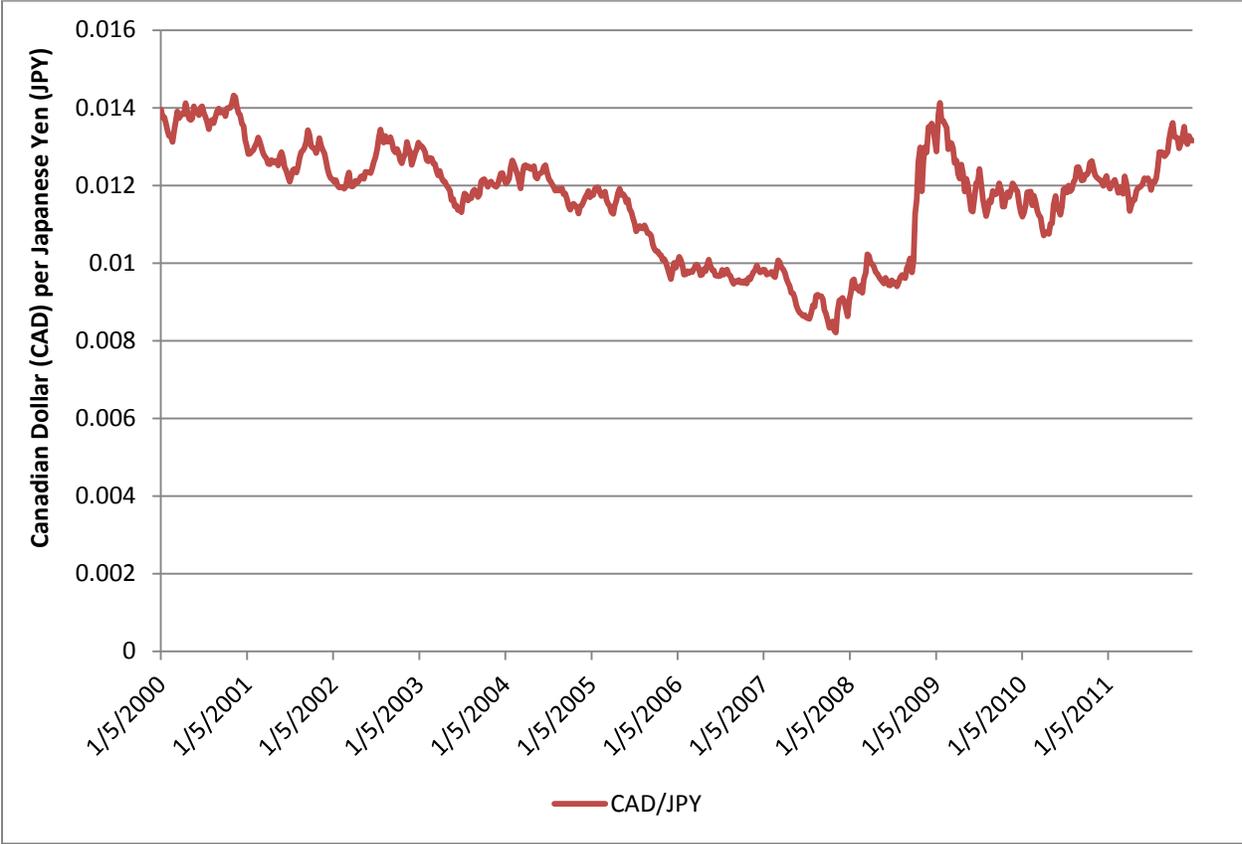
Source: PACIFIC Exchange Rate Service, the University of British Columbia http://fx.sauder.ubc.ca/data.html.

Figure 5.6: Exchange Rate between China and Japan from January 2000 to December 2011
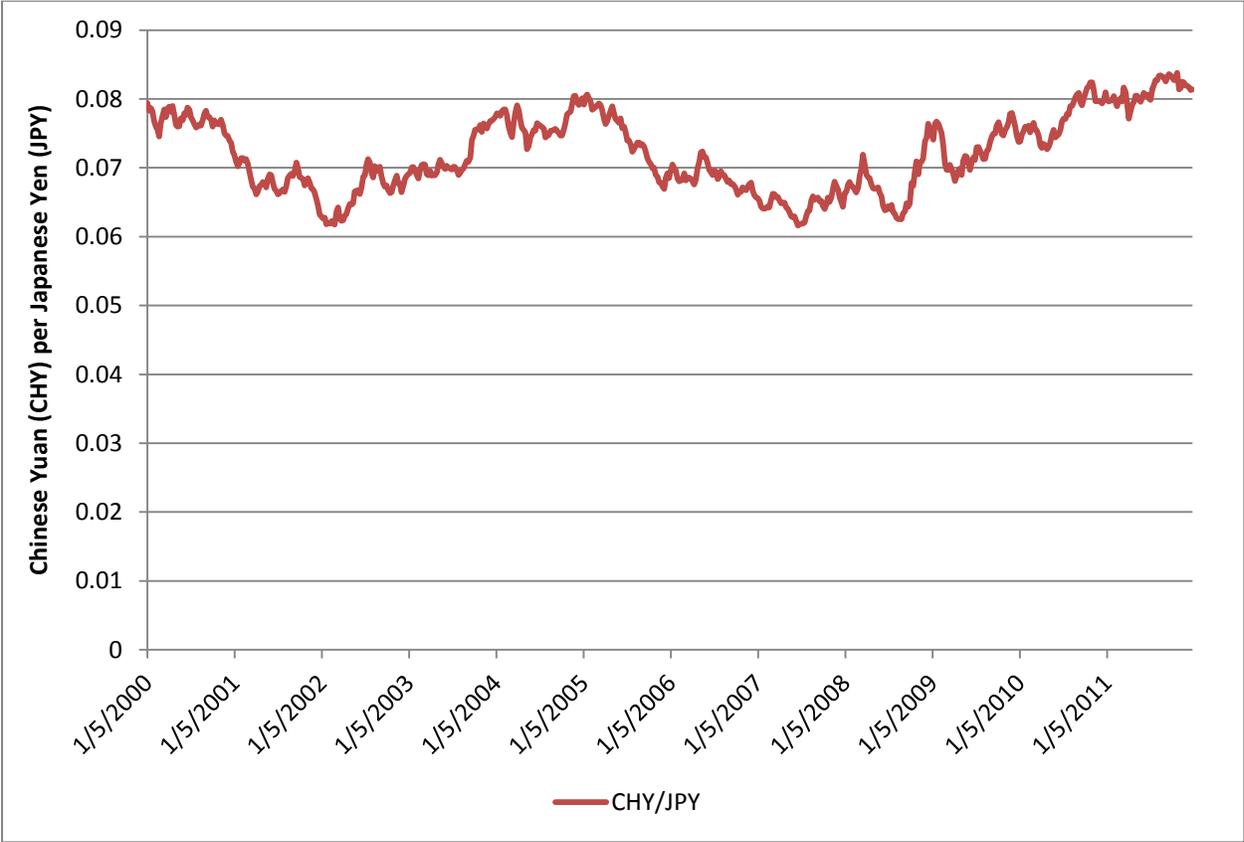
Source: PACIFIC Exchange Rate Service, the University of British Columbia http://fx.sauder.ubc.ca/data.html.

Figure 5.7: Exchange Rate between EU and the U.S. from January 2000 to December 2011
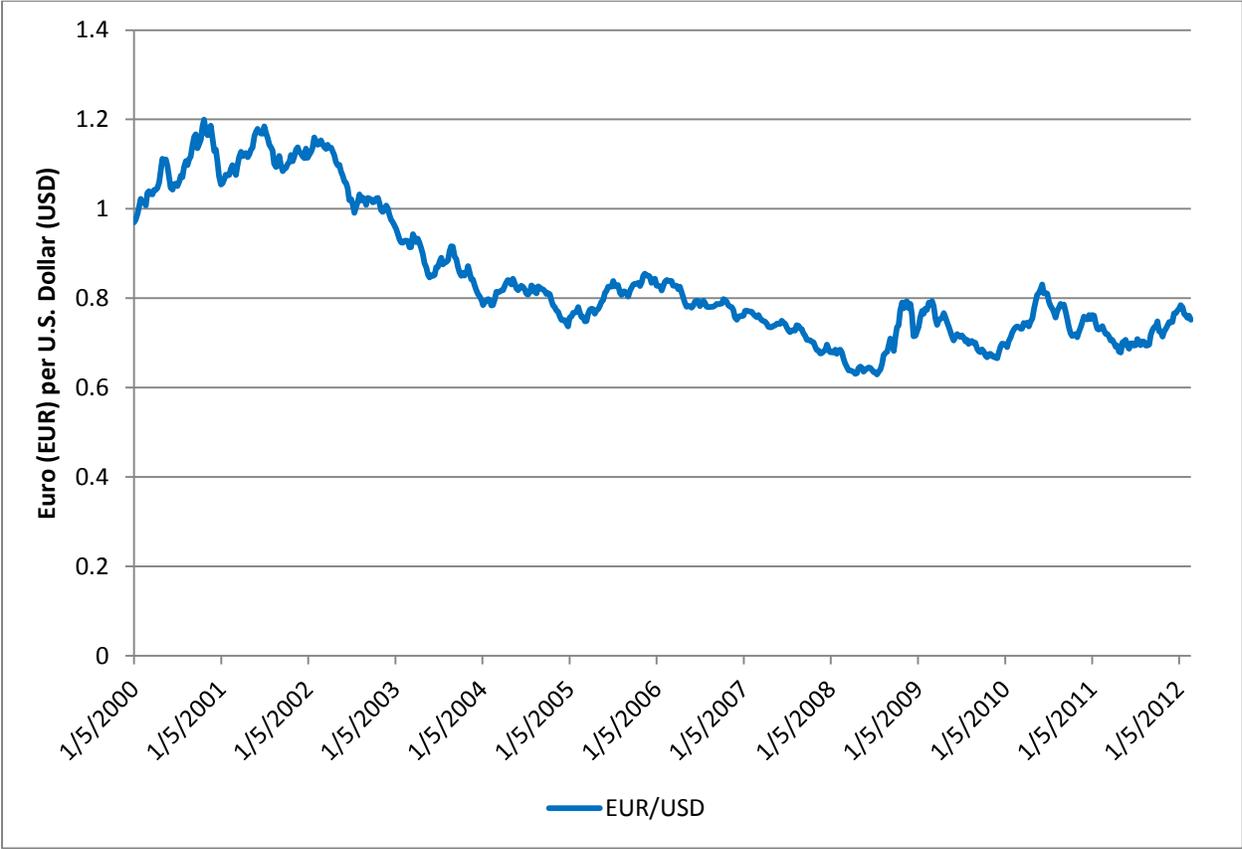
Source: PACIFIC Exchange Rate Service, the University of British Columbia http://fx.sauder.ubc.ca/data.html.

Figure 5.8: Exchange Rate between China and the U.S. from January 2000 to December 2011
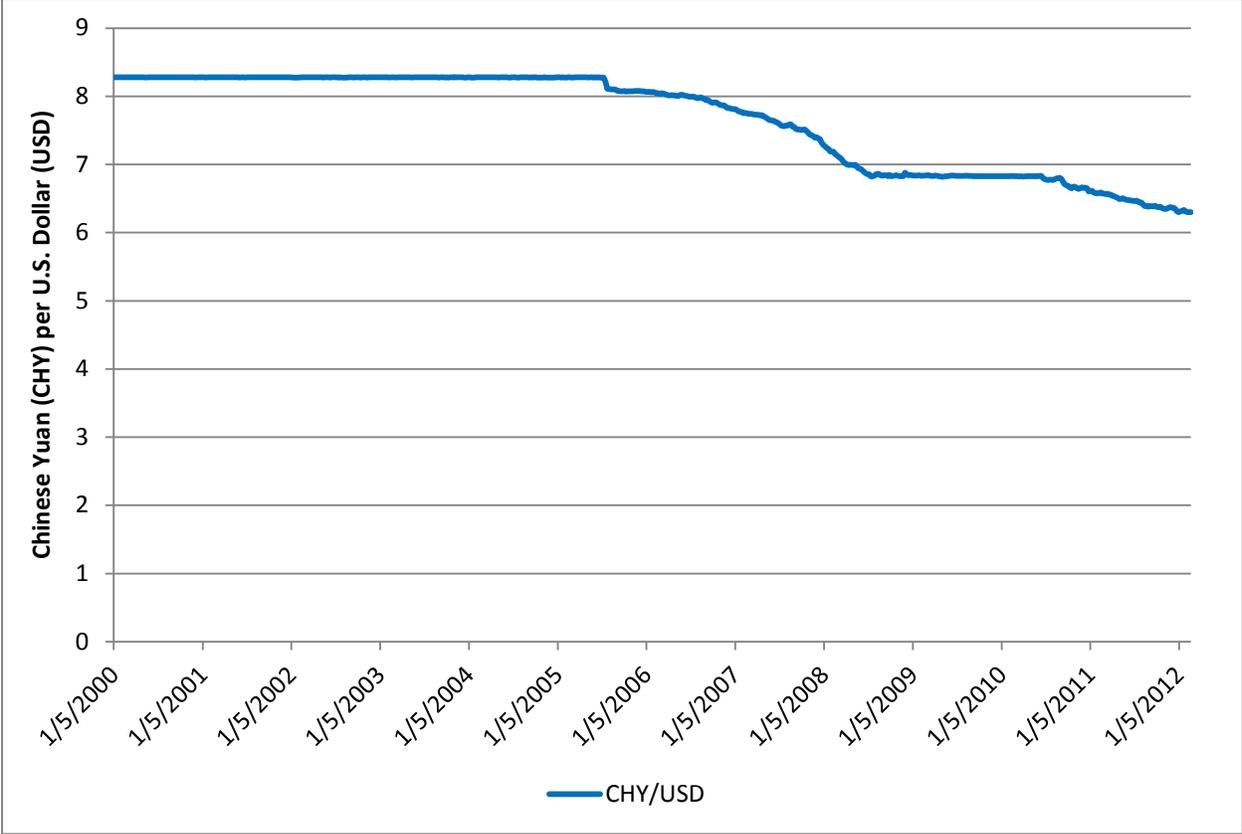
Source: PACIFIC Exchange Rate Service, the University of British Columbia http://fx.sauder.ubc.ca/data.html.

Figure 5.9: Exchange Rate between South Korea and the U.S. from January 2000 to December 2011

Source: PACIFIC Exchange Rate Service, the University of British Columbia http://fx.sauder.ubc.ca/data.html.

Chapter 6 - ESTIMATION RESULTS

6.1 Econometric Issues

Endogeneity

The quantity variables, Q^{ex} and Q^{im}, in the RDE and RSE model are both right-hand-side endogenous variables. Thus, there is an endogeneity problem in the estimation of both the RDE and the RSE model, and a traditional Ordinary Least Squares (OLS) method would lead to inconsistent coefficient estimates. The 2SLS method can be used to solve this endogeneity problem. Goldberg and Knetter (1999) indicated that "the natural instruments in this context are cost shifters for the exporting group of interest, since they are excluded from the estimating equation, but are correlated with quantity" (Goldberg and Knetter 1999, p.42).

I follow Goldberg and Knetter's method to conduct 2SLS estimation of the RDE and the RSE models. For Q^{ex} in the RDE model, the instruments I use are the supply shifters in the U.S., including energy price, labor cost, and soybean-corn price ratio futures prices and a time trend; the exchange rates between the U.S. and other importing countries such as the EU, China, and South Korea; and all exogenous variables in the corresponding case of the RDE model. Similarly, for Q^{im} in the RSE model, the instruments I use are the demand shifters of the Japanese market including Japanese real income and a time trend, the exchange rates between Japan and other non-GM soybean exporting countries such as Canada and China, and all exogenous variables in the corresponding case of the RSE model.

In the two-country partial equilibrium trade model, I use the 3SLS method for the estimation to take care of both the endogeneity issue and contemporaneous cross-equation correlations in the system.

Autocorrelation

An autocorrelation problem is a violation of the assumption that the errors are uncorrelated. I check the correlation between the current residual and the lagged residual obtained from the OLS estimation and test for the significance of coefficient ρ. Table 6.1 shows the test results for autocorrelation. Results indicate that the null hypothesis is rejected for all four models. Therefore, I use an autoregressive model with AR(1) to correct the autocorrelation problems.

Heteroskedasticity

I use White's test for heteroskedasticity (White 1980) to check for heteroskedasticity problems[18] for each model. The null hypothesis is:

$$H_0: \sigma_i^2 = \sigma^2 \; for \; all \; i.$$

Table 6.2 includes the White's test results for the RDE and RSE models. Results show that the null hypothesis is rejected for all four models. Thus, the heteroskedastic-consistent (White robust) standard errors should be used in hypothesis testing of parameters and constructing confidence intervals for all models. The standard errors reported in all tables of estimation results are heteroskedastic-consistent (White robust).

6.2 Results for the Residual Demand Elasticity Model

The Traditional Approach

I use the traditional approach to estimate the RDE model with OLS and 2SLS, and the results are reported in Table 6.3. The adjusted R^2s for two models were 0.97 and 0.96,

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[18] Other tests to detect heteroskedasticity are Breusch-Pagan tests and Goldfeld-Quandt tests.

respectively.[19] The Hausman-Wu test results reject the null hypothesis of the exogeneity of the quantity variable at the 1% significance level. Thus, the 2SLS method is preferred. I focus on the results from the 2SLS estimation. The Durbin-Watson statistic in the 2SLS is 2.17, and the heteroskedastic-consistent (White robust) standard errors are used and reported. As in Goldberg and Knetter (1999), I initially included labor cost of the competitors and a time trend in the estimation, but these variables were eventually dropped from the model based on the significance levels of coefficient estimates and Akaike Information Criterion.

The coefficient estimate (-0.5638) of the quantity indicates that the U.S. non-GM soybean exporters' market margin is 56.4% in the Japanese import market. Table 7.6 provides the estimates of market margins in previous studies, which vary from as low as an insignificant number (statistically 0) to as high as 0.93. A market margin of 56.4% is relatively large, and such a margin is probably consistent with the market situation, because the average market share of U.S. non-GM soybeans in the Japanese market was as high as 73% from 2000-2011. On the other hand, this estimate may not be accurate because it is made through the traditional approach of the RDE model, which does not include the interaction between non-GM and GM soybeans.

Of interest also are the coefficients of the cost shifters of competing exporters (Canada and China) and the exchange rates between Japan and these two countries. The two coefficient estimates are positive, and these are not of the expected sign. A larger value of the exchange rate indicates a lower cost of the exporters in Canada or China, which should lead to a lower U.S. export price in terms of Japanese currency.

The coefficient estimate of the demand shifter, the personal disposable income in Japan, has the expected positive sign and is significant at the 1% level. This indicates that an increase

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[19] Wooldridge (2006) discusses the relationship between the R^2 measures from OLS and 2SLS estimation.

in the PDI for Japan results in a higher U.S. non-GM soybean export price in the Japanese market. This is consistent with the information that people of lower income consume more inexpensive, high-calorie foods and people of higher income consume more vegetables and soybeans in Japan (Ministry of Health, Labour and Welfare 2010).

The New Approach

I also include the interaction between non-GM and GM soybeans in the RDE model. The new model is estimated using both OLS and 2SLS, and the results are reported in Table 6.3. The adjusted R^2s for two models are 0.96 and 0.94, respectively. The Hausman-Wu test results reject the exogeneity of the quantity variable at the 1% level so that the 2SLS estimation is preferred. For the 2SLS estimation, the Durbin-Watson statistic is 2.19, and the heteroskedastic-consistent (White robust) standard errors are used and reported. The labor cost of the competitors and a time trend were included in the estimation, but the variables were then dropped from the model based on the significance levels of coefficient estimates and Akaike Information Criterion.

Now the coefficient estimate of the quantity is only -0.3286 and is statistically significant at the 1% level. Thus, the U.S. non-GM soybean exporters' market margin is 32.9% in the Japanese import market. Therefore, the inclusion of the interaction between non-GM and GM soybeans has greatly reduced the estimate of U.S. exporters' market margin from 56.4% to 32.9%. These results show that the RDE model without the inclusion of the interaction between non-GM and GM soybean overestimates U.S. non-GM soybean exporters' market margin. This result is consistent with that of Mulik and Crespi (2011) in which the Lerner index was lower after the entry of GM rice than that provided before the entry.

Another indicator is the coefficient estimate (0.7499) of the U.S. GM soybean price, which has the expected positive sign and is significant at the 1% level. This indicates that the model with the interaction between non-GM and GM soybeans is preferred.

The inclusion of the interaction between non-GM and GM soybeans also helps alleviate the problem associated with the unexpected signs of the coefficient estimates of the cost shifters of competition exporters (Canada and China) and the exchange rates between these exporters and Japan. Now one coefficient estimate, the exchange rate between Canada and Japan, has the expected negative sign, and the other coefficient estimate is still of the unexpected sign but is insignificant.

The coefficient estimate on the personal disposable income in Japan still has the expected positive sign and is significant at the 1% level. The magnitude (2.0) in this case with the interaction is smaller than that (3.5) in the benchmark case.

6.3 Results for the Residual Supply Elasticity Model

The Traditional Approach

The traditional approach is used to estimate the RSE model with OLS and 2SLS, and the results are reported in Table 6.4. The adjusted R^2s for two models were 0.99 and 0.96, respectively. The Hausman-Wu test results reject the exogeneity of the quantity variable at the 1% significance level. Thus, the 2SLS method is preferred. The Durbin-Watson statistic in the 2SLS is 2.03 and the heteroskedastic-consistent (White robust) standard errors are used and reported. I included labor cost of the import competitors and a time trend in the estimation, but those variables were eventually dropped based on the significance levels of coefficient estimates and Akaike Information Criterion.

The coefficient estimate of the quantity is 0.1914, and it is statistically significant. This means that the Japanese non-GM soybean importers' market margin is equal to the adjusted Lerner Index, 0.1914/(1+0.1914) = 16.1%, in the U.S. export market. Although no previous study has analyzed Japanese importers' mark-down, this estimate is probably comparable with other agricultural commodity trades shown in Table 6.6. For instance, Portuguese dried salted cod importers had a 10.5% mark-down (Andersen et al. 2008), and Chinese soybean importers had a 13% mark-down (Song 2006). On the other hand, this estimate may not be accurate, because it is from the traditional approach of the RSE model, which does not include the interaction between non-GM and GM soybeans.

Of interest also are the coefficients of the cost shifters of competing importers (the EU, China, and South Korea) and the exchange rates between the U.S. and these three countries. The coefficient estimates of the three exchange rates have the expected negative sign and are significant. A larger value of the exchange rate indicates a higher cost of the importers in the competing importing countries, which should lead to fewer U.S. exports to those countries and a lower price of U.S exports in the Japanese market.

The coefficient estimate of the supply shifter, the soybean-corn price ratio, has the expected positive sign and is significant at the 1% level. This indicates that an increase in the SCR of future prices will lead to higher soybean import prices. The coefficient estimate of the labor cost for the U.S. is insignificant, indicating that the labor cost for the U.S. had little influence on Japanese non-GM soybean import price.

The New Approach

I add the interaction between non-GM and GM soybeans into the RSE model and estimate the new model using both OLS and 2SLS. The results are reported in Table 6.4. The

adjusted R^2s for two models are both 0.99. The exogeneity of the quantity variable is rejected at

the 1% level by the Hausman-Wu test, so the 2SLS estimation is preferred. For the 2SLS

estimation, the Durbin-Watson statistic is 2.14, and the heteroskedastic-consistent (White robust)

standard errors are used and reported. Labor cost of the importing competitors and a time trend

were included in the estimation, but these variables were eventually dropped based on the

significance levels of coefficient estimates and Akaike Information Criterion.

The coefficient estimate of the quantity is 0.0627 and is statistically significant. Thus,

the Japanese non-GM soybean importers' market margin is the adjusted Lerner Index,

$0.0627/(1+0.0627) = 5.9\%$, in the U.S. export market. This means that the inclusion of the

interaction between non-GM and GM soybeans has largely reduced the estimate of Japanese

importers' market margin from 16.1% to 5.9%. These results show that the RSE model without

the inclusion of the interaction between non-GM and GM soybean overestimates the Japanese

non-GM soybean importers' market margin.

Another indicator is the coefficient estimate (0.9641) of the Japanese GM soybean price,

which has the expected positive sign and is significant at the 1% level. This result shows that the

model with the interaction between non-GM and GM soybeans is preferred.

The coefficient estimate of the exchange rate between the U.S. and South Korea has the

expected negative sign and is significant. A higher exchange rate increases the importing cost of

the importers in South Korea, which should result in fewer U.S. exports to South Korea and a

lower price of U.S exports in the Japanese market. The coefficient estimates of two other

exchange rates are insignificant.

The coefficient estimate on the soybean-corn price ratio still has the expected positive

sign and is significant at the 1% level. The magnitude (0.03) in this new approach is smaller

than that (0.32) in the traditional approach. The coefficient estimate of the labor cost of the U.S.

has the expected positive sign but is insignificant. This result is the same as that from the

traditional approach.

6.4 Results for the Two-Country Partial Equilibrium Trade Model

Finally, I estimate the two-country partial equilibrium trade model for the traditional

approach and the new approach including interaction between non-GM and GM soybeans. The

two-country partial equilibrium trade model includes both a RDE equation and a RSE equation.

I estimate the two-country partial equilibrium trade model to account for possible

contemporaneous correlation between the RDE equation and the RSE equation. The 3SLS

method is used to estimate this partial equilibrium trade model.

The Traditional Approach

The 3SLS results of the traditional version of the partial equilibrium trade model are

reported in Table 6.5. The adjusted R^2s of the RDE and RSE equation are both 0.96. The

autocorrelation is corrected for each equation. The heteroskedastic-consistent (White robust)

standard errors are used and reported. I included labor cost of the competitors and a time trend

in the estimation, but I then dropped these variables based on the significance levels of

coefficient estimates and Akaike Information Criterion.

The signs, magnitudes, and significance levels of the parameter estimates of the partial

equilibrium trade model are very close to the results of the traditional approach of the RDE

model and the RSE model. The coefficient estimates of the two quantity variables in the 3SLS

estimation of the partial equilibrium trade model show that the U.S. non-GM soybean exporters'

market margin is 56.5%, and the Japanese non-GM soybean importers' market margin (adjusted

Lerner Index) is equal to $0.192/(1+0.192) = 16.1\%$. These results are mostly comparable to the

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estimates of market margins in previous studies. For example, although the data and independent variables differ from those of this study, Andersen et al. (2008) showed that Norwegian exporters had a market margin 1.7 times larger than that of Portuguese importers (see Table 6.6). Yamaura (2011) showed that U.S. non-GM soybean exporters had a market margin five times larger than that of Japanese importers (see Table 6.6). However, I need to keep in mind that these estimated market margins of the traditional approach may not be accurate, because the interaction between non-GM and GM soybeans is not taken into account.

The New Approach

The 3SLS results of the partial equilibrium trade model with the interaction between non-GM and GM soybeans are reported in Table 6.5. The adjusted R^2s of the RDE and RSE equation are 0.95 and 0.99, respectively. I address the autocorrelation issue in both equations, and the heteroskedastic-consistent (White robust) standard errors are used and reported. The labor cost of the competitors and a time trend were included in the estimation, but these variables were eventually dropped from the model based on the significance levels of coefficient estimates and Akaike Information Criterion.

Estimation of both the RDE and RSE equations as systems in the partial equilibrium trade model improves the estimation of some coefficients. The coefficient estimate (-0.2613) of the exchange rate between the U.S. and China has the expected negative sign and becomes statistically significant in the 3SLS estimation of the partial equilibrium trade model. The coefficient estimate (0.0416) of another variable, the labor cost of the U.S., also becomes statistically significant in this new estimation of the system. The coefficient estimates of other variables are similar to those in the new approach of the RDE and RSE models.

In the 3SLS estimation, the coefficient estimate (-0.3322) of the quantity variable in the

RDE equation implies that the U.S. non-GM soybean exporters' market margin is 33.2%. Thus,

the inclusion of the interaction between non-GM and GM soybeans has greatly reduced the

estimate of U.S. non-GM soybean exporters' market margin from 56.5% to 33.2%. In addition,

the coefficient estimate (0.0641) of the quantity variable in the RSE equation shows that the

Japanese non-GM soybean importers' market margin (adjusted Lerner Index) is

$0.0641/(1+0.0641) = 6\%$. Thus, the estimate of importers' market margin has also been reduced

from 16.1% to 6% when the interaction between non-GM and GM soybeans is included in the

estimation.

The coefficient estimate (0.7401) of the U.S. GM soybean price in the RDE equation has

the expected positive sign and is significant at the 1% level. In the RSE equation, the coefficient

estimate (0.9684) of the Japanese GM soybean price also has the expected positive sign and is

significant at the 1% level. Both results indicate that the model with the interaction between

non-GM and GM soybeans is preferred.

The Lerner indices, which represent the market margins for U.S. exporters and Japanese

importers, calculated with the results of the 2SLS and 3SLS estimations, are included in Table

6.7. For comparing magnitudes of the Lerner indices for U.S. exporters and Japanese importers,

the adjusted Lerner indices for Japanese importers are calculated from both the 2SLS and 3SLS

estimations. The Lerner index for U.S. exporters is a mark-up over the price. Therefore, the

U.S. exporters' market margin is the difference between the price received and marginal cost.

The adjusted Lerner index for Japanese importers is a mark-down over marginal value.

Therefore, the Japanese importers' market margin is the difference between marginal value (i.e.,

Japanese consumer's price) and the price paid. The Lerner indices for U.S. exporters and the

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adjusted Lerner indices for Japanese importers by the 2SLS estimations are close to those produced by 3SLS estimations. This is consistent with previous studies, such as the Goldberg and Knetter (1999) study[20]. The Lerner indices for U.S. exporters are much greater than the adjusted Lerner indices for Japanese importers in all models by both methods, suggesting that the U.S. non-GM soybean exporters have much greater market margins than do Japanese non-GM soybean importers. More importantly, the estimation results in the RDE, RSE, and partial equilibrium trade models show that, when the interaction between non-GM and GM soybeans is *not* taken into account, the market margins of both U.S. exporters and Japanese importers are greatly *overestimated*. After taking the interaction into account, the new approach can significantly improve the accuracy of the estimates of those market margins of exporters and importers in international soybean markets. Therefore, the inclusion of the interaction between non-GM and GM commodities in the empirical models is necessary and preferred.

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[20] Goldberg and Knetter (1999) used three methods: 2SLS, SUR, and 3SLS.

Table 6.1: Test Results for Autocorrelation

	Coefficient	Std. Error	T-value	Probability	Result
The Traditional Approach					
RDE	0.9278	0.0149	62.29	0.000	*Reject H_0*
RSE	0.9484	0.0124	76.43	0.000	*Reject H_0*
The New Approach					
RDE	0.7829	0.0250	31.32	0.000	*Reject H_0*
RSE	0.9527	0.0111	85.57	0.000	*Reject H_0*

Table 6.2: White's Test Results for Heteroskedasticity

	White's Test Statistics	Probability	Result
The Traditional Approach			
RDE	202.41	0.000	***Reject H_0***
RSE	240.57	0.000	***Reject H_0***
The New Approach			
RDE	192.85	0.000	***Reject H_0***
RSE	206.27	0.000	***Reject H_0***

Table 6.3: Estimation Results of the RDE Models

Dependent Variables: Price of U.S. Non-GM Soybean exports (in Japanese Yen)

	The Traditional Approach		The New Approach	
	OLS	2SLS	OLS	2SLS
$Intercept$	26.8567**	3.8460***	23.6141***	5.4606***
	(12.2064)	(0.9458)	(6.2565)	(1.3643)
lnQ^{ex}	-0.0200*	-0.5638***	-0.0104**	-0.3286***
	(0.0116)	(0.1960)	(0.0088)	(0.1239)
$lnP^{GM,US}$			0.7855***	0.7499***
			(0.0737)	(0.0779)
$lnER^{JP,CA}$	-0.2908	0.4916*	0.0495	-0.0084
	(0.3501)	(0.2829)	(0.1596)	(0.1237)
$lnER^{JP,CH}$	0.9279***	1.0406***	0.2037	0.1738
	(0.3458)	(0.3096)	(0.1770)	(0.1537)
$lnIncome^{JP}$	1.5357*	3.5168***	1.6544***	2.0009***
	(0.9178)	(0.9535)	(0.4451)	(0.4999)
$Adjusted\ R^2$	0.9706	0.9598	0.9636	0.9427
DW	2.2339	2.1762	2.1183	2.1918
$Hausman-Wu$		9.78***		16.03***

*, **, and *** indicate coefficient estimates are statistically significant at the 10%, 5%, and 1% level, respectively.

The values in the parenthesis are heteroskedastic consistent standard errors.

Table 6.4: Estimation Results of the RSE Models

Dependent Variables: Price of Japanese Non-GM Soybean Imports (in U.S. Dollar)

	The Traditional Approach		The New Approach	
	OLS	2SLS	OLS	2SLS
$Intercept$	22.6517***	0.4530***	-0.3506	-0.0012
	(2.0187)	(0.0405)	(0.6524)	(0.0014)
lnQ^{im}	0.0066***	0.1914*	0.0007***	0.0627*
	(0.0024)	(0.0979)	(0.0001)	(0.0354)
$lnP^{GM,JP}$			0.9641***	0.9687***
			(0.0238)	(0.0240)
$lnER^{US,EU}$	-0.0221	-0.0290**	0.0044	0.0201
	(0.2971)	(0.0032)	(0.0241)	(0.0267)
$lnER^{US,CH}$	-4.6931***	-4.6063***	0.1757	0.3195
	(0.9711)	(0.9580)	(0.2109)	(0.2247)
$lnER^{US,KO}$	-0.5055***	-0.4663***	-0.0685***	-0.0877***
	(0.1954)	(0.1903)	(0.0237)	(0.0258)
$lnSCR^{US}$	0.3151***	0.3209***	0.0322***	0.0302***
	(0.0722)	(0.0735)	(0.0111)	(0.0111)
$lnLC^{US}$	0.1538	-0.0105	0.0085	0.0394
	(0.1163)	(0.1434)	(0.0105)	(0.0307)
$Adjusted\ R^2$	0.9882	0.9598	0.9952	0.9945
DW	2.0323	2.0283	2.1338	2.1419
$Hausman - Wu$		12.17***		23.48***

*, **, and *** indicate coefficient estimates are statistically significant at the 10%, 5%, and 1% level, respectively.
The values in the parenthesis are heteroskedastic consistent standard errors.

Table 6.5: Estimation Results (3SLS) of the U.S.-Japan Partial Equilibrium Trade Models

	The Traditional Approach		The New Approach	
	RDE eq.	RSE eq.	RDE eq.	RSE eq.
$Intercept$	3.8542***	0.4534***	5.6076***	-0.0011
	(0.8083)	(0.0600)	(0.9004)	(0.0007)
lnQ^{ex}	-0.5651***		-0.3322***	
	(0.1612)		(0.0863)	
$lnP^{GM,US}$			0.7401***	
			(0.0406)	
$lnER^{JP,CA}$	0.4915***		-0.0149	
	(0.1747)		(0.0922)	
$lnER^{JP,CH}$	1.0370***		0.1818	
	(0.2541)		(0.1441)	
$lnIncome^{JP}$	3.5260***		2.0563***	
	(0.8499)		(0.3546)	
lnQ^{im}		0.1920**		0.0641***
		(0.0917)		(0.0111)
$lnP^{GM,JP}$				0.9684***
				(0.0030)
$lnER^{US,EU}$		0.0276		0.0193
		(0.2417)		(0.0183)
$lnER^{US,CH}$		-4.6235***		-0.2613*
		(1.0935)		(0.1402)
$lnER^{US,KO}$		-0.4640**		-0.0919***
		(0.2177)		(0.0165)
$lnSCR^{US}$		0.3214***		0.0298***
		(0.0681)		(0.0051)
$lnLC^{US}$		-0.0112		0.0416**
		(0.2436)		(0.0172)
$Adjusted\ R^2$	0.9598	0.9601	0.9464	0.9946
DW	2.1867		2.1991	

*, **, and *** indicate coefficient estimates are statistically significant at the 10%, 5%, and 1% level, respectively. The values in the parenthesis are heteroskedastic consistent standard errors.

Table 6.6: Estimates of Inverse of Residual Demand Elasticity and Residual Supply Elasticity for Agricultural Commodities

Authors	Agricultural Commodity	Source Country	Destination Country	Coefficient of lnQ^{ex} (Inverse of Residual Demand Elasticity)	Coefficient of lnQ^{im} (Inverse of Residual Supply Elasticity)	Methods	Number of Observations
Carter et al. (1999)[a]	Wheat	U.S.	Japan	-0.93***		2SLS	86
		Canada		-0.49			88
		Australia		-0.08			85
Yang and Lee (2001)	Wheat	U.S.	South Korea	-0.384**		SUR	27
		Canada		-0.146***			
		Australia		-0.142**			
	Corn	U.S.		-0.054			
		China		-0.032			
Cho et al. (2002)	Wheat	U.S.	Indonesia	-0.004		SUR	22
			Japan	-0.112			
			South Korea	-0.614***			
			Malaysia	-0.121***			
			Philippine	-0.838***			
			Singapore	-0.160***			
Saghaian and Reed (2004)	Beef (Ribs)	Australia	Japan	-0.117**		SUR	94
		Canada		-0.171**			
		New Zealand		-0.187***			
		U.S.		-0.322***			
Poosiripinyo and Reed (2005)[b]	Chicken	Brazil	Japan	-0.253***		GLS	180
		China		-0.108			
		Thailand		-0.081			
		U.S.		-0.229***			
Song (2006)	Soybean	U.S.	China	-0.04***	0.13***	3SLS	74
Andersen et al. (2008)	Dried salted Cod	Norway	Portugal	-0.173***	0.105***	3SLS	156
Felt et al. (2010)	Pork 1st Subperiod	Denmark	Japan	-0.02*		GMM	148
		Canada		-0.05*			
		U.S.		0.01			
	2nd Subperiod	Denmark	Japan	-0.01			
		Canada		-0.04*			
		U.S.		-0.10*			
Mulik and Crespi (2011)	Basmati Rice 1st Period	India	U.S.	1.2%		3SLS	74
			U.K.	27.33%			
			Kuwait	13.84%			
	2nd Period	India	U.S.	2.31%			
			U.K.	19.12%			
			Kuwait	5.69%			
Yamaura (2011)	Non-GM Soybean	U.S.	Japan	-0.22*	0.04*	3SLS	60

a: Carter et al. (1999) have different observations in each model.

b: In Poosiripinyo and Reed (2005), residual demand elasticities of Brazilian and Chinese chicken are for whole birds, and those of Thai and U.S. chicken are for cuts of other types.

Table 6.7: Estimates of Lerner Indices (<u>Market Margins</u>) for U.S. Exporters and Japanese Importers

	2SLS	3SLS
The Benchmark Case		
U.S. Exporters' Lerner Index	56.38%	56.51%
Japanese Importers' Adjusted Lerner Index	16.07%	16.11%
The Case with Interaction		
U.S. Exporters' Lerner Index	32.86%	33.22%
Japanese Importers' Adjusted Lerner Index	5.90%	6.02%

Note: The Lerner index for Japanese importers is the inverse of residual supply elasticity: $LI^{im} = \frac{Q}{P} * \frac{\partial P}{\partial Q} = \frac{1}{\varepsilon_s}$.
The adjusted Lerner index for Japanese importers is the inverse of one plus residual supply elasticity:
$Adjusted\ LI^{im} = \frac{\frac{Q}{P} * \frac{\partial P}{\partial Q}}{1 + \frac{Q}{P} * \frac{\partial P}{\partial Q}} = \frac{1}{1 + \varepsilon_s}$.

Chapter 7 - CONCLUSIONS

In this dissertation, theoretical RDE, RSE, and two-country partial equilibrium trade models are developed, and the corresponding empirical models are specified for U.S.-Japan soybean trade. I compare two versions of these models: a new approach in which the interaction between non-GM and GM soybeans is taken into account and the traditional approach in which the interaction is ignored.

In each of the three models (the RDE model, the RSE model, and the partial equilibrium trade model), the traditional approach overestimates the market margin of U.S. non-GM soybean exporters and that of Japanese non-GM soybean importers. By taking into account the interaction between non-GM and GM soybeans, the new approach significantly reduces the estimates of the corresponding market margins of U.S. exporters and Japanese importers to improve the accuracy of such estimates. The high statistical significance of the coefficient estimate of the interaction term, the U.S. GM soybean price or the Japanese GM soybean price, in all three models also suggests that the new approach, which includes the interaction between non-GM and GM soybeans, is necessary and preferred.

The partial equilibrium trade model includes both an RDE equation and an RSE equation in a system to address the possible contemporaneous cross-equation correlation. Thus, the estimation results of the partial equilibrium trade model are further improved, compared to those of the RDE model and the RSE model. Using the traditional approach to estimate the partial equilibrium trade model, I find that the U.S. non-GM soybean exporters' market margin is 56.5% and the Japanese non-GM soybean importers' market margin is 16.1%. However, the results from using the new approach show that the market margins of U.S. exporters and Japanese importers are 33.2% and 6%, respectively. By taking the interaction between non-GM and GM

soybeans into account, the new approach improves the accuracy of the estimates of market margins of soybean exporters and importers. U.S. non-GM soybean exporters do have a significant market margin in international markets, but it is not as large as the one suggested by the traditional approach. Although Japanese non-GM soybean importers enjoy some market margin, it is relatively small.

The theoretical and empirical models and results in this dissertation can be useful for industry participants in international soybean markets, academic researchers, and government policy makers. Japan is an important importer of world soybean trade. Japan imports non-GM soybeans to make soybean food products in Japan such as tofu or natto, which are the main food choices for Japanese consumers. Since U.S. non-GM soybeans account for over 70% in the Japanese import market and over 65% in Japanese non-GM soybean consumption[21], the Japanese soybean consumption has heavily depended on U.S. non-GM soybeans. Additionally, the U.S. GM soybean cultivation acreage has increased in the past 15 years, and over 90% of soybean acreage was dedicated to GM soybeans in 2011. With the decreasing non-GM soybean production in the U.S., Japanese non-GM soybean importers have to pay higher premiums for U.S. non-GM soybeans. Given the significant share of U.S. soybeans in the Japanese soybean import market, it is usually believed that U.S. non-GM soybean exporters could influence the market price while Japanese non-GM soybean importers were just price takers. However, my results indicate that, although U.S. non-GM soybean exporters have some market power, it is not as great as that suggested through the traditional approach. It is also shown that Japanese non-

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[21] Japanese non-GM soybean consumption includes Japanese domestic soybeans and imports. Japanese domestic soybean productions are all non-GM.

GM soybean importers can still influence import price, albeit to a smaller extent. All of these results and information should prove useful for industry participants in related markets.

Since the beginning of this century, other large agricultural exporting countries such as Brazil and Argentina have been increasingly stronger competitors to the U.S. in international markets of agricultural commodities (Yang and Lee 2001; Poosiripinyo and Reed 2005; Song 2006; Felt et al. 2010). Better policies based on new and improved research are needed to assist agricultural producers and exporters in the U.S. My new estimation results for international soybean markets can prove helpful not only to U.S. policy makers but also to other large agricultural exporting country policy makers. Also, new estimation results are useful for Japanese and other policy makers in large agricultural importing countries (i.e., the EU, China, South Korea, or Mexico). The empirical models and estimation results can also provide some references for academic researchers analyzing competition issues for differentiated products in international markets of agricultural commodities.

Three possible extensions of this research are empirical studies on the market margins of exporters and importers in other major soybean exporting and importing countries, empirical studies on international markets of other agricultural commodities, and studies on international markets with horizontal or mixed product differentiation. When non-GM and GM soybean data from other large soybean-producing countries such as Argentina, Brazil, and China and the data from other large soybean-importing countries such as EU, China, and South Korea are available, empirical studies using the new approach on the market margins of exporters and importers of those countries can provide much needed and useful results. Similar studies on international markets of other non-GM and GM commodities such as corn, cotton, and canola can also offer practical insights. This dissertation includes a new approach based on capturing the interaction

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between two vertically differentiated products (non-GM and GM soybeans). Future research on

the interaction of products with other types of product differentiation such as horizontal or mixed

product differentiation could be useful for international markets of products with those special

characteristics.

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