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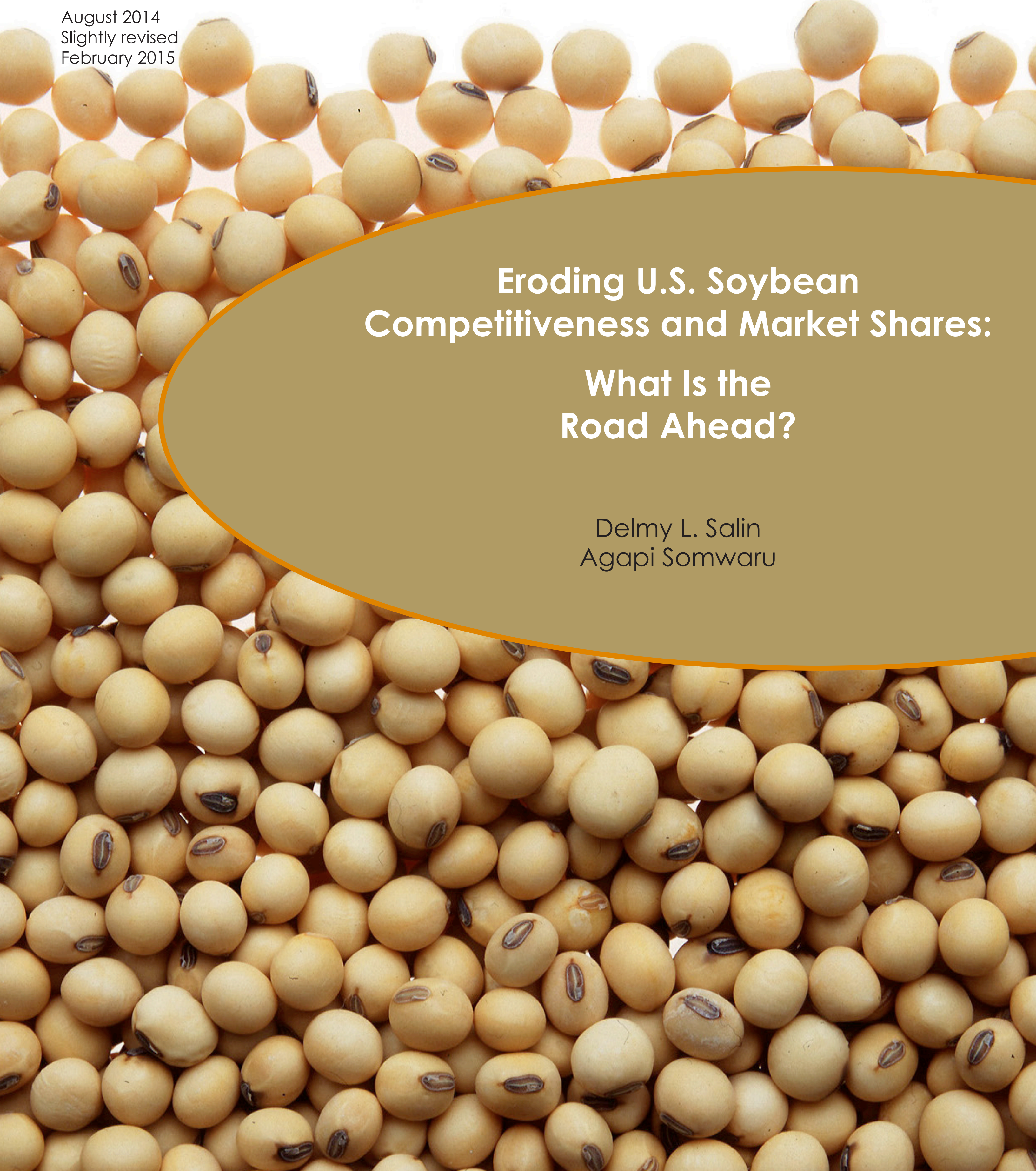

Eroding U.S. Soybean Competitiveness and Market Shares:

What Is the Road Ahead?

Delmy L. Salin
Agapi Somwaru

For more information: Delmy.Salin@ams.usda.gov

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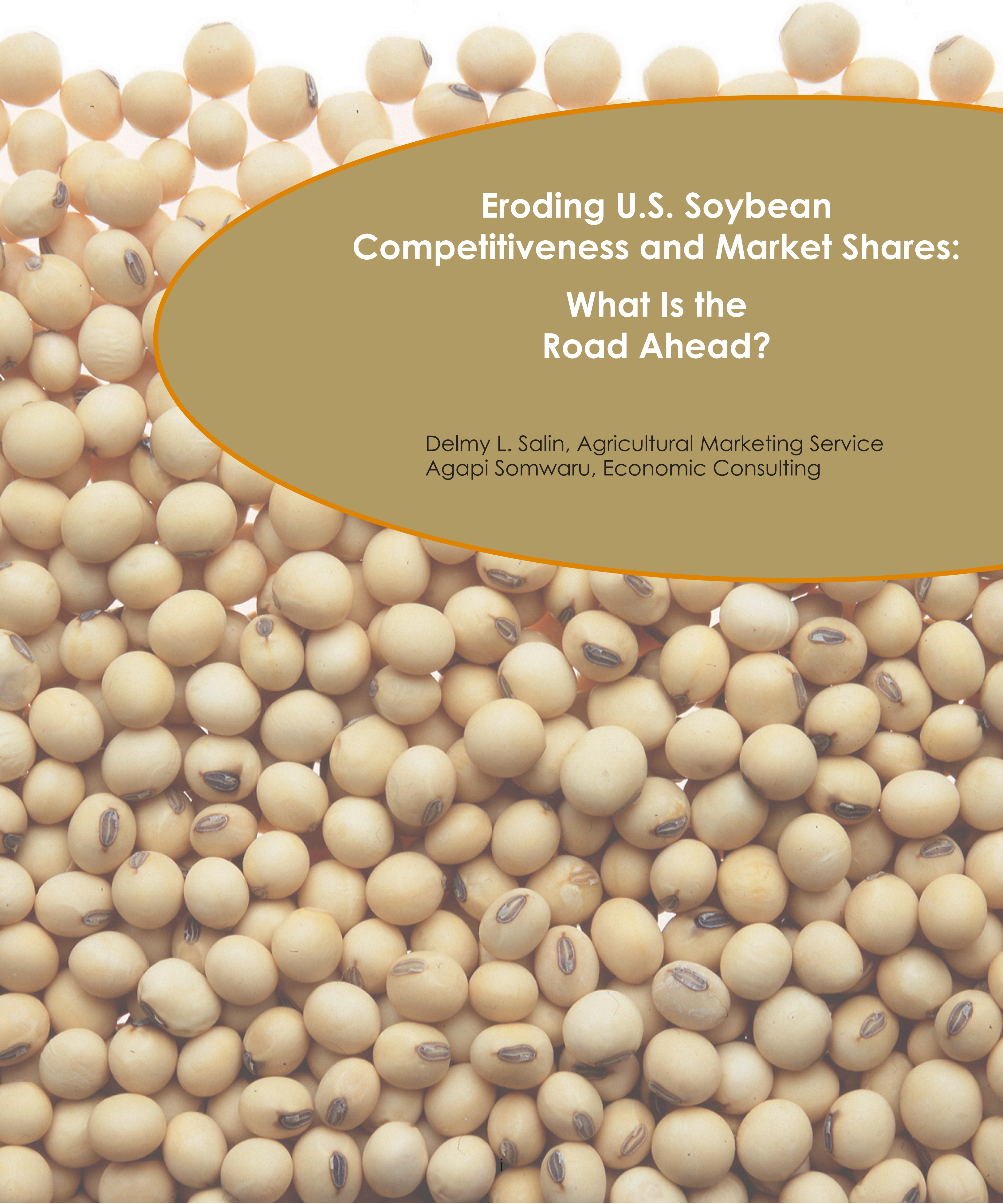
What Is the Road Ahead?

Delmy L. Salin, Agricultural Marketing Service
Agapi Somwaru, Economic Consulting



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Abstract

Although the United States is still the dominant country in the world soybean market, the U.S. market share of soybean world trade is declining. This study quantifies the decline that result from changes in ocean freight rates and Brazil's infrastructure development. The results suggest that the U.S. world market share could further decline by 18.5 percentage points without improvements in the U.S. infrastructure from the farm to the port. A decline of 1 percent in the U.S. soybean market share is equivalent to $500 million lost in export sales, based on a world soybean trade volume of 100 million metric tons and today's price of soybeans. Market shares for the United States, Argentina, and Brazil converge and reach equilibrium over the study period, despite the variability of the ocean freight rates.

Contents

Executive Summary

Since the 1990s, the United States, the world's leading producer of soybeans, has lost market share to Argentina and Brazil. The United States' market shares declined from 71 percent in 1992 to 47 percent in 2012. The United States has lost its cost advantage over South America, but did not price itself out of the market because increases in the world soybean market result in the growth in its market share as the dominant country. For the last 13 years, China, the world's largest soybean importer, has been responsible for all the growth in the global soybean trade. At the farm, the 2013 per-bushel total production costs in the main producing areas of the U.S. Midwest averaged $9.62 per bushel, compared with $7.14 per bushel in Argentina, $8.15 per bushel in the Brazilian State of Mato Grosso, and $7.68 per bushel in Paraná. Although variable costs in the United States are lower, fixed costs—due to land values—are much higher than in Mato Grosso and Paraná. However, transportation costs can at times give South America soybean exports a competitive edge over U.S. soybeans.

The challenge to the United States as the dominant country in the world soybean market depends on the competing countries' ability to reduce their transportation cost by improving their infrastructure capacity. Differences in transportation costs can make South America soybean exports more profitable than those of the United States, diverting trade from the United States to Brazil or Argentina, or the reverse. Since 2007, the Brazilian government began comprehensive infrastructural improvement, with major institutional and regulatory changes to facilitate agricultural exports. In 2013, Brazil surpassed U.S. soybean exports for the first time, becoming the top world soybean exporter. The road ahead for U.S. soybean competitiveness is uncertain. It is not clear how much Brazil infrastructure will improve or when. We only know that it is improving and Brazil has been gaining in soybean market share as a result. We also do not know how much Brazil's freight rates might be reduced in the future as a result of improvements to its transportation infrastructure.

This study quantifies the changes of the United States' market shares over time in the world soybean market using a dynamic model. The study also examines the effects of ocean freight spreads and evaluates the possible impact of Brazil's infrastructural improvements on the U.S. position in the soybean global market by using sensitivity (multivariate) analysis. Due to data availability, the base estimated model uses ocean freight rates and trade data for the period from 1992 to 2012.

The dynamic model's results indicate that the United States is the dominant country in the world soybean market. Brazil's and Argentina's relative importance in the world soybean market are considered the major competing countries. Other competing countries are Paraguay and Canada. The dynamic model's analysis shows that the market shares converged. This implies that the U.S. maintains its leading position despite the variability of ocean freight rates over the period under study.

The dynamic model's results suggest that, under current conditions, the U.S. market share could be stable as the overall market grows. However, the initial position of the dominant country eroded and the market shares of the competing countries grew faster than the dominant country. Note that the same results were obtained when changes in ocean freight rates over the estimated period were considered. This model's outcomes suggest that the ocean freight rates are not a significant force in the shares of the world soybean market. With overall increase of the global soybean market Argentina and Brazil attained a larger market share as long as there is no indication that Argentina or Brazil might limit production to maintain a stable international market price environment.

The sensitivity analysis findings indicate that the U.S. world soybean market share could further decline by 18.5 percentage points without improvements in the U.S. infrastructure from the farm to the port. In the future, if Brazil's infrastructure improves and there is a reduction in ocean freight rates to the point where they are similar to the rates from the U.S. Pacific Northwest (PNW), then sensitivity (multivariate) analysis suggests that Brazil's exports will probably increase relative to those of the United States. In this case, Brazil's global export market shares for the period of 1992–2012 would have increased from 6 percent in 1992 (or 47 percentage points) to 52 percent (or 27 percentage points) in 2012, primarily a result of possible structural improvements in Brazil. The sensitivity (multivariate) analysis shows the United States' world market share would have declined by 2 percentage points in 1992 to almost 18 percentage points in 2012 as a result of assumed structural changes in Brazil and no improvements in the U.S. infrastructure. For example, assuming the world soybean trade is 100 mmt (WASDE September 2013), a 1-percent decline in the U.S. soybean market share is equivalent to half a billion dollars lost in export sales (1 million metric tons times $500/mt).

The sensitivity analysis shows that the market penetration depends on the underlying technology and infrastructure from farm to port. This implies that, in the future, the United States' infrastructural improvements are critical to maintain its competitiveness and market dominance in the world soybean market. Potential improvements in U.S. infrastructure from farm to port would maintain the U.S.'s leading role in the global soybean market. Other things equal, this would probably result in higher income for farmers.

Objectives and Organization

This study: (1) quantifies the dynamic changes of the United States' market shares in the world soybean market, (2) examines the effects of ocean freight spreads on underlying market structures where the United States operates as a dynamic dominant firm model, and (3) analyzes the impact of Brazil's potential infrastructural development on the world soybean market.

The study begins with an analysis of the structure of the shipping industry and its relationship to the world economy, focusing on the dry-bulk market segment because of its importance to U.S. agricultural exports. Second, it examines the characteristics of the United States and South America dry-bulk grain markets. Third, a dynamic model that incorporates time using difference equations analyzes the behavior of the underlying market interactions in a world market where the United States is the dominant soybean supplier. The model estimates the impact of changes in ocean freight spreads on the behavior of the dominant and the competing countries in the global soybean market. Fourth, it performs a sensitivity analysis[1] of the potential impact of Brazil's infrastructural development on the soybean global market. The final section contains the conclusion and recommendations for further research.

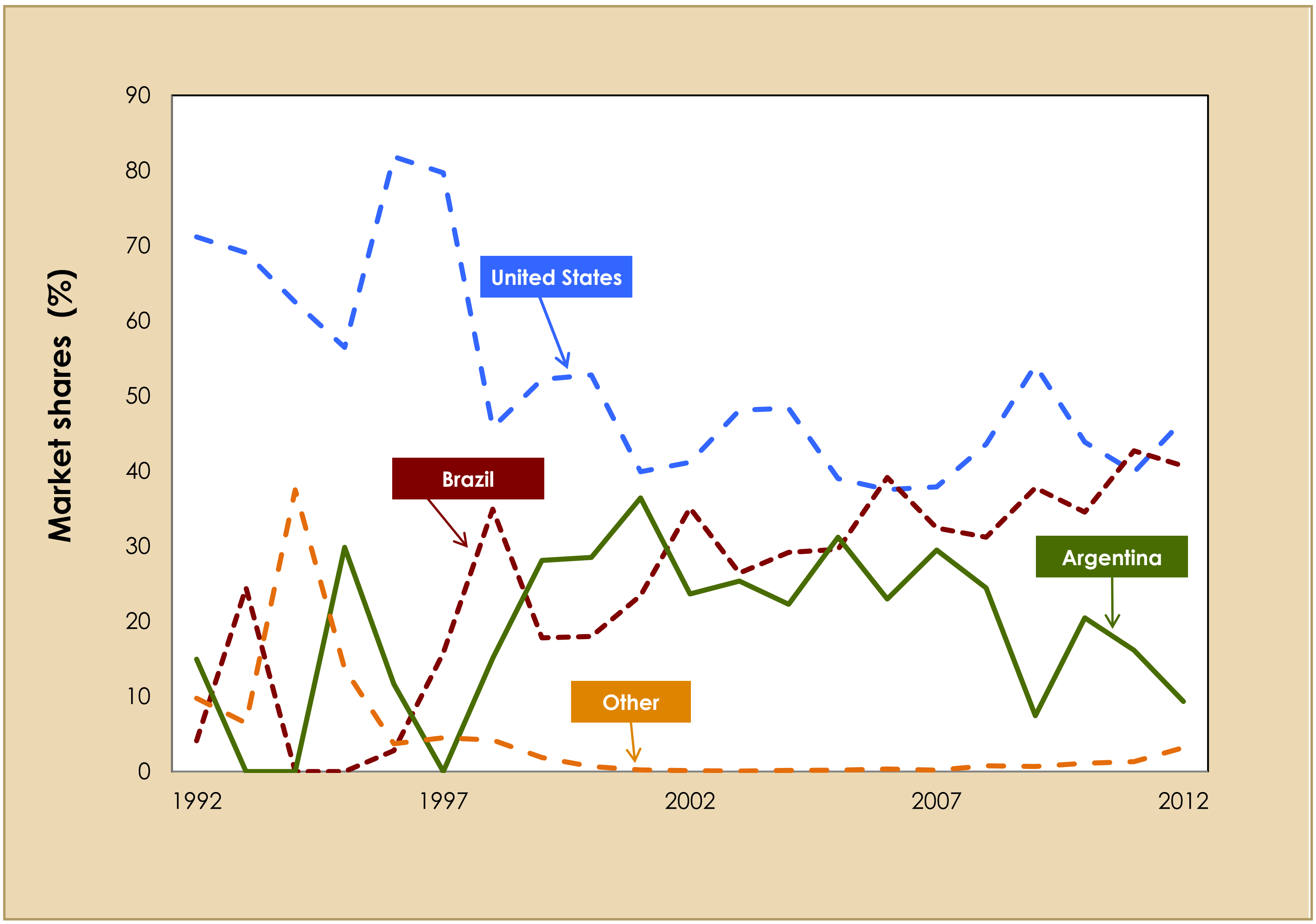
1 Sensitivity analysis is an economic modeling tool to analyze probable events by considering alternative possible outcomes. In this case, there is not a clear understanding of how much Brazil infrastructure will improve and when. We only know that is improving. We also do not know how much Brazil's freight rates will be reduced. Unlike scenario analysis, which assesses one uncertain condition at a time, sensitivity analysis can assess changes of several uncertain conditions at the same time to evaluate an outcome.

Market Shares in the World Soybean Market

For decades, the United States has had a dominant market share of the international soybean trade. Argentina and Brazil have been smaller competitors of the United States. However, since the 1990s, Argentina and Brazil have captured a growing share of the international soybean market. In 2000, these two countries accounted for 47 percent of the world's soybean market and the United States accounted for 53 percent.[2] The United States' market shares declined from 71 percent in 1992, stabilized 8 years later at 53 percent, and rested at 47 percent in 2012 (figure 1 and table 8). While the market grew, nominal prices for soybeans increased in the global market, as measured by CIF Rotterdam[3] prices (figure 2).

The United States has lost its cost advantage over South America, but did not price itself out of the market because increases in the world soybean market result in the growth in its market share as the dominant country (figure 1). From 2005-2013, the world soybean trade volume increased 73 percent from 63.8 to 110.6 million metric tons (mmt), respectively (FAS 2014). Argentina and Brazil's costs of producing and transporting soybeans are competitive with the United States, making their exports also competitive (USITC 2012; Schnepf, R., E. Dohlman, and C. Bolling, 2001; and Dohlman, 2000). The exports of both countries have been rising.

Figure 1. Market shares of the United States, Brazil, and Argentina in the world soybean market

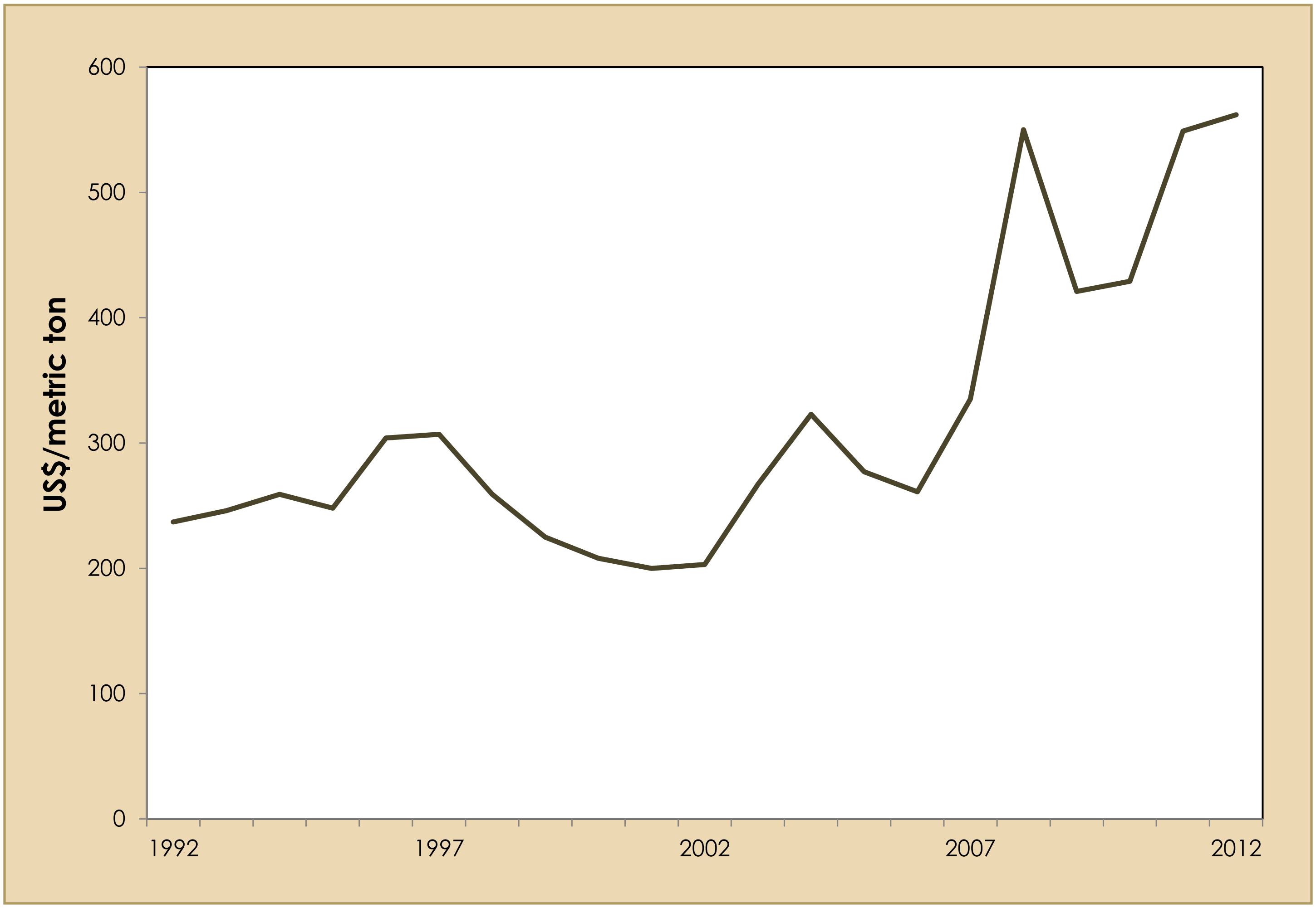


Source: USDA/Foreign Agricultural Service/Circular Series

2 Other major competing countries include Paraguay and Canada. Uruguay, Ukraine, China, Bolivia, and Russia are proportionally smaller participants in the world soybean market shares (FAS 2014).

3 The cost of the goods, insurance, and freight delivered to Rotterdam.

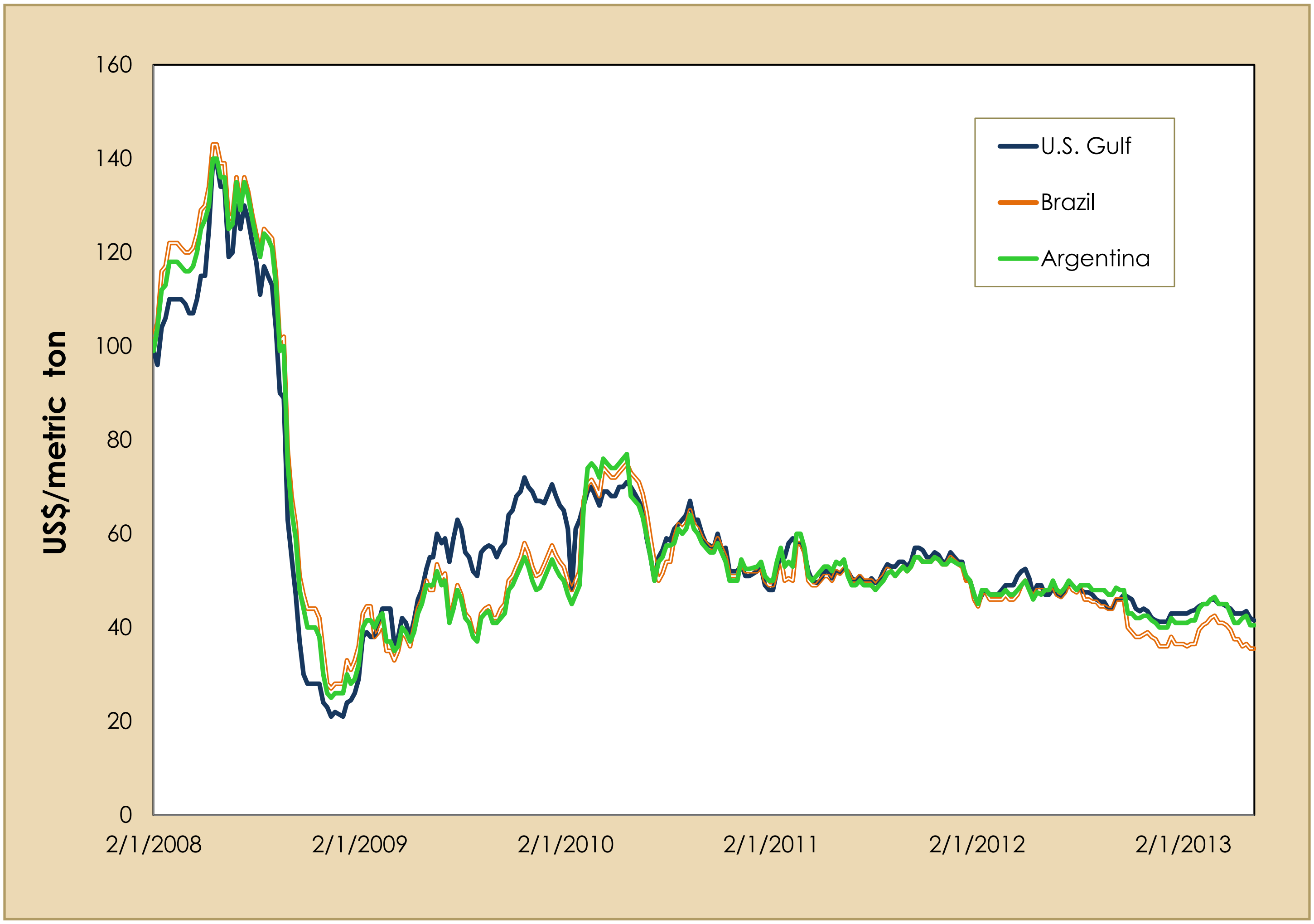
Figure 2. CIF* Rotterdam price for soybeans



* The cost of the goods, insurance, and freight delivered to Rotterdam
Source: USDA/Foreign Agricultural Service/Oilseed-Trade

At the farm, per-bushel total production costs in the main producing areas of the U.S. Midwest averaged $9.62 per bushel (ERS 2013), compared with $7.14 per bushel in Argentina (DIMEAGRO 2013). Per-acre costs in Brazil demonstrate a similar comparative advantage. For example, the cost is $8.15 per bushel in the Brazilian State of Mato Grosso and $7.68 per bushel in Paraná (CONAB 2013). Although variable costs in the United States are lower, fixed costs—due to land values—are much higher than in Mato Grosso and Paraná. However, transportation costs can at times give South America soybean exports a competitive edge over U.S. soybeans (figure 3).

Figure 3. Weekly freight rates



Source: O'Neil Commodity Consulting

China soybean imports represent about two-thirds of the soybean global trade, up from 25 percent in 2000 (FAS 2013). For the last 13 years, China's increased imports have been responsible for all the growth in the global soybean trade. For this reason, the analysis focuses on the soybean trade with China as the destination. U.S. soybean exports account for 44 percent of the Chinese soybean market. Brazil and Argentina soybean market share of China's imports are 41 and 10 percent, respectively. Soybeans account for 80 to 90 percent of U.S. bulk agricultural exports to China, representing 33 mmt in 2012. China is the United States' largest agricultural export market, accounting for 18 percent of total U.S. agricultural exports and valued at $25.9 billion (FAS 2014). Transportation costs account for about 15 percent of the total landed cost[4] of shipping U.S. soybeans to Shanghai, China, and 14 to 28 percent of the cost of shipping Brazilian soybeans (Salin 2013). Ocean transportation represents about 52 percent of the total transportation cost from the U.S. Gulf to Shanghai and 27 percent from the Pacific Northwest (PNW) (Salin 2013, Olowolayemo 2012), and 30 to 65 percent of the total cost of shipping from Brazil to Shanghai.

4 The landed cost is the total cost of goods to a buyer, including the cost of transportation without handling costs.

South American and U.S. soybeans compete with one another because each produces genetically modified (GM) soybeans. U.S. soybean production is supported by a complete and balanced transportation system that includes all major modes of transportation (truck, rail, barge, and ocean vessel) from the farm to major export markets (USDA 2010). For that reason, the production cost advantages of Brazil and Argentina did not undermine the dominant position held by the United States in the world soybean market.

The challenge to the United States as the dominant country in the world soybean market depends on the competing countries' ability to improve their infrastructure capacity and reduce their transportation cost. Consequently, transportation cost and infrastructure improvements are critical factors in the soybean world trade structure. Small differences in transportation costs can make South America soybean exports more profitable than U.S. soybeans, diverting soybean trade from the United States to Brazil or Argentina, or vice versa.

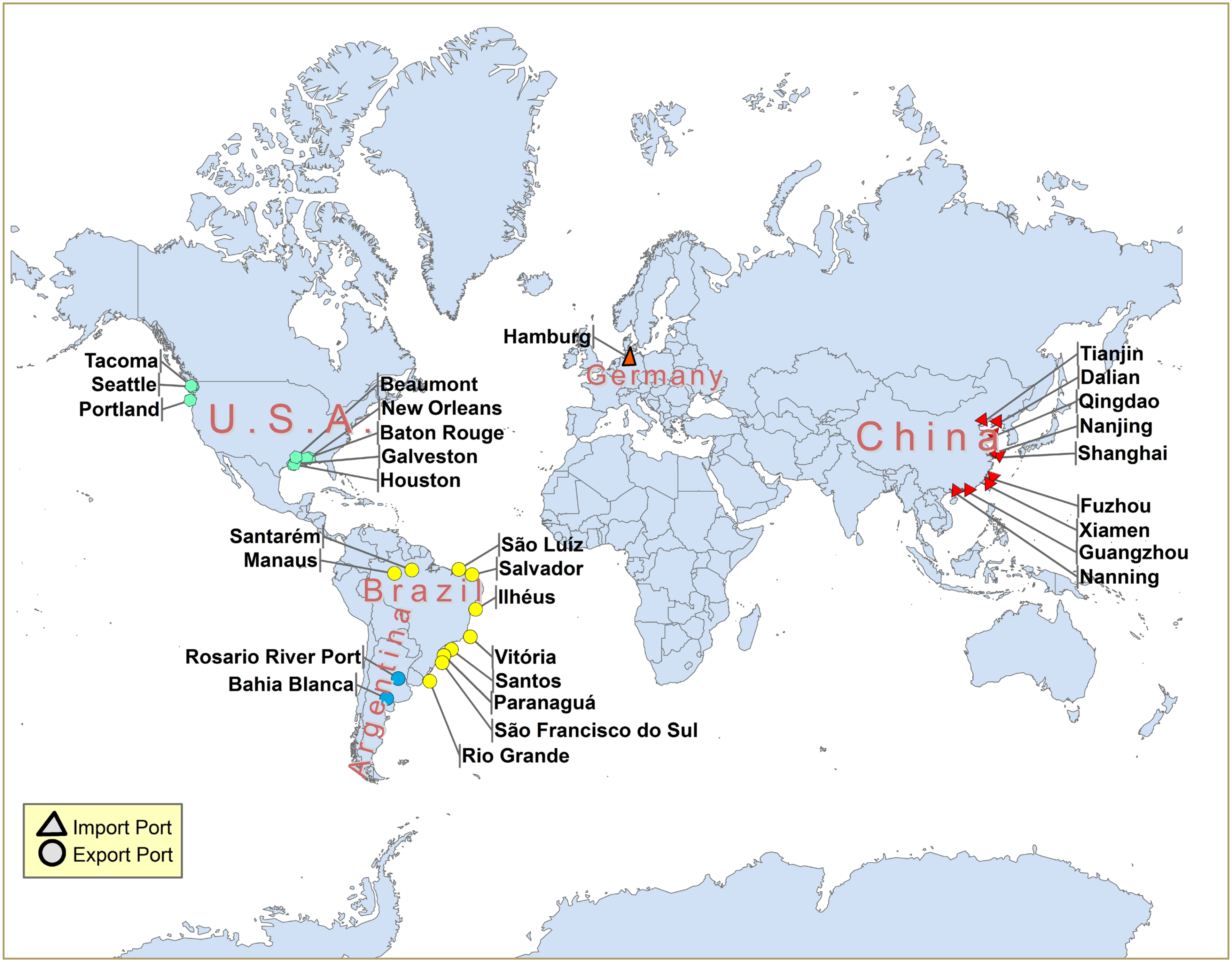
In 2007, the Brazilian government began a comprehensive infrastructural improvement strategy, with major institutional and regulatory changes to facilitate agricultural exports (Salin 2013-14). In 2013, Brazil surpassed U.S. soybean exports for the first time, becoming the top world soybean exporter. The road ahead for U.S. soybean competitiveness is uncertain. It is not clear how much Brazil infrastructure will improve or when. We only know that it is improving and Brazil has been gaining in soybean market share as a result. We also do not know how much Brazil's freight rates might be reduced in the future as a result of improvements to its transportation infrastructure.

Changes in ocean transportation costs are important to the agricultural sector because roughly 81 percent of U.S. agricultural exports are shipped by ocean carriers to major export markets (McGregor 2013). The United States exports about 25 percent of its grain production, mostly through ports located in the U.S. Gulf[5] (56 percent) and the PNW (28 percent) (figure 4).

The major grain ports in the U.S. Gulf are New Orleans, Baton Rouge, Houston, Beaumont, and Galveston (figure 4). The PNW grain ports are Portland, Seattle, Tacoma, and Kalama. Brazil's largest soybean export ports are Santos, Paranaguá, and Rio Grande. Argentina's ports are Bahia Blanca and Rosario River (figure 4). China's main entry gateways for U.S. grain are the ports of Shanghai, Qingdao, Nanjing, Nanning, Tianjin, Dalian, Huangpu, Xiamen, Fuzhou, and Guangzhou (figure 4).

5 The U.S. Gulf includes the East Gulf, the Mississippi River, and North and South Texas.

Figure 4. Major export and import ports for world soybeans



The World Economy and the Shipping Industry

World economic growth is the main factor determining ocean transportation demand, accounting for about 80 percent of the annual changes in shipping tonnage demand (RS Platou 2007-2011). Shipping demand is also influenced by exchange rates, shifts in international trade patterns, and seasonal variations in production and consumption (USDA 2010). From 2002 to 2008, the world merchant fleet operated at full capacity because there was a shipbuilding capacity shortage, resulting in record freight rates, as well as record prices for secondhand and most new-built vessel types (tables 1 and 2) (Platou 2008).

Table 1. World economic and shipping indicators, 2005-2013

		2005	2006	2007	2008	2009	2010	2011	2012	2013[1]
		World dry bulk carriers charter rates								
Vessel Type	**Size (dwt)[2]**	$/day								
Handysize	37,000	16,690	15,860	27,210	30,950	12,000	16,500	12,596	8,725	8,900
Supramax	55,000	23,040	21,800	43,945	48,315	15,200	20,800	14,888	9,533	9,500
Panamax	75,000	27,855	27,855	52,230	56,475	19,700	25,300	14,863	9,592	9,000
Capesize	170,000	49,335	49,335	102,875	116,175	35,300	40,300	16,354	11,600	11,700
Vloc[3]	200,000+						41,500	17,500	11,925	11,800
World economy growth rate[1] (percentage change)										
World GDP Growth		4.7	5.2	5.3	2.7	-0.4	5.2	3.9	3.2	2.9
World trade		7.6	9.2	7.9	2.8	-10.6	12.8	6.1	2.7	2.9
World merchant fleet[2] (percentage changes)										
Tonnage demand		5.8	7.5	9.1	6.4	-2.5	11	7.7	6.5	4.9
Fleet growth		7.2	7.9	8	7.8	7.7	7	8.2	7.3	5.3
Utilization rate		90.7	90.3	91.2	90.0	81.5	85.1	84.7	83.9	83.7

[1]As of August 2013
[2]Deadweight carrying capacity (dwt): The weight of cargo a ship is able to carry when immersed to the appropriate load line, expressed in tons, including total weight of cargo, fuel, fresh water, stores, and crew.
[3] Vloc: Very Large Ore Carriers
Source: Drewry Maritime Research. Shipping Insight. Monthly Analysis of the Shipping Market. September 2013. International Monetary fund (IMF), Accessed October 23, 2013. RS Platou monthly,www.plaou.com

Since the end of 2010, tonnage demand has been marginally lower than the fleet growth rate, with an average vessel-capacity-utilization rate of 84.6 percent (table 1). In 2012, Handysize, Supramax, and Panamax[6] freight rates dropped 70 to 83 percent from their 2008 peak (table 1). Slow economic growth resulted in the lowest vessel-capacity-utilization rate of 83.8 percent since the 2008-09 economic crises. The price of newly built vessels declined almost 50 percent from the 2008 peak, especially for Panamax and Capesize vessels (table 2). Low prices encouraged vessel owners to buy larger and more energy-efficient vessels, resulting in an increase in the fleet supply. In addition, the major shipbuilders were reluctant to cancel or postpone deliveries placed prior to 2009 because they wanted to maintain shipyard employment. This reluctance pushed world transport capacity upward and lowered shipping costs (UNCTAD 2012).

Table 2. Vessel new building prices, 2005-2013

		2005	2006	2007	2008	2009	2010	2011	2012	Aug-2013
Vessel Type	**Size (dwt)[1]**	**$/mt**								
Handysize	37,000	21.1	22.3	33.2	38.0	29.1	24.8	22.9	19.6	19.1
Supramax	55,000	30.9	31.5	40.7	47.1	34.9	31.8	30.0	26.0	25.1
Panamax	75,000	35.2	35.7	46.6	54.4	38.7	35.3	32.6	27.4	25.9
Post-Panamax	95,000			50.2	58.8	43.0	38.4	34.5	30.4	28.9
Capesize	170,000	61.6	62.1	83.9	97.3	69.0	57.9	51.6	46.0	45.1
Vloc[2]	200,000+						65.4	59.3	52.3	51.1

[1] Deadweight carrying capacity (dwt) is the weight of cargo a ship is able to carry when immersed to the appropriate load line, expressed in tons, including total weight of cargo, fuel, fresh water, stores, and crew ship.
[2] Vloc: Very Large Ore Carriers
Source: Drewry Maritime Research, Shipping Insight, Monthly Analysis of the Shipping Market, September 2013

6 These are vessel sizes. See table 1 for definitions.

The Structure of the World Cargo-Carrying Fleet

As of August 2013, the world's cargo-carrying fleet consisted of 23,734 vessels with nearly 1.30 billion deadweight tons (dwt) (table 3). Dry bulk and container ships accounted for more than half the world fleet, representing 38 percent of the orderbook[7] fleet capacity (table 3). In 2012, the world cargo fleet average age per dwt was 19 years; about half of the bulk carriers were less than 5 years old (UNCTAD 2012 and Drewry Maritime Research 2012). The expected useful life of a bulk carrier is about 25 years under normal market conditions (O' Neil 2014). China is the largest shipbuilder, followed by the Republic of Korea, Japan, and the Philippines (UNCTAD 2012). China and the Republic of Korea are the largest builders of bulk and container carriers, respectively.

In 2012, most of the world's cargo fleet was registered in Panama, Liberia, Marshall Islands, Hong Kong, Singapore, Bahamas, Malta, Greece, China, Cyprus, and Japan (DOT 2013). However, companies that own and operate vessels do not have to be located where the vessel is registered (USDA 2010). Based on total gross tonnage, the parent companies of the top 10 fleets are located in Japan, Greece, Germany, China, United States, United Kingdom, Norway, Republic of Korea, Denmark, and Hong Kong (IHS 2010, IMO 2012, and USDA 2010).

Table 3. World cargo-carrying fleet—orderbook and delivery schedule, 2013–2017

Vessel Type	Fleet size as of Aug. 2013		Orderbook		Orderbook capacity as % of fleet
	No. of vessels	Capacity (1,000 dwt)	No. of vessels	Capacity (1,000 dwt)	
Dry bulk[1]	9,728	705,617	1,582	125,939	17.8
Container[2]	5,122	16,866	459	3,430	20.3
Oil Tanker[1]	3,217	422,707	381	44,792	10.6
Chemical[1]	4,105	88,075	242	8,340	9.5
LPG[3]	1,199	20,781	100	3,460	16.7
LNG[3]	363	53,907	113	18,273	33.9
Total	23,734	1,307,953	2,877	204,234	

[1] Dry bulk, oil tanker, and chemical sizes are in 1,000 dwt; Deadweight carrying capacity (dwt) is the weight of cargo a ship is able to carry when immersed to the appropriate load line, expressed in tons, including total weight of cargo, fuel, fresh water, stores, and crew. Source: Illustrated Dictionary of Cargo Handling, 2nd edition, Peter R. Brodie, 1996.
[2] Containership sizes are given in 1,000 TEU capacity; a Twenty Foot Unit (TEU) is equivalent to a 20-foot shipping container.
[3] LPG and LNG (Liquid Petroleum Gas and Liquid Natural Gas) ship sizes are given in 1,000 cubic meter (cbm) capacity.
Source: Drewry Maritime Research, Shipping Insight, Monthly Analysis of the Shipping Market, September 2013

7 "Orderbook" refers to ships that have been ordered, but have not yet been delivered.

Bulk Shipping

U.S. grain is mostly exported in ocean bulk vessels. In 2012, bulk vessels carried 92 percent of total waterborne grain tonnage exports, with 8 percent being transported in containers (McGregor 2013). The world dry bulk carrying fleet consists of 9,728 vessels with a capacity of 705.6 million dwt (table 4). The dry bulk shipping market consists of two categories: major and minor bulk cargoes (UNCTAD 2012). Major bulk commodities such as iron ore, coal, and grain are typically transported by large Capesize and Panamax vessels. Grain is typically transported in Panamax and smaller vessels. This category accounts for about two-thirds of the world bulk market. Minor bulk cargoes, such as fertilizers, steel products, construction materials (cement and aluminum), non-grain agricultural products, forest products, and minerals (mostly phosphate rock), are most often shipped by smaller Handymax and Handysize vessels. Minor bulk represent one-third of the world bulk market. Bulk vessels are classified by size (USDA 2010, UNCTAD 2012, and Ariston 2013):

- Handysize vessels represent about 12 percent of the bulk cargo capacity and include ships of 10,000–40,000 dwt. These ships are frequently used to transport grain but can load more than 30 cargo types in shallow waters or low-volume trade routes.
- Handymax and Supramax together account for nearly 22 percent of the bulk fleet and include ships of 40,000–60,000 dwt.[8] They serve the markets and ports that are too small to receive Panamax shipments. Handymax and Supramax type vessels can come equipped with cranes for loading and unloading (geared) or without cranes (ungeared).
- Supramax vessels are larger in size than the Handymax but smaller than the Panamax vessels. Based on the type of cargo, Supramax mainly competes with Panamax vessels in small and medium-size ports with insufficient drafts, berth length overall (LOA), or the storage capacity to handle 58,000 mt of cargo or larger.
- Panamax represent 20 percent of the bulk fleet capacity. They carry 60,000–80,000 dwt and are small enough to transit the Panama Canal. They are generally used to ship grain to Europe and Asia, but they also carry coal, iron ore, and some minor bulks such as steel products, cement, and fertilizers.
- Post-Panamax are larger vessels designed to cross the Panama Canal after its expansion in 2015. Post-Panamax ships account for about 7 percent of the bulk segment with a capacity of 80,000–110,000 dwt.
- Capesize is the largest segment of the bulk market, accounting for 31 percent of the bulk fleet capacity. It includes vessels of 110,000–200,000 dwt. Capesize vessels are too large to cross the Panama and Suez Canals. Their navigation is restricted to a few ports, most of which are located in Brazil, Australia, and China (UNCTAD 2012). Iron ore and coal are typically transported by these large vessels.
- Very Large Ore Carriers (Vloc) are vessels of 220,000 or more dwt; they represent 8 percent of the world bulk fleet. They usually transport iron ore and coal.

8 A Handymax vessel typically has a capacity of 35,000- 49,000 dwt (O'Neil 2013). Supramax vessels have a capacity of 50,000-60,000 dwt, accounting for about 90 percent of the new-built Handymax vessels (Maritime Connector 2013).

Table 4. World dry bulk carrying fleet and orderbook delivery schedule, 2012-2017

Vessel Type	Size (dwt)[1]	Fleet size as of Aug. 2013		Orderbook[2]		Orderbook capacity as % of fleet
		No. of vessels	Capacity (1,000 dwt)	No. of vessels	Capacity (1,000 dwt)	
Handysize	10,000-40,000	3,017	85,205	362	11,750	14.6
Handymax/Supramax	40,000-60,000	2,930	154,952	515	28,947	14.1
Panamax	60,000-80,000	1,863	142,048	402	31,749	18.5
Post-Panamax	80,000-110,000	484	46,869	73	7,194	35.2
Capesize	110,000-200,000	1,240	219,936	199	37,435	10.6
Vloc[3]	220,000+	194	56,607	31	8,863	33.2
Total		9,728	705,617	1,582	125,939	18.4

[1]Deadweight carrying capacity (dwt) is the weight of cargo a ship is able to carry when immersed to the appropriate load line, expressed in tons, including total weight of cargo, fuel, fresh water, stores, and crew ship.

[2] Ships that have been ordered but not yet delivered

[3] Vloc: Very Large Ore Carriers

Source: Illustrated Dictionary of Cargo Handling, 2nd edition, Peter R. Brodie, 1996

The Dynamics of U.S. and South America Bulk Market Transportation

No single factor determines the U.S. and South America ocean freight rates and spreads. Rather, the freight rates and resulting spread relationships are the result of the interaction of various underlying forces, such as the type of cargo, vessel size, route, fuel costs, canal and port fees, and changes in market conditions.

The types of cargo and destination port limitations determine the vessel size and its route around the world; each commodity requires certain vessel configurations and not every port can accommodate all ship sizes (O' Neil 2013). Iron ore, coal, and steel products comprise about 40 percent of all dry-bulk vessel cargo (O' Neil 2013). Historically, grains and oilseeds represent 11 to 14 percent of world dry-bulk trade (O' Neil 2013). Dry-bulk vessels have four to seven cargo holds, into which coal, ore, fertilizer, grains, and other cargo can be directly poured and easily discharged (table 5). These vessels are configured differently than general cargo (tween-deck vessels), tanker, liquid bulk, and container ships.

Larger ships—Capesize and up—are not typically used to carry grains and oilseeds because of port limitations at both loading and discharge ports (O'Neil 2013). However, during vessel supply shortages, the iron ore market can reach down into Supramax-, Panamax- and even Handymax-size vessel markets and split shipments (O'Neil 2013). This increase in vessel tonnage demand pushes up grain freight rates and causes the rerouting of vessels. The coal trade often uses Panamax vessels and competes with grain for the service of these vessels (O'Neil 2013).

Conversely, the U.S. grain and oilseed trade is not likely to use the Capesize or larger fleet services because most grain and oilseed loading and receiving ports do not have the berth length overall or salt water arrival draft[9] to accept the larger vessels (O'Neil 2013). Because of deeper loading drafts, Brazilian shippers can export grain and oilseeds to China in larger ships than the United States.[10] Brazil's grain cargo can range from 60 to 68,000 mt. U.S. grain and soybean shipments to China from the U.S. Gulf and PNW ports are usually 50,000 to 58,000 mt because of draft limitations at loading ports and Panama Canal navigation restrictions (table 5, 6 and 7). However, after the Panama Canal expansion project is completed in 2015, grain cargo shipments from the U.S. Gulf to major export markets could increase by 6,000 to 8,000 mt, depending on the vessel capabilities and configurations and on Mississippi river draft restrictions (O'Neil 2013).

The maximum deep transit drafts recommended by industry are provided in Table 5 below.

Table 5. Recommended deep transit drafts

Port Region	Meters	Feet
U.S. Mississippi River	13.72–14.33	45–47
Columbia River in the PNW	12.80–13.10	42–43 of fresh water arrival draft
Bahia Blanca, Argentina	13.71	45
Rosario River ports, Argentina	10.36–10.55	33.9–34.6
Port of Santos, Brazil	12.2–13.3	40–43.6
Paranaguá, Brazil	10.05–13.3	33-43.6
Rio Grande, Brazil	10.5–18	34.4–59

Source: ANTAQ 2013; APPA 2013; Blue Water shipping 2013; CGPBB 2013; NABSA 2013; and O'Neil 2013

9 Standard measures of berth lengths and depths.

10 The general cargo space of a 74,000 dwt Panamax vessel loaded to a 12.04 m draft is about 58,000 tons. It is about 68,500 tons at 13.10 m draft (O'Neil 2013). A 78,700 dwt Post-Panamax vessel at 13.10 meters can load approximately 75,000 tons cargo (O'Neil 2013).

Changes in commodity availability and economic conditions in different regions of the world shift market demand, encouraging carriers to reroute vessels to areas with the greatest demand (and highest rates). An increase in demand in one region motivates vessels to ballast (deadhead or travel empty) from the Asian Pacific routes to the U.S. Gulf or elsewhere to meet the current demand shift (O'Neil 2013). In these cases, the party that charters an empty vessel in one region may have to pay the owner or operator a ballasting bonus[11] to compensate for the cost of fuel to shift the ship from its current location to the new point of loading (O'Neil 2013). However, the ballast bonus does not necessarily compensate for the vessel's total operating expenses. In times of high vessel supply and low demand, vessel owners will attempt to reduce cargo-carrying capacity by slow steaming.[12] This action reduces fuel consumption and lowers operating cost for vessel operators, while creating inefficiency in the world vessel cargo carrying capacity, which in turn mitigates the lessened demand for ships (O' Neil 2013; Prince 2013; and Mongelluzo 2012). Under low-demand market conditions, the cost of repositioning a vessel from an area of low demand to one of higher demand is born by the vessel owner/operator without any compensation.

Table 6. Vessel size, draft, and cargo holds

Vessel Category	Size (dwt)[1]	Draft[2]	# of cargo holds
Handysize	20,000 – 25,000 25,000 – 34,000	9.5–10 m (31–33 ft.) 9.8–10.2 m (32–33 ft.)	4–5 depending on age 5
Handymax	35,000 – 49,000	10–12.04 m (33–35 ft.)	5
Supramax	50,000 – 63,000	12–13 m (39–43 ft.)	5
Panamax	70,000 – 85,000	13.75–14 m (45–46 ft.)	7
Suezmax (Tanker)	75,000 –100,000	18–20 m (60–66 ft.)	8[3]
Capesize	125,000–195,000	20 m (66 ft.)	9[3]
Vloc[4]	200,000+	20–30 m (66–98 ft.)	Not used for grains

[1]Deadweight carrying capacity (dwt); Draft is the number of feet that the hull of a ship is beneath the surface of the water
[2]The depth of a loaded ship in the water
[3]Not often used for grains
[4]Vloc: Very Large Ore Carriers
Source: Jay O'Neil Consulting; Hartmann Reederei 2013, Maritime Connector 2013, and DOT 2008

11 Ballast Bonus is a one-time special payment, above the chartering price, made by the new entity chartering a vessel that has to sail a long distance in ballast (empty) to reach the next loading port (DOT 2008; O'Neil 2013).

12 Slow steaming means reducing vessel speeds to save fuel and improve the utilization of fleet capacity.

Table 7. Vessel size and route

Destination	Origin	Cargo Size (mt)	Vessel type
China	U.S. Gulf	50–58,000	Supramax
	U.S. PNW	50–55,000	
	Argentina	50–55,000	Panamax
	Brazil	55–68,000	
Japan	U.S. Gulf	40–48,000	Handymax
	U.S. PNW	40–48,000	
	Argentina	40–48,000	
	Brazil	40–48,000	
Mexico	U.S. Gulf	25–45,000	Handysize/Handymax
	U.S. PNW	25–45,000	
	Argentina	25–45,000	
	Brazil	25–45,000	
Egypt	U.S. Gulf	50–60,000	Panamax
	U.S. PNW	50–60,000	
	Argentina	50–60,000	
	Brazil	50–68,000	

Source: Jay O'Neil Consulting

The United States–South America Ocean Freight Spread

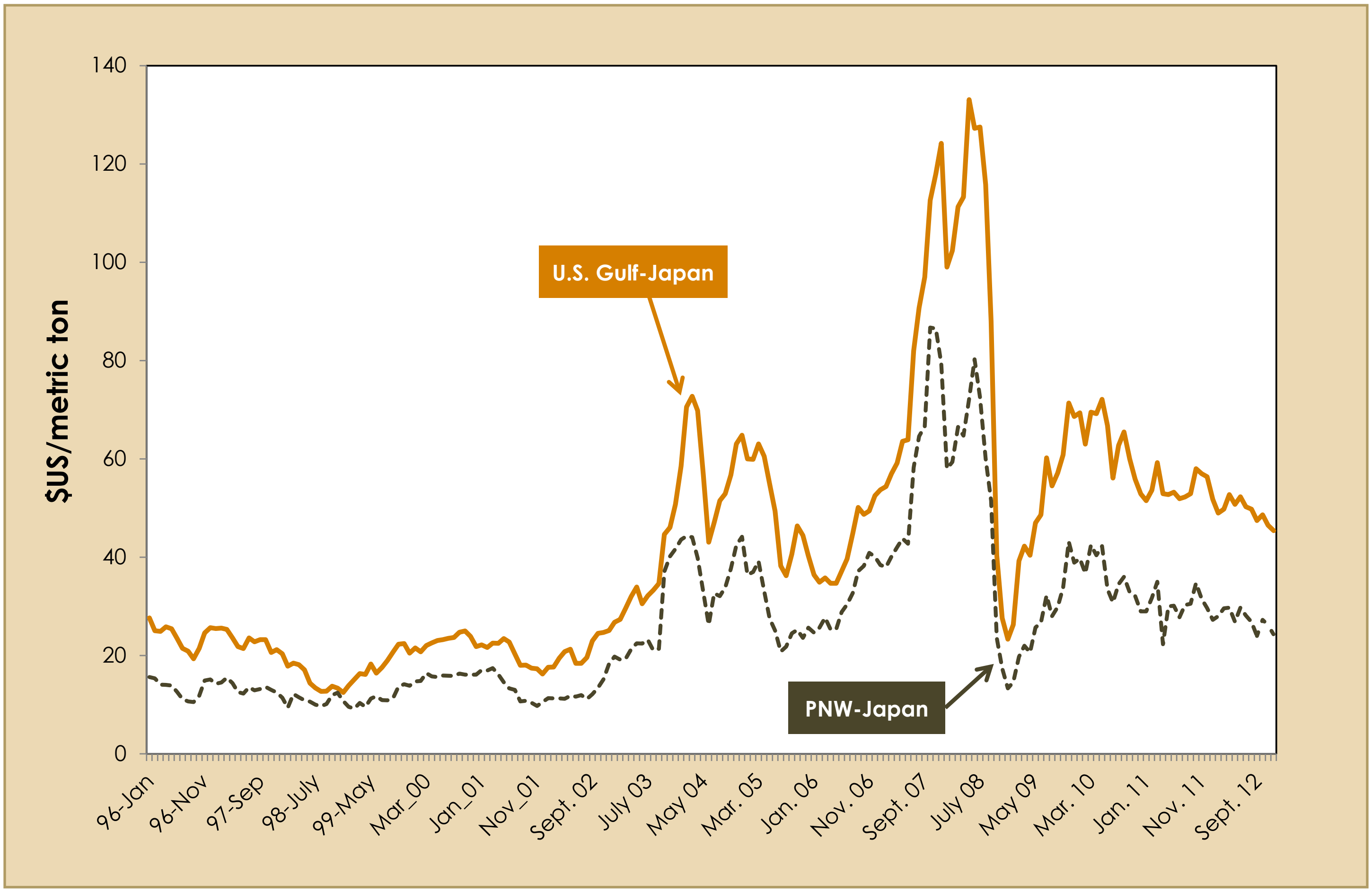
Ocean freight spread is the cost difference between two vessel routes to the same destination, such as the U.S. Gulf and the Pacific Northwest (PNW) versus South America to Asia (China and Japan), or the U.S. Gulf versus South America to Europe and China.

Ocean freight spreads between North America and South America to Asia can be at a premium or discount depending on current market conditions, vessel availability, port loading conditions and fees, ballasting bonus, daily revenue (daily hire rate), cargo and ship size, length of voyage (transit days, including loading and unloading time in port), Panama Canal toll charges and delays as well as bunker fuel costs (O'Neil 2013; Salin 2011). Bunker fuel, sometimes known as fuel oil, is a type of liquid fuel which is fractionally distilled from crude oil. It is less refined and more polluting than other petroleum products. Its costs can represent 35 to 60 percent of a vessel's operating cost and are reflected in the freight rates shown in Figure 3.

The ocean rates from the PNW and U.S. Gulf to Japan[13] are higher than the rates to China because of higher Japanese port fees and berth restrictions that limit the size of the receiving vessels (figure 5). This is called "Japanese markup." Japanese grain buyers typically receive their cargoes in Handymax vessels (table 7). China's ports can receive Panamax and larger vessels, resulting in lower rates.

13 Ocean rates from the PNW and U.S. Gulf to China are not available from 1992-2006. For that reason, we used ocean rates from the PNW and U.S. Gulf to Japan.

Figure 5. Monthly freight rates from the U.S. Gulf and Pacific Northwest (PNW) to Japan



Source: O'Neil Commodity Consulting

Analyzing the World Soybean Market Shares: Model and Results

To understand the behavior of the underlying forces of the world soybean market, an extensive econometric analysis was performed using a dynamic approach. We use a dynamic model that incorporates time into its structure because the purpose of this study is to capture how the market shares are likely to change over time. This is accomplished by the specification and empirical estimation of a mathematical difference equation system and by making use of techniques in the specialized field of economics called "econometrics." This empirically estimated system enables us to analyze the behavior of the underlying market over time, in which the United States is the dominant country in the world soybean market. The model developed for this paper includes the theoretical specification, the model layout and the empirical framework used for capturing the dynamic changes of the world soybean market (see the Appendix for details). Due to data availability, the base model uses ocean freight rates and trade data for the period from 1992 to 2012. The Appendix presents detailed results on the empirical estimation, the impact of ocean freight rates on market shares and the performance of the sensitivity analysis. Several statistical tests were performed to analyze and validate the behavior of the world soybean market shares and gain insights into the impact of Brazil infrastructural improvement on the United States competitiveness, keeping the U.S. infrastructure constant. The United States is the dominant country in the world soybean market. Brazil's and Argentina's relative importance in the world soybean market are considered the competing countries. Other competing countries are Paraguay and Canada.

Results

On the demand side, we identified China as the major driver of the world soybean trade. On the supply side, the United States is the dominant country in the world soybean market and Argentina and Brazil are modeled as the two main competing countries (Appendix). The model results suggest that, under current conditions, the U.S. market share could be stable as the overall market grows (see Appendix table A-1). The same results were obtained when changes in ocean freight rates over the estimated period were considered. This model's outcomes suggest that the ocean freight rates are not a significant force in the shares of the world soybean market (see Appendix table A-2). In the future, as the competing countries—Argentina and Brazil—acquire a larger market share, any price or supply management policy initiated solely by the United States is more likely to become less effective and more costly to administer. In sum, the dynamic interplay between the United States, Argentina, and Brazil in the world soybean market is very important in understanding the impact on market shares.

Sensitivity Analysis – Brazil's Transportation Infrastructure Improvement and Pacific Northwest Ocean Freight Rates

To estimate the long-term U.S. position in the world soybean market and provide insights into the impact of Brazil's infrastructure improvements, a sensitivity analysis was performed (see Appendix for details). Sensitivity analysis is a way to predict the outcome—in this case, the world market shares—in response to a situation other than the status quo. Here, the assumptions made were that Brazil's infrastructure improves and its freight rates are reduced.

It is uncertain how much Brazil's infrastructure will improve and when; we know only that it is improving. We also do not know how much Brazil's freight rates will be reduced. Sensitivity analysis is a way to gain insights by assessing changes of several uncertain conditions at the same time—in this case, world market shares—in response to a situation other than the status quo. Sensitivity analysis, which is also known as what-if analysis, is used to evaluate the model's outcomes when key factors under certain assumptions change. In this case, using data from 1992 to 2012, applying the assumptions that Brazil's infrastructure advancements reduced its transportation freight rates equivalent to the lowest U.S. transportation rates, we develop new exports for Brazil and export shares (see column 6, table 8) to carry the sensitivity analysis. Using the assumed export market shares (table 9), we re-estimated the model to capture the effect of the sensitivity analysis on the world soybean market (see Appendix tables A-3 and A-4). Since we assume more than one change, this sensitivity analysis is called a multivariate sensitivity analysis. The sensitivity analysis conducted in this paper aims to shed light into the impacts of Brazil's transportation infrastructure potential improvements and possible competitive ocean freight rates on the world soybean market shares.

In constructing the sensitivity analysis, we account for the following:

- We assume that Brazil's domestic infrastructure (farm to port) greatly improves, increasing Brazil's ability to export soybeans to China (see column 6, table 8).
- We consider Brazil's ocean freight rates as improving and become equivalent to the U.S. PNW ocean freight rates (see column 6, table 8).
- We assume that exports from the United States, Argentina, and the rest of the world remain the same, but market shares change (see columns 2, 4, and 5, table 9) because Brazil's exports under sensitivity analysis change (column 3, table 9).[14]

14 Given Brazil's new market shares, the United States, Argentina and other countries shares adjust because we keep the total observed export data from 1992-2012.

It is worth noting that instead of designing a sensitivity analysis where we change one factor at the time, we perform an analysis where we allow for changes (conditions) on all factors at the same time. In this way, we accounted for the compounded impact (biggest change) of all possible improvements of Brazil's competitiveness in the world soybean market (see tables 8 and 9, and Appendix for details).

For the sensitivity analysis, we assume that if Brazil could have improved its infrastructure during the period of the study and reduced its transportation cost to the level of the United States cost, then Brazil's global export market shares for the period 1992 to 2012 would have increased from 6 percent in 1992 (or 47 percent points) to 52 percent (or 27 percent points) in 2012 (see column 6, table 8, and table 9). At the same time, the United States' world market share would have declined by 2 percentage points in 1992 to almost 18.5 percentage points in 2012 as a result of structural improvements in Brazil.

Using the shares developed for the sensitivity analysis, we re-estimate the model (see Appendix and tables A-3 and A-4). The sensitivity results (Appendix tables A-3 and A-4) show that the estimated market shares depend on the countries exporting capacity, which in turn depends on the underlying technology and infrastructure from farm to port, as well as the competitiveness of ocean freight rates in the case of world soybean market.

It is worth noting that 2013 Brazil production costs—particularly from Mato Grosso (MT) and Paraná (PR)—were lower than those of Iowa because of lower land prices. Brazilian and U.S. soybeans directly compete with one another because both countries use the same technological advancements. Brazil can import technology and increase planted area to increase exports, but Brazil's export capacity is hindered by the lack of a complete and balanced transportation system like that of the United States that includes all major modes of transportation (truck, rail, barge, and ocean vessel). In 2013, infrastructural improvement reduced transportation costs in Brazil's Midwest, especially in MT (the largest Brazilian soybean-producing State). Mato Grosso's transportation costs as a percentage of the total landed cost to Shanghai had declined from 45 percent in 2005 to 28 percent in 2013, but were still higher than Iowa's. However, exporters in Rio Grande do Sul, the second largest soybean exporting state, have lower transportation costs than the United States' routes to China through the PNW and from Iowa through the U.S. Gulf to Shanghai (Salin 2014).

Brazil Infrastructure Improvements

In 2007, the Brazilian government began a comprehensive infrastructural improvement strategy and implementation to increase Brazil agricultural competiveness by establishing the Growth Acceleration Program (PAC 1) 2007–2010. PAC 1 was integrated into the multi-year National Plan of Logistics and Transportation (PNLT) 2008-2023 (Salin 2013). By March 2010, with less than half of the first logistic package (PAC 1) projects completed, the Government announced the second Growth Acceleration Plan (PAC 2), 2011-2014 (Salin 2013). It was expected that the Brazilian infrastructure would be ready for the country's hosting the 2014 World Cup.

At the end of 2013, the ninth evaluation results of Growth Acceleration Program 2 (PAC 2), 2011-2013, showed that Brazil did not finish the projects as planned (Salin 2014). However, several port, rail, and highways (BR-163) projects are underway and scheduled to finish by the end of 2015. In 2013, the agricultural exporters in Midwestern Brazil gained a competitive boost from strategic port improvements and extended railways miles with a new intermodal grain terminal (Salin 2014).

Two major railroad improvements contributed to Brazil's soybean competitiveness in 2013 (Salin 2014):

The Ferronorte railroad (Rondonópolis-Alto Araguaia), finished 153 railway miles, including an intermodal yard in Rondonópolis, facilitating the flow of grains from Mato Grosso (MT) to the southern port of Santos.

In 2011, the Brazilian government introduced new rail regulation. The new law states that Brazilian railroads are required to sell to other railroads the rights to use idle capacity if they are not using the rail tracks at full capacity. This was a major step to increase railway use within the next 15 years. This law has a significant impact on the Brazilian grain and soybean exports route to China by facilitating access to the southern ports of Santos, Paranaguá, and Rio Grande. These three ports accounted for 67 percent of Brazil total exports and 74 percent of exports to China in 2013. In the United States, railroads have no obligation to allow other railroads to use their rails. Instead, access is negotiated with competing railroads at an agreed-upon price.

We can also conclude that the United States infrastructural and technological improvements are critical to maintain U. S. competitiveness in the world soybean market. Improved U.S. infrastructure would result in an increase in market share, a more competitive U.S. export sector, and higher income to farmers. For example, assuming world soybean trade is 100 mmt (WASDE September 2013), a 1-percent decline in the U.S. soybean market share is equivalent to half a billion dollars lost in export sales (1 mmt X $500/mt).[15]

Table 8. Market shares data: actual and for Brazil's sensitivity analysis[1]

Actual market shares					Sensitivity analysis	
Year	United States (%)	Brazil (%)	Argentina (%)	Other[2] (%)	Brazil's new market shares (%)	Brazil
1992	71.18	4.09	14.96	9.76	6.02	46.99
1993	69.06	24.47	0.00	6.47	32.70	33.65
1994	62.50	0.00	0.00	37.50	0.00	0.00
1995	56.46	0.00	29.85	13.69	0.00	0.00
1996	81.84	2.80	11.66	3.70	4.30	53.52
1997	79.69	15.80	0.00	4.51	22.92	45.02
1998	45.78	34.93	15.09	4.20	47.85	37.00
1999	52.22	17.80	28.10	1.87	26.03	46.21
2000	52.81	18.01	28.52	0.67	27.04	50.19
2001	39.91	23.43	36.44	0.21	33.73	43.91
2002	41.16	35.07	23.64	0.14	46.39	32.26
2003	48.12	26.42	25.37	0.08	38.36	45.17
2004	48.35	29.19	22.29	0.17	40.36	38.25
2005	38.99	29.58	31.22	0.21	39.78	34.47
2006	37.53	39.16	22.97	0.35	53.05	35.47
2007	37.89	32.42	29.48	0.21	44.98	38.73
2008	43.59	31.21	24.43	0.77	41.70	33.61
2009	54.08	37.78	7.45	0.69	48.91	29.46
2010	43.86	34.55	20.47	1.12	44.90	29.96
2011	39.85	42.69	16.15	1.31	53.81	26.06
2012	46.81	40.67	9.33	3.19	51.62	26.92

[1]Assumes Brazil's infrastructure and transportation cost is as competitive as the U.S. PNW transportation cost, measured in market shares (percentage).
[2]Other competing countries include Paraguay and Canada.

15 This statement is based on the concept known as "elasticity." The coefficients are considered elasticities because the estimated equation is expressed in double logarithmic form (Appendix). For example, the coefficient value for the entire estimation period, 1992–2012, is 0.0627 percent (Appendix, Table A-1). After Brazil's infrastructural improvements, for the entire estimation period sensitivity analysis, the coefficient declines to 0.0527 (Appendix, Sensitivity analysis table A-3). This is equivalent to 1-percent declines in market shares (0.0627 - 0.0527 =0.01). When we account for fluctuations in ocean freight and we considered the period from 2010 to 2012, the coefficient declines from 0.1253 rates (Appendix, Table A-2) to 0.1084 percent (Appendix, Sensitivity analysis table A-4). In this case, the loss of U.S. soybean sales would be larger, equivalent to nearly 1.7 percent (0.1253 - 0.1084 = 0.017), assuming improvements in Brazil's infrastructure and transportation.

Table 9. New market shares for conducting sensitivity analysis

New market shares				
Year	United States (%)	Brazil (%)	Argentina (%)	Other[1] (%)
1992	69.76	6.02	14.66	9.57
1993	61.53	32.70	0.00	5.76
1994	62.50	0.00	0.00	37.50
1995	56.46	0.00	29.85	13.69
1996	80.58	4.30	11.48	3.64
1997	72.96	22.92	0.00	4.13
1998	36.69	47.85	12.10	3.37
1999	47.00	26.03	25.29	1.68
2000	46.99	27.04	25.38	0.60
2001	34.54	33.73	31.54	0.19
2002	33.98	46.39	19.52	0.11
2003	40.31	38.36	21.26	0.07
2004	40.72	40.36	18.77	0.15
2005	33.35	39.78	26.70	0.18
2006	28.96	53.05	17.72	0.27
2007	30.85	44.98	24.00	0.17
2008	36.94	41.70	20.70	0.65
2009	44.41	48.91	6.12	0.57
2010	36.92	44.90	17.23	0.95
2011	32.12	53.81	13.01	1.06
2012	38.17	51.62	7.61	2.60

[1]Assumes Brazil's infrastructure and transportation cost is as competitive as the U.S. PNW transportation cost, measured in market shares (percentage).
[2]Other competing countries include Paraguay and Canada.

Conclusions and further research

The world soybean market is growing, but the U.S. market share is lower than it was in 1980. After hitting a low in 1994, the U.S. market share stabilized at between 40 and 50 percent. Nominal prices declined in the international market as market supplies exceeded demand for soybeans. Our empirical analysis shows that market shares converged to their so-called steady-state values or dynamic equilibrium values in the late 1990s and 2000s.

Based on the observed data, Argentina and Brazil behave as major "competing countries" in the international soybean market. There is no indication that Argentina or Brazil limited production in order to maintain a stable international market price.

However, in 2013, Brazil for the first time surpassed U.S. soybean exports, becoming the top world soybean exporter. The 2013 Brazil record soybean exports were supported by favorable weather conditions and increased efficiency in the agricultural sector. The exports were driven by Brazil's ability to expand soybean production area and yields, as well as the Brazilian government infrastructural improvements. U.S. producers decreased planted area in 2013, and a summer drought lowered yields resulting in lower production levels than expected. Consequently, since Brazil and U.S. producers use the same production and technological advancements, making their soybeans relative substitutes, transportation cost and structural infrastructure improvements are critical factors to U.S soybean competiveness.

Brazil can import production technology and increase planted area to augment its exports, but Brazil's export capacity is hindered by the lack of a complete and balanced transportation system that includes all major modes of transportation (truck, rail, barge, and ocean vessel) like that of the United States. Mato Grosso's transportation costs as a percentage of the total landed cost to Shanghai had declined since 2005, but were still higher than Iowa's. However, exporters in Rio Grande do Sul, the second largest soybean exporting State, have lower transportation costs than the United States' routes to China through the PNW and from Iowa through the U.S. Gulf to Shanghai.

The empirical analysis suggests that the U.S. world market share could further decline by 18.5 percentage points without improvements in the U.S. infrastructure from the farm to the port if Brazil advances its transportation infrastructure. The empirical dynamic model outcomes also indicate that for an expanding market, a major exporter, even with no cost advantage, does not necessarily price itself out of the market, but instead maintains a constant market share over the long run. As long as the major players continue operating as they have, market shares are expected to converge to equilibrium despite the variability or fluctuations of the ocean freight rates over time.

The multivariate sensitivity analysis results indicate that in the long run, the United States, Brazil, and Argentina market shares depend on the countries' exporting capacity, which in turn depends on the underlying technology and infrastructure from farm to port and—in the case of the world soybean market—the competitiveness of ocean freight rates. It also can be concluded from the sensitivity analysis that the United States' infrastructural improvements are critical for maintaining its competitiveness in the world soybean market. Improved U.S. infrastructure would result in an increase in market share, more competitive U.S. exports, and higher income to farmers. For example, assuming the world soybean trade is 100 mmt (WASDE September 2013), a 1-percent decline in the U.S. soybean market share is equivalent to half a billion dollars lost in export sales (1 mmt times $500/mt).

Further research is needed to understand the underlying forces that move soybeans from the farms to markets and to the exporting ports. In this context, the interaction of cash and future prices; storage versus transportation cost; and freight rates for truck, barge, rail, and ocean need to be captured and analyzed.

Appendix: Methodology

The Gaskins dynamic model analyzes the behavior of the dominant and the competing countries in the global soybean market by estimating the impact of changes in ocean freight spreads. The Gaskins (1971) dynamic firm/country model applies to the global soybean market structure because it captures theoretically the economic behavior of the major players in world soybean market where there is a dominant-firm (or country) with competing-firms (or countries). In this context, the model captures the dynamics of the world soybean market and examines the potential impact of Brazil's infrastructure development on the U.S. soybean global market share.

The analysis considers the soybean-producing nations as dominant-competing countries, rather than exporting nations. Early studies by Carter et al. (1994); and McCalla et al. (1981) suggested that the international grain market should be viewed as an oligopoly among exporting nations. While wheat was often employed as the example, the same argument can be applied to soybeans. By viewing the market through the Gaskins dynamic oligopolistic model, one is able to ascribe similar characteristics to the soybean market. In other words, by considering the market in a dominant-country framework with competing countries, one is able to exploit and analyze the interplay of the dominant country to competing countries.

In the last decade, several papers have enriched the theory of the dynamic limit pricing. Kamien and Schwartz (1971), Gaskins (1971), and Baron (1973) have made major contributions. In the Gaskins oligopolistic structural model the dominant firm sets prices. The behavior of the dominant firm allows potential competitors to enter in response to prices, with the outcome depending on the markets shares of the dominant firm and its competitors. In Gaskins' dynamic model, a low-cost dominant firm does not drive out the competing firms in the long run.

This study uses Gaskins' (1971) dynamic model because its structure applies to the global soybean market. In the last 12 years, the annual growth rate of the world soybean trade averaged 18.47 percent, with China being the major destination of soybean exports worldwide. The United States, Brazil, and Argentina over the 12-year period export growth rates are 18.98, 25.87 and 29.15 percent, respectively. The Gaskins oligopolistic model provides a unique framework as it pertains to a growing market where the dominant firm/country maintains a stable market share, as long as the market grows. Furthermore, the model accommodates a wide range of differences in the relative costs of production between the dominant firm/country and the competing countries, even for cases where the dominant firm lacks a cost advantage.

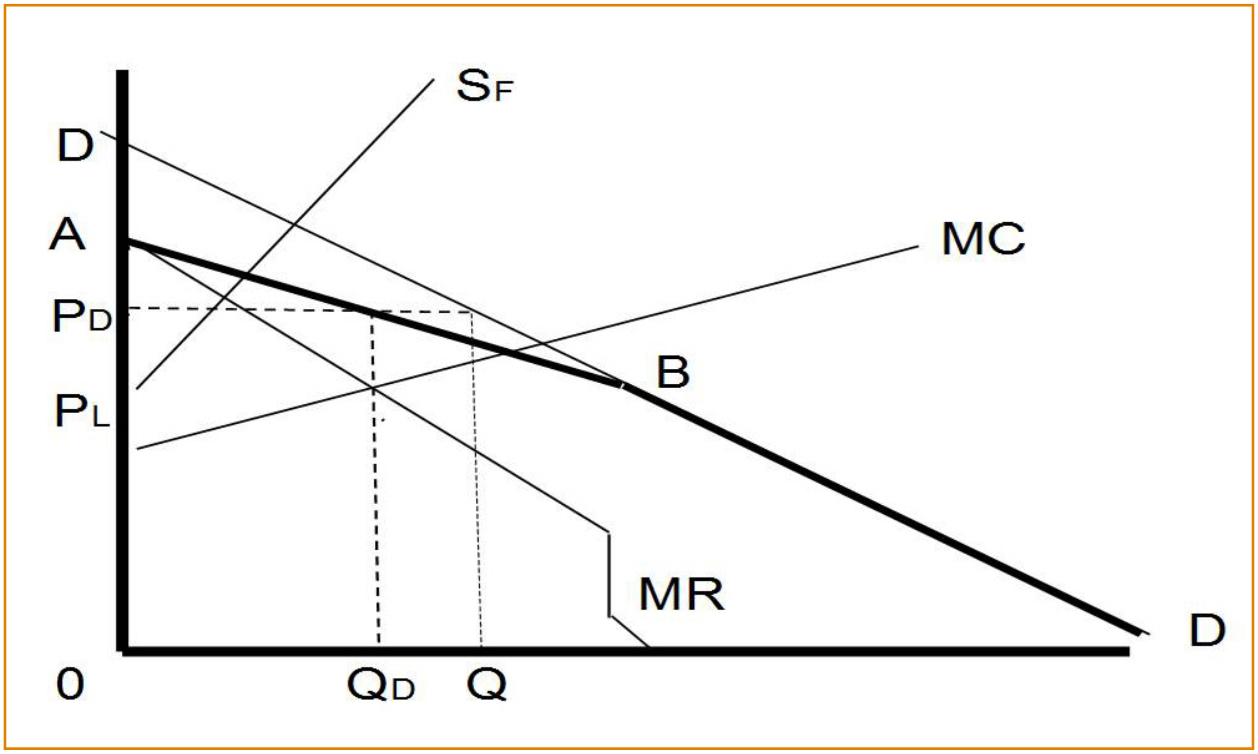
In the next section, we present the theoretical foundation of the model and analyze the Gaskins (1971) dynamic model based on the dominant firm's position in a growing market. This is followed by an examination of the global soybean market shares and how their dynamics are affected by ocean freight spreads. We indirectly evaluate the dominant-competing countries behavior captured in the Gaskins model using transitional dynamics.

Theoretical specification

The model's theoretical framework is based on the challenge facing U.S. soybean exporters due to market penetration by competing firms—or in this case, South American exporting firms. The international soybean market is mostly characterized by the presence of a few firms that operate worldwide. In this study, we treat the countries where the firms are originated rather than the firms. The smaller exporting firms in this study are considered competing countries because as a group they respond to the existing price and individually cannot influence the world market price (Scherer and Ross 1990).

Figure A-1 captures graphically the global soybean market in a simplified case where the dominant country has lost any cost advantage that would have precluded others from entering the international market. DD is market demand, S_F is the competing supply schedule, and MC is the dominant country's marginal cost curve. The dominant country incorporates the competing supply schedule into market demand to construct residual demand ABD over which it operates. Using standard first order conditions, the dominant country would supply Q_D at the market price P_D and the competing would supply $Q - Q_D$. In this case, by virtue of its position of market power, the dominant country takes on the responsibility of restricting supply to the market.
This creates a situation where the competing country can enjoy a free ride on the big country's price-enhancing efforts.

Figure A-1. The model of dominant firm with competitive fringe



In this specification, the competing supply will increase in the long run if the market price yields excess rents to the competing country (or countries). If the competing supply increases, then the dominant firm's (country's) captive residual demand shrinks and its market share declines. The current soybean case is like Figure A-1, where production (plus transportation) costs in the competing countries are as low or lower than the costs of the dominant country. With the supply price of the competing countries approaching the market price generated by the demand curve ABD and the dominant firm's/country's marginal cost curve (MC), the chance of the dominant firm making excess profits disappears. The model predicts, all other things being equal, greater penetration over time by the competing countries. If demand is constant, the competing firm/country expansion will effectively crowd out the dominant firm/country.

The Gaskins dynamic model (1971) accommodates a growing market and a dominant firm that has higher costs of production than the competing countries. It considers cases in which there are very moderate growth rates in the product market to ensure stabilized market share for all participants in the market, which is a more suitable for the world soybean market. Indirectly, we evaluate the dominant-competing country's behavior captured in the Gaskins model using transitional dynamics.

The Model

The dominant producer wishes to maximize the objective function given by:

(1) $$V = \int_0^\infty [p_t - c][q_t(p_t)]e^{-rt}dt$$

where V is the present value of the firm's profit stream, p_t is product price, c is average firm's total cost of production, $q_t(p_t)$ and r are the dominant producer's output, which depends on the product price (p_t) and the discount rate, respectively. Assume that the dominant producer's current sales can be represented as follows:

(2) $$q_t(p_t) = f(p_t)e^{\gamma_t} - x_t,$$

where $f(p_t)$ is initial demand, γ_t is the market growth rate, and x_t is the level of competing sales. The rate of entry/expansion by competing producers depends on the market price. The entry response coefficient, k, is a growing exponential function of time. Assume $\overline{p}$ is the limit price (the price that yields a competing supply equal to zero, see figure 3), and x_0 is the initial output of the competing country.

(3) $$k_t = k_0 \pi r^{\gamma t}$$

(4) $$\dot{x}(t) = k_0 e^{\gamma t}[p(t) - \overline{p}]$$

In the control theory framework, $\dot{x}_t$ (the level of rival sales) is the state variable, and p_t (product price) is the control variable. We can collect terms to state the dominant producer's optimal control problem as:

Maximize:

(5) $$V = \int_0^\infty \{[p_t - c](f(p_t)e^{\gamma_t} - x_t\}e^{-rt}dt, \gamma < r$$

subject to:

(6) $$\dot{x}_t = k_0 e^{\gamma_t}[p_t - \overline{p}]\ x(0) = x_0$$

or $f(p_t)e^{\gamma t}$ is total demand at price p_t, x_t is the total supply for competing firms, and c is the dominant firm's cost of production. The rate of change of x_t is an increasing function of the price set by the dominant firm.

The necessary conditions generate the simultaneous differential equations:

$$(7) \qquad \dot{x}^*_t = k_0 e^{\gamma_t}\left[p^*_t - \bar{p}\right], x^*(0) = x_0.$$

$$(8) \qquad \dot{z}^*_t = \left[p^*_t - c\right]e^{-rt}, \qquad \lim_{t \to \infty} z^*(t) = 0$$

Where x^*_t is the optimal rival sales and, as stated above, is an increasing function of the price set by the dominant firm, and z^*_t is the optimal shadow price of an additional rival entry, which depends on total demand ($f(p_t)e^{\gamma t}$), total supply (x_t), the dominant firm's cost of production (c) and the entry response coefficient (k) (see Gaskins, 1971 for more details).

This model demonstrates that as price (p_t) and total completing sales, or the optimal portion of the market supplied by the competing firms, (w_t) (where), reach their equilibrium levels, the dominant firm's share approaches a constant. The optimal pricing strategy which is greater than the limit price yields a steady-state long-run market share for the dominant firm s_t where the conditions of optimization are met as follows:

$$(9) \qquad s_t = \frac{f(p)e^{\gamma_t} - w_t e^{\gamma_t}}{f(p)e^{\gamma_t}} = \frac{f(p) - w_t}{f(p)}$$

where $f(p)$ is the total world demand of the market and w_t is the optimal portion of the market supplied by the competing countries—Brazil, Argentina, and the rest of the world. In this model, a country with no cost advantage will not price itself out of the market. Gaskins demonstrated that if the curvature of the demand curve is not too large, an increase in the growth rate of the market will always increase the dominant country's market share. This allows the dominant country with insignificant cost advantages to "maintain a constant market share over the long haul" (Gaskins, pg. 137).

In summary, by applying the Gaskins model that pertains to a growing market and a dominant country that has lost its cost advantages over competing countries, we can conclude that even a very moderate rate of growth in the product market ensures convergence of market shares.

Empirical Framework: Market Shares and the Dynamics of the Soybean World Market

The theory outlined above provides us with broad guidelines for model specification to indirectly estimate the dynamic theoretical Gaskins model. By applying transitional dynamics to analyze the market shares of the world soybean market we attempt to determine its consistency with the behavior of a dominant and competing countries' approach. In other words, we indirectly evaluate the position of the dominant country's market share as well as the competing countries' share as if they follow the Gaskins dynamic theoretical model specification. For this reason, we estimate the growth pattern, the speed of convergence and the stability of the global soybean market following Barro and Sala-i-Martin (1996). We assess this by estimating the following transitional equation:

$$log(s_{it} / s_{i,t-1}) = \alpha - (1 - e^{-\beta}) * \log(s_{i,t-1}) + u_{it} \tag{10}$$

where s_{it} are the market shares of the dominant and competing countries. The subscript *i* denotes the country; the subscript *t* denotes the year; α and β are coefficients to be estimated and u_{it} is the random disturbance. We assume that the disturbance term has zero mean and its variance is distributed independently over time and across countries (Barro and Sala-i-Martin, 1992). In estimating the transitional dynamics, we deviate from Barro and Sal-i-Martin because we do not impose any restriction(s) or condition(s) on the estimated coefficients. Unlikely, the neoclassical growth theory (Barro and Sala-i-Martin 1992) where the β coefficient is restricted $0<\beta<1$, we allow the β coefficient to take any value. If $\beta>1$, then we can observe an overshooting effect or so-called leapfrogging where a competing economy that starts out behind the dominant country goes ahead at some future date.[16] The condition $\beta>0$ insures converge of the growth rates. If $0<\beta<1$ holds, then we observe absolute convergence. After testing, the shares are stationary and this implies they do not have unit roots. A higher positive coefficient *β* reflects greater tendency toward convergence while the dispersion of the market shares rises with the variance of the disturbance term. The smaller the variance , the smaller the variability of the market shares growth rates.

We applied the NLIN procedure in SAS (SAS/STAT, 2009). The procedure fits nonlinear specifications and estimates the parameters using nonlinear least squares. This allows great flexibility in modeling the relationship between the dependent or response variable and independent variables. In estimating the parameters, the procedure uses iterative process for finding those values of the parameters that minimize the weighted residual sum of squares. The NLIN procedure determines converge by using *R*, the relative offset measure by Bates and Watts (1981).

The data used in the empirical estimation are from O'Neil Commodity Consultants from 1996 to 2012 (figure 3). The periods and sub-periods (tables A-1 and A-2) were selected based on the nonparametric tests results. Since our estimation period starts in 1992, we used cubic splines technique to extrapolate from 1996 to 1992 for obtaining the missing freight rates for the years 1992-1995. We also used the bootstrap technique (100 samples), generated a series of extrapolated data, and performed nonparametric tests with the observed series of the ocean rates. The test results indicated no statistical significant differences between the observed data and the data with the extrapolated rates.

16 Testing for convergence is beyond of the scope of the paper.

We also estimated the models for alternative values of extrapolated ocean rates to account for possible bias, but the estimation results remained the same.   Please note that nonparametric test results with the observed data were not statistical significant, given that Brazil's participation in the world soybean market was minimal in 1992-1993 and it did not export in 1994-1995 (tables 7 and 8). Performing nonparametric tests on these three ocean rates in SAS, we found that the rates in the *first period* (1992–2002) are statistically different from those in the *second period* (2002–2004) and different from those in the *third period* (2005–2012) (tables A-1 and A-2). Specifically, we apply the nonparametric procedure NPAR1WAY that performs tests for location (mean) differences on the raw data.

For the selection of sub-periods 1 through 5, we use the rates from U.S. Gulf and U.S. PNW to Japan. These rates are depicted in figure 5 above. We again performed nonparametric tests and found that the rates are statistically significant in the five sub-periods: 1992–2001(first), 2002–2004 (second), 2005–2006 (third), 2007–2009 (fourth), and 2010–2012 (fifth) (see table A-2).

The estimation results of the nonlinear unconditional regressions clearly indicate that the United States is the dominant country in the world soybean market and that the market shares of the United States, Argentina, and Brazil have converged and stabilized (tables A-1 and A-2). The estimated parameters of this dynamic model of the world soybean market are widely known as the β *converge* and σ *converge*. In our model, the β *converge* measures the growth of the competing countries' shares compared to the dominant country's share. Depending on the magnitude of the estimate, β *converge* determines if the market shares will converge and stabilize in the long run. The σ *converge* measures the dispersion or variation of the magnitude of the market shares across the competing countries.

The β *converge* estimates for the entire period and for the three periods are positive, implying that the market shares are converging (table A-1). From 1992–2012, the effect of the initial position of the dominant country declined and the market shares of the competing countries grew faster than the dominant country. Over time, the market shares of the dominant and competing countries have stabilized. The β *converges* of the first and second periods are almost the same (0.0533 and 0.0662, respectively) and have the largest value in the third period (0.1086). For the entire period as well as the three periods under study, the positive values of the β *converge* clearly indicate that Brazil and Argentina export growth in the world market increased dramatically compared to that of the United States. The positive values of β *converge* estimates imply absolute convergence and the higher coefficient corresponds to a greater tendency toward convergence (table A-1).

The estimated variance, or σ *converge*, measured by the variance of the regression, captures the dispersion of the process or the degree of uneven growth of the market shares. For the entire period (1992–2012), the market converged with minimal dispersion of 0.0052 (table A-1). The estimated σ *converge* for the first period is the smallest (0.0883), compared with the third period (0.0118). The smallest σ *converge* value occurs in the second period (0.0042). This indicates that the growth of the market shares during the second period increased with a smaller degree of variability than in the first and third periods.

The model suggests that the U.S. market share could be stable as the overall market grows. In the future, as the competing countries—Argentina and Brazil—acquire a larger market share, any price or supply management policy initiated solely by the United States becomes less effective and more costly to administer. In this regard, the interplay between the United States, Argentina, and Brazil becomes a very important factor in regard to soybeans in the world market.

Table A-1. Estimation results of the transitional dynamics of the world soybean market, 1992–2012

Years	Parameter	95% Confidence Limits			
		Estimate	Standard error	Lower bound	Upper bound
Entire period 1992–2012	**α** (Intercept)	0.0963	0.0997	–0.3329	0.5255
	β (strength of converge)	0.0627	0.1303	–0.4977	0.6231
	σ (converge—steady state) (second moment of the distribution)	0.0052			
First period 1992–2002	**α** (Intercept)	0.0569	0.4103	–1.7083	1.8221
	β (strength of converge)	0.0533	0.2578	–1.0561	1.1626
	σ (converge—steady state) (second moment of the distribution)	0.0883			
Second period 2003–2004	**α** (Intercept)	0.2117	0.0409	0.0359	0.3875
	β (strength of converge)	0.0662	0.0143	0.00458	0.1279
	σ (converge—steady state) (second moment of the distribution)	0.0042			
Third period 2005–2012	**α** (Intercept)	0.2251	0.0775	–0.1082	0.5585
	β (strength of converge)	0.1086	0.059	–0.1453	0.3626
	σ (converge—steady state) (second moment of the distribution)	0.0118			

Accounting for Ocean Freight Changes

We also applied transitional dynamics to the world soybean market while accounting for changes in ocean freight rates over the estimated period. In this case, the estimated dynamics cover the following five sub-periods: 1992–2001 (first), 2002–2004 (second), 2005–2006 (third), 2007–2009 (fourth), and 2010–2012 (fifth) (see table A-2). The sub-periods follow fluctuations in freight rates observed during the study period (figure 5). The β *converge* of the sub-periods are positive, with values 0.0469, 0.0131, 0.0561, 0.11, 0.1253, respectively, implying that world soybean market shares absolutely converge given that the estimates of the β *converge* are positive (table A-2). Higher coefficients—0.11 and 0.1253—in the fourth and fifth sub-periods, respectively, indicate a greater tendency toward convergence. Again, the effect of the initial position of the dominant country declined and the market shares of the competing countries grew faster. Furthermore, the market shares of the dominant and competing countries stabilized over time despite the great variability in the ocean freight rates (figs. 3 and 5). When we account for observed changes or fluctuations in freight rates over the period under study, the β *converge* estimates indicate that sustained convergence is likely to remain for the dominant as well as the competing countries (especially in the most recent period, because the lagging economies tend to grow faster (table A-2)).

The estimated σ *converge* captures the dispersion of the process or the degree of uneven growth of the market shares. In the second sub-period, the market converged with a minimal dispersion of 0.0036. The estimated σ *converge* in the fourth sub-period is the largest (0.1062) (table A-2). Note that the β *converge* lie within the 95-percent confidence limits of the lower and upper bounds for the estimates of all sub-periods, reflecting a statistical significance of 0.05 (table A-2).

In summary, the Gaskins model suggests that the U.S. market share will be stable as the overall market grows. As the competing countries—in this case Argentina and Brazil—acquire a larger market share, any price or supply management policy initiated solely by the United States, the dominant country, might become less effective and more costly to administer. In this regard, the interplay between the United States, Argentina, and Brazil becomes an important factor in the world soybean market.

Table A-2. Estimation results of the transitional world soybean market accounting for freight rates and time intervals, 1992–2012

Years	Parameter	Estimate	Standard error	95% Confidence Limits: Lower bound	95% Confidence Limits: Upper bound
1st sub-period 1992–2001	**α** (Intercept)	0.0557	0.4069	–1.6951	1.8065
	β (strength of converge)	0.0469	0.2275	–0.9321	1.0259
	σ (converge—steady state) (second moment of the distribution)	0.0869			
2nd sub-period 2002–2004	**α** (Intercept)	0.0365	0.0402	–0.1363	0.2093
	β (strength of converge)	0.0131	0.0132	–0.0435	0.0696
	σ (converge—steady state) (second moment of the distribution)	0.0036			
3rd sub-period 2005–2006	**α** (Intercept)	0.1742	0.1038	–0.2724	0.6207
	β (strength of converge)	0.0561	0.0371	–0.1036	0.2157
	σ (converge—steady state) (second moment of the distribution)	0.0212			
4th sub-period 2007–2009	**α** (Intercept)	0.2363	0.2326	–0.7645	1.237
	β (strength of converge)	0.1100	0.1034	–0.3347	0.5547
	σ (converge—steady state) (second moment of the distribution)	0.1062			
5th sub-period 2010–2012	**α** (Intercept)	0.3138	0.2197	–0.6316	1.2593
	β (strength of converge)	0.1253	0.1067	–0.3339	0.5845
	σ (converge—steady state) (second moment of the distribution)	0.0464			

Sensitivity Analysis – Brazil's Transportation Infrastructure Improvement and Pacific Northwest Ocean Freight Rates

The values of the β *converge* (table A-3) under the sensitivity analysis are positive but greater than those in table A-1. This indicates that the United States remains the dominant country even though the competing countries' shares improved faster and converged in 2012. When we account for observed changes or overtime fluctuations in freight rates, the results indicate that the United States is still the dominant country but the rate of convergence increases for the competing countries (table A-4). The competing countries tend to converge toward the United States and the rate of convergence is faster under the sensitivity assumptions.

The σ *converge* of the second moment of the distribution has smaller values, indicating that the growth of the market shares of the competing countries would increase with a smaller degree of variability under the sensitivity assumptions (tables A-3 and A-4).

We can conclude by using the findings of conducting the sensitivity analysis that values of the *converge* coefficients are not the same as those when we use the observed data. The sensitivity results indicate that the underlying technology and infrastructure from farm to port as well as the competitiveness of ocean freight rates affect the world soybean market (see tables 8 and 9). We can also conclude that the United States' infrastructural improvements are critical to maintain its competitiveness in the world soybean market. Improved U.S. infrastructure would result in an increase in market share and more competitive U.S. export sector and higher income for farmers.

Table A-3. Estimation results of the transitional dynamics of the world soybean market, 1992–2012*

Years	Parameter	95% Confidence Limits			
		Estimate	Standard error	Lower bound	Upper bound
Entire period 1992–2012	**α** (Intercept)	0.0826	0.1247	–0.4538	0.6191
	β (strength of converge)	0.0527	0.1303	–0.5079	0.6134
	σ (converge—steady state) (second moment of the distribution)	0.00629			
First period 1992–2002	**α** (Intercept)	–0.00081	0.4778	–2.0566	2.055
	β (strength of converge)	0.0268	0.2216	–0.9267	0.9804
	σ (converge—steady state) (second moment of the distribution)	0.0924			
Second period 2003–2004	**α** (Intercept)	0.2934	0.1186	–0.217	0.8038
	β (strength of converge)	0.0576	0.0427	–0.1261	0.2413
	σ (converge—steady state) (second moment of the distribution)	0.0395			
Third period 2005–2012	**α** (Intercept)	0.2078	0.0822	–0.1458	0.5613
	β (strength of converge)	0.1002	0.0582	–0.1502	0.3507
	σ (converge—steady state) (second moment of the distribution)	0.014			

* Note: The sensitivity analysis assumes Brazil's improved infrastructure and transportation cost is as competitive as PNW transportation cost.

Table A-4. Estimation results of the transitional dynamics of the world soybean market, 1992–2012*

Years	Parameter	Estimate	Standard error	95% Confidence Limits Lower bound	95% Confidence Limits Upper bound
1st sub-period 1992–2001	α (Intercept)	0.0123	0.4748	–2.0304	2.0549
	β (strength of converge)	0.0276	0.2159	–0.9016	0.9567
	σ (converge—steady state) (second moment of the distribution)	0.0912			
2nd sub-period 2002–2004	α (Intercept)	0.0631	0.035	–0.0873	0.2136
	β (strength of converge)	0.0188	0.0116	–0.031	0.0686
	σ (converge—steady state) (second moment of the distribution)	0.0029			
3rd sub-period 2005–2006	α (Intercept)	0.1137	0.1288	–0.4404	0.6678
	β (strength of converge)	0.0458	0.0449	–0.1472	0.2389
	σ (converge—steady state) (second moment of the distribution)	0.0342			
4th sub-period 2007–2009	α (Intercept)	0.2162	0.2279	–0.7642	1.1966
	β (strength of converge)	0.1033	0.0989	–0.3221	0.5287
	σ (converge—steady state) (second moment of the distribution)	0.1095			
5th sub-period 2010–2012	α (Intercept)	0.2665	0.2198	–0.6791	1.212
	β (strength of converge)	0.1084	0.102	–0.3304	0.5473
	σ (converge—steady state) (second moment of the distribution)	0.0518			

* Note: The sensitivity analysis assumes Brazil's improved infrastructure and transportation cost is as competitive as PNW transportation cost.

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