Decreasing Brazil's Transportation Costs Through Improvement in Infrastructure: A General Equilibrium Analysis on the Soybean Complex World Market

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In 2005, the soybean complex exports represented 8 percent of Brazil's total exports, while earnings totaled $9.5 billion. Brazil is currently the second largest exporter in both soybeans and joint products. However, the transportation costs in Brazil are the bottleneck to soybean expansion. Brazil has a 63.22-percent disadvantage to the U.S. in internal transportation costs. This study analyzes the impact of reduction in Brazilian internal transportation costs on the international soybean complex. Results show that Brazil could become the leading exporter of soybeans if costs were reduced by 30 percent. However, the soybean joint products sector would lose market share.

The soybean industry is an important contributor to Brazil's agricultural export income. In 2005, exports of soybeans and soybean-derived products composed eight percent of Brazil's total exports, with earnings totaling approximately $9.5 billion. Furthermore, Brazil is currently the second largest exporter in both soybean oilseed and joint products. However, even with all these satisfactory aspects, Brazil still has some room for improvement. One way to accomplish these improvements is to reduce internal transportation costs. This study analyzes the impact of a reduction in Brazilian internal transportation costs on the international soybean market and measures trade flows, economic growth, and welfare indicators for all impacted regions.

The first part of the study points out the internal transportation problems in Brazil with an export cost-competitiveness analysis. A conceptual analysis is done to explain the effects of transportation costs on international trade, followed in the same section by a breakdown of Brazil's soybean transportation channels and its possible improvements. The subsequent section discusses the methodology adopted. Simulation results and scenarios are then discussed, and the final section consists of a summary and conclusions.

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Transportation Costs: The Bottleneck to Brazil's Soybean Expansion

The Export Competitiveness among Brazil, United States, and Argentina

Table 1 shows that Brazil and Argentina are more competitive than the U.S. on the production side. The U.S. is more efficient than Brazil and Argentina in the variable costs aspects. On the other hand, the fixed costs in the U.S. are extremely high compared to South American counterparts, especially Brazil. Although the total production cost is less in Brazil and Argentina, the internal transportation costs are considerably higher compared to the U.S. In the case of Mato Grosso (MT) in Brazil, such high transportation costs can be explained by the farm-port distance, lack of paved roads, and the small numbers of railroads.

In summary, the internal transportation from farm to the port and shipping costs to the import port play a crucial role in the export cost competitiveness by narrowing the spread between the three major soybean exporters. Lastly, estimating the transportation cost for these three countries serves as a measurement tool as to what rates should be adopted to shock the model.

Conceptual Analysis of Transportation Costs Reduction in Brazil

The effects of Brazil's reduction in transportation costs on the soybean industry world market are illustrated in Figure 1. The initial situation amid no improvement in transportation costs is represented

Table 1. Soybean Production Costs and Export-Cost Competitiveness: U.S., Brazil (Mato Grosso and Paraná), and Argentina (2003/04).

		Brazil		
Cost item	U.S. Heartland	Mato Grosso	Paraná	Argentina
Variable costs, US$ per acre:				
Seed	28.67	12.79	10.54	18.57
Fertilizers and chemicals	24.83	82.47	60.83	23.82
Machine operation repair	22.13	18.02	22.82	21.36
Hired labor, harvest and misc.	2.26	15.93	21.15	28.44
Total variable costs	77.88	129.21	115.35	92.21
Fixed costs:				
Depreciation of machinery/equipment	51.36	16.83	18.96	22.14
Land costs (rental rate)	97.45	15.46	25.91	72.78
Taxes & insurance plus farm overhead	18.15	5.35	6.54	23.98
Total fixed costs	166.96	37.63	51.40	118.90
Total production costs	244.84	166.84	166.75	211.11
Costs per bushel, US$ per bushel (% U.S. cost):				
Yield, bushels/acre	46.00	43.07	41.38	50.00
Total costs per bushel	5.32	3.87 (73)	4.03 (76)	4.22 (79)
Internal trans. & marketing, US$/bu.	0.48	1.80	0.81	0.72
Cost at border	5.81	5.67 (98)	4.84 (83)	4.94 (85)
Freight costs to Rotterdam	0.39	1.25	1.25	1.03
Price at Rotterdam	6.20	6.92 (112)	6.09 (98)	5.97 (96)

Source: USDA/ERS (2006), Schnepf et al. (2001), Rebolini (2005), CONAB (2006) Paraná State Department of Agriculture (SEAB) (2006), CIF Rotterdam prices (USDA - FAS 2006); U.S. FOB Gulf port prices (ASA 2006); U.S. producer price (USDA - NASS 2006); Argentinean internal transportation and marketing costs to port: Schnepf et al. (2001) and Lence (2000); Brazil FOB prices are from Rio Grande (Safras and Mercado) and Paranagua (Reuters) (USDA - FAS 2006).

by the dotted line. Since Brazil is a large soybean exporting country, as Brazil reduces its transportation costs the soybean domestic price goes up to P_C'. Consequently, the soybean price in the importing countries and competing exporting countries drops to a level represented by the long-dash-double-dot line (right above the black line). However, the decrease in transportation costs becomes an attraction for Brazilian soybean producers to expand their crop. As a result of the expansion the soybean supply in Brazil increases, shifting the supply curve outward (S_B to S_B'). As a consequence of the soybean supply increase, the world excess supply moves in the same direction as the Brazil's soybean supply (ES_{SB} to ES_{SB}'). Therefore the domestic soybean price in Brazil reaches P_C'', capturing both local transportation-cost reductions and soybean crop expansion effects. As a result, the domestic consumption of soybeans by the joint sectors decreases from Q_2 to Q_1. On the other hand, Brazil's soybean exports rises from $Q_2 - Q_3$ to $Q_1 - Q_4$. For importing countries, the soybean price goes down, causing an increase of soybean imports (from $Q_8 - Q_9$ to $Q_7 - Q_{10}$) and a decrease in exports (from $Q_{11} - Q_{14}$ to $Q_{12} - Q_{13}$) for the competing exporting countries.

The total effects for the soybean joint-products

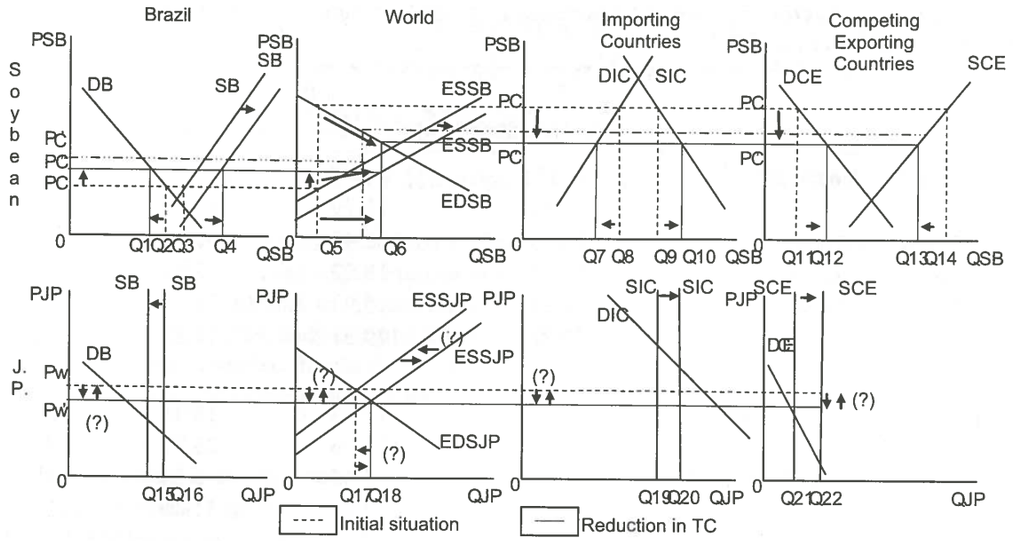

Figure 1. Effects of Reduction in Transportation Costs in Brazil and in the World Soybean Industry Market.

sector are ambiguous. The magnitude of the soybean supply shift plays a crucial role in determining the soybean joint products excess supply movement. In Figure 1, the domestic soybean price increases in Brazil and goes down for the rest of the world. Since soybeans are the primary input for the soybean industry and approximately 60 percent of the soybeans are crushed in the exporting countries, soybean crush decreases in Brazil and increases for the importing and exporting competing countries. Consequently, soymeal and soyoil supply increases for both importing and competing exporting countries. Nevertheless, the effects on the world price and trade flows of soybean-derived products are uncertain.

Brazil's Transportation Channels and Possible Improvements

Based on a study done by the National Cargo Transportation Users Association (ANUT) (2004), this section analyzes the soybean transportation channels which might affect Brazil's competitiveness the most.

The São Luís Port Channel

In 2003, this channel was utilized to transport approximately 1.67 MMT of soybean exports (MDIC 2006) originating from the Center-West (CW), Northeast (NE), and North (N) regions (CONAB, 2006).[1] The main transportation mode for this channel is the railroad. Two railroads connect farmers from these three regions to the São Luís port in the state of Maranhão (NE)—the Norte Sul and the Carajás. However, soybeans originating in the northeast of MT must travel approximately 700 kms along the BR-158 road to reach Marabá, Pará, where the beginning of the Carajás railroad is located. After reaching Marabá, the train travels to the port, another 500 kms. Additionally, a waterway was being used as a transportation option for this channel—the Mortes–Araguaia Rivers waterway. Environmental issues have been a problem for this

[1] Center-West soybean producing states: Mato Grosso (MT), Mato Grosso do Sul (MS), and Goiás (GO). Northeast: Maranhão (MA), Piauí (PI), and Bahia (BA). North: Tocantins (TO), Pará (PA), and Rondônia (RO

waterway; consequently, soybean transportation through this route has ended.

In relation to transportation improvements in this channel, the ANUT study (2004) points out some essential investments. From Ribeirão Cavalheiro (MT) to Marabá (PA), the Carajás Railroad terminal, the road is unpaved in certain parts. Therefore, an essential improvement would be to pave the road. As stated above, the Mortes–Araguaia Rivers waterway is not being used because of environmental issues. Hence, if this waterway undergoes development, it must comply with all the environmental laws in Brazil.

The Santos Port Channel

Last year, Santos was the largest soybean exporting port in Brazil, with 7.3 MMT (MDIC 2006). This transportation route handles the soybeans in the Cerrado, Paraná, and South regions through roads, railroads, and waterways. A great part of the soybeans landed at the port are transported by truck (almost 3 MMT). Two railroads link the port—the Centro-Atlântica and the Brasil. The Brasil Railroad System is formed by the Ferronorte, Ferroban, and Novoeste railways. Another important transportation mode is the Tiete–Paraná Rivers waterway. This waterway links Goiás in CW to Santa Maria da Serra, São Paulo, nearly 250 kms from Santos, where the soybeans are transferred to trucks.

Planned investments include acquisition of locomotives and railcars; the expansion of the Ferronorte railroad from Alto Araguaia (MT) to Rondonópolis (MT); and widening the bases of bridges on the rivers paths, making it possible for larger barges to navigate, thereby increasing volume capacities. The most important of these improvements is the expansion of the Ferronorte Railroad into Rondonópolis (MT); according to Fuller et al. (2001), this expansion would result in a decrease in transportation costs of $0.45/ton.

The North Region Ports Channel

The North region has two important ports for the soybeans coming from North and Northwest of MT: Itacoatiara and Santarém, located in the states of Amazonas (AM) and Pará (PA), respectively. In 2005, both ports accounted for nearly 0.78 MMT exports of soybean (MDIC 2006). After 1997, soybeans from the North and Northwest part of MT were sent to these ports through a combination of a less-congested road to the city of Porto Velho (RO) and the Madeira–Amazon Rivers waterway. Another waterway that is planned to be constructed is the Teles Pires–Tapajós Rivers waterway. This waterway would link Cachoeira Rasteira (North MT) and Santarém port. In addition, the use of the BR-163 road that connects Sinop (MT) to Santarém (PA) also represents a possible decrease in transportation charges. However, most of this road is unpaved and drivable during only eight months of the year.

The planned improvements for this exporting channel are therefore improvements in the Madeira–Amazon Rivers waterway, paving of the BR-163 from Sinop (Center MT) to Santarém, and construction of the Teles Pires–Tapajós Rivers waterway. Of these improvements, the first two are the most important and the most likely to occur in the near future. Fuller et al. (2001) calculated that the development of the Madeira-Amazon waterway would lower total route costs by nearly $11.50/ton. The same study also estimated that the BR-163 improvement would reduce total route costs in the range of $10.50–$11/ton. The Teles Pires–Tapajós Rivers waterway would lower the transportation costs in the range of $2.27–$16.81/ton (AHIMOR 2006).

Methodology

The software utilized in this study is the Global Trade Analysis Project (GTAP). The GTAP 6 Data Package covers 87 regions and 57 sectors. The 87 regions are combined into 7 regional aggregates: Brazil, U.S., Argentina, EU, China, Japan, and the rest of the world (ROW). The 57 GTAP sectors were aggregated into soybean, soybean joint products, other food, mining and manufactures, and services and activities. A proxy is utilized to capture the effect of reduction in transportation costs; for this study, the proxy is an export tax reduction in the Brazilian soybean.

Simulation Results

Scenario 1

The first scenario we model is a small reduction in transportation costs due to improvements in the

Santos Port channel. Table 2 shows that Brazil gains export market share in soybeans. Brazilian exports increase to all importing countries, with ROW increasing 62 percent. This export increase comes from the cheaper soybeans supplied by Brazil to the world market. As a consequence, the U.S. and Argentina lose market share with EU importing more soybeans from Brazil (14.67-percent and 14.39-percent decrease of soybean imports from the U.S. and Argentina, respectively).

However, the soybean joint products have a different result than the soybeans. Brazil's export market share goes down, and only Argentina gains. The gain is not that significant compared to Brazil's loss of market share. This can be explained by the soybean price increase in Brazil resulting in less soymeal and soyoil being produced. Table 3 presents the changes in prices for the soybean and soybean derived goods and other market and economic indicators.

Table 3 presents the possible benefits of the transportation improvement that was assumed to occur in Brazil for Scenario 1. As a consequence of Brazil increasing soybean exports, the GDP for the nation goes up (0.17 percent), while other exporting countries experience a reduction in GDP. According to the variation of per-capita utility (UPC), there are gains only for the importing countries due to cheaper soybeans and soybean joint products supplied in the world market. On the other hand, Brazil has a decrease in UPC due to the price increase of both soybeans (2.42 percent) and soybean joint products (1.23 percent). For the exporting countries, the EVs are negative, with Brazil having the biggest impact. This is due to the domestic soybean and soybean joint products price increase, which consequently causes deterioration in real income and welfare. Due to lower CIF prices, importing countries have a positive equivalent variation.

Scenario 2

The second scenario modeled is a large reduction in transportation costs due to improvements and establishment of all exporting channels. Table 4 presents the simulation results regarding variation in export sales by each exporting country and destination.

For soybeans, a greater reduction in transportation costs results in greater market share for Brazil than for the competing exporting countries. On the other hand, as the local soybean price goes up (see Table 5 below) amid a decrease in transporta-

Table 2. Scenario 1: Exports to World Markets (Sales in US$ million).

	Exporters (Soybeans)								
	Brazil			U.S.			Argentina		
Importers	Before	After	% Ch.	Before	After	% Ch.	Before	After	% Ch.
EU	1686.2	2398.0	42.2	1176.8	1004.1	-14.6	240.3	205.7	-14.3
China	620.6	938.5	51.2	1191.4	1080.9	-9.2	989.1	900.7	-8.9
Japan	151.1	240.6	59.1	753.3	719.6	-4.4	3.7	3.5	-4.1
ROW	395.9	642.8	62.3	2686.7	2618.2	-2.5	321.5	314.3	-2.2
	Exporters (Soybean joint products)								
	Brazil			U.S.			Argentina		
Importers	Before	After	% Ch.	Before	After	% Ch.	Before	After	% Ch.
EU	19.9	18.2	-8.5	91.7	91.3	-0.4	73.3	74.2	1.2
China	5.8	5.2	-9.4	10.5	10.4	-1.0	8.1	8.2	0.6
Japan	0.3	0.2	-9.7	27.8	27.5	-1.3	2.0	2.0	0.3
ROW	575.0	527.61	-8.2	732.8	734.0	0.2	1588.6	1617.6	1.8

Source: GTAP simulation results.

Table 3. Scenario 1: Most Important Market and Economic Indicators.

		Soybeans			Soybean joint products		
Market indicators	Unit	Brazil	U.S.	Argentina	Brazil	US	Argentina
Local price	%-ch.	2.42	−0.57	−0.65	1.23	−0.18	−0.44
FOB price	%-ch.	−10.94	−0.57	−0.65	1.23	−0.18	−0.44
CIF price	%-ch.	−10.39	−0.54	−0.62	1.17	−0.17	−0.42
Econ. indicators	Brazil	U.S.	Argentina	EU	China	Japan	ROW
GDP (%-ch.)	0.1726	−0.0066	−0.0566	0.0031	0.0111	0.0002	−0.0037
UPC (%-ch.)	−0.077	−0.0003	−0.0162	0.0215	0.0011	0.0050	0.0015
EV - US$ million	−344.48	−30.35	−39.46	371.29	226.29	42.04	90.96

Source: GTAP simulation results.

Table 4. Scenario 2: Exports to World Markets (Sales in US$ million).

	Exporters (Soybeans)								
	Brazil			U.S.			Argentina		
Importers	Before	After	% Ch.	Before	After	% Ch.	Before	After	% Ch.
EU	1686.2	3095.8	83.6	1176.8	856.2	−27.2	240.3	175.9	−26.8
China	620.6	1281.4	106.4	1191.4	974.8	−18.1	989.1	814.8	−17.6
Japan	151.1	345.5	128.6	753.3	682.5	−9.4	3.7	3.4	−8.7
ROW	395.9	943.8	138.3	2686.7	2540.1	−5.4	321.5	305.8	−4.8
	Exporters (Soybean joint products)								
	Brazil			U.S.			Argentina		
Importers	Before	After	% Ch.	Before	After	% Ch.	Before	After	% Ch.
EU	19.9	16.5	−17.1	91.7	90.9	−0.9	73.3	75.1	2.3
China	5.8	4.7	−18.8	10.5	10.2	−2.1	8.1	8.2	1.0
Japan	0.3	0.2	−19.4	27.8	27.1	−2.7	2.0	2.0	0.4
ROW	575.0	479.4	−16.6	732.8	734.8	0.2	1588.6	1644.4	3.5

Source: GTAP simulation results.

Table 4. Scenario 2: Exports to World Markets (Sales in US$ million).

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Source: GTAP simulation results.

tion costs, the soybean joint products production decreases. Therefore, Brazil loses market share, especially to Argentina.

As for the GDP, Table 5 shows Brazil's improved transportation routes result in a GDP growth higher than in Scenario 1, while the U.S. and Argentina lose market share and thus a small amount of GDP. With the exception of the ROW and Japan, the importing countries gain economic growth due to cheaper imported soybeans (decrease of the CIF price), especially from Brazil. In regard to the welfare indicators, the UPC and EV are more negative for the exporting countries than in Scenario 1. Such high negative variation in the Brazilian UPC might be explained by the higher soybean and soybean joint-products prices compared to the initial situation with no transportation improvement. In contrast, the importing countries gain from the lower price of imported soybeans. Likewise, for the EV welfare measure, the exporting countries lose and importing countries gain.

Summary and Conclusion

This study analyzed the effects of improvements in the transportation infrastructure of Brazil on the world soybean complex. After estimating the export-cost competitiveness for the three largest exporting countries (U.S., Brazil, and Argentina), the analysis was carried out using a computable general equilibrium (CGE) model. The export-cost-competitiveness analysis shows Brazil has a 63.22% cost disadvantage to the U.S. in internal transportation. Therefore a domestic transportation analysis simulated the adoption of new transportation routes and improvements in the existing routes that can reduce transportation charges.

By reducing the transportation costs, our results in both scenarios show that Brazil gains market share in the exports of soybeans but loses on the value-added products. This is a consequence of a decrease in soybean joint-products production due to higher local soybean price. The competing exporting countries lose market share in the soybean market. However, for the soybean joint-products market, only Argentina gains market share from Brazil. The U.S. share declines, but the drop is insignificant. Brazil's economy grows, but only by a small amount. The overall situation is a decrease in all indicators for the U.S. and Argentina. In contrast, the importing countries in general show modest welfare and economic gains as they benefit from low-cost products.

Finally, the decrease in internal transportation costs for Brazil results in the country becoming the leading soybean exporter in the world (Scenario 2). However, the soybean joint-products industry produces less due to higher domestic soybean prices. Therefore, in conclusion, a reduction in internal transportation charges in Brazil favors the farmers because their returns rise, but the crushing sector suffers, as they have to buy more costly soybeans to produce their derived products. For Brazil, in the short run, who gains and loses is determined by the economic and welfare indicators. Economic growth rises, but welfare indicators fall. So we can conclude that soybean farmers are better off from this transportation-cost improvement, but the soybean crushing industry is worse off.

References

AHIMOR. 2006 "Hidrovia do Tapajós." http://www.ahimor.gov.br/tapajos/index.htm. Accessed September 2006.

ANUT. 2004. "Transporte – Desafio ao Crescimento do Agronegocio Brasileiro." Available at: www.anut.org.br/ trabalhos.asp. Accessed March 2004.

ASA. 2006. *Weekly Update*. http://www.asasoya.org. Accessed August 2006.

CONAB. 2005. "Corredores de Escoamento da Producao Agricola." www.conab.gov.br. December.

Fuller, S., T. H Yu, L. Fellin, A. Lalor, and R. Krajewski. 2001. "Effects of Improving Transportation Infrastructure on Competitiveness in World Grain Markets." *Journal of International Food & Agribusiness Marketing* 13:61–85.

Lence, S. H. 2000. "A Comparative Market Analysis of Major Agricultural Products in the United States and Argentina." MATRIC Research Paper, 00-MRP 2. Ames: Iowa State University.

MDIC. 2006. "Aliceweb." aliceweb.desenvolvimento.gov.br/. Accessed August 2006.

Rebolini, J. M. 2005. "Soja: Costo por Tonelada en Argentina, Brasil y EE.UU." *Margenes Agropecuarios* October.

Schnepf, R., E. Dohlman, and C. Bolling. 2001. "Agriculture in Brazil and Argentina: Development and Prospects for Major Field Crops." U.S. Department of Agriculture, Economic Research Service, Market and Trade Economics Division. November.

SEAB. 2006. "Estimativas de Custos." http://www.pr.gov.br/seab/. Accessed August, 2006.

USDA - ERS. 2006. "Commodity Costs and Returns: US and Regional Cost and Return Data." www.ers.usda.gov/Data/CostsAndReturns/. Accessed August 2006.

USDA - FAS. 2006. "Oilseeds: World Markets and Trade." www.fas.usda.gov. Accessed July 2006.

USDA - NASS. 2006. "Database—National Statistics." www.nass.usda.gov. Accessed August 2006.