Impacts of Transportation and Logistics on Brazilian Soybean Prices and Exports

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Abstract

As Brazilian soybean exports doubled between 2001/02 and 2011/12 and major production areas consolidated in remote inland Cerrado regions, moving product to port has proven to be a challenge. A review of the literature, data analysis, and interviews with experts in the logistics chain revealed that a lack of grain storage, overreliance on trucking, poor road conditions, and inefficient operations at rail terminals and ports impede a smooth flow of grain from farm to port. Because of the comparatively low per-unit values of agricultural bulk commodities, transportation may account for a large share of the total cost of soybean exports. As a result, it was hypothesized that increases in transportation costs may reduce farm-gate prices, affecting producer profitability and, thus, national production. To test that hypothesis, this study examined transportation costs from inland production regions to traffic hubs and the Santos seaport. A comparison of theoretical producer prices calculated based on logistics costs versus actual local prices was employed to confirm that transport inefficiencies have led to depressed farm gate prices.

Keywords

Supply chain interruptions, Brazilian soybean logistics, Brazilian soybean transport costs, infrastructure shortcomings, Brazilian transportation

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Transportation Journal, Vol. 58, No. 1, 2019

Brazilian soybean production soared from 39.5 mmt in 2000/01 to an estimated 115 mmt for 2017/18 (USDA 2018) and production expanded from traditional cropping areas in the East into the Center-West. This study set out to answer the following questions: (1) How high are transport costs for different locations along a gradient of increasing distance to the port? (2) How do prices derived from those costs compare with the regional prices paid to the producers along this path?

This comparison allows conclusions regarding whether the noticeable differences in farm-gate prices result mainly from the high cost of transport—and whether improved transportation costs would promote further increases in agricultural production in remote areas.

Study Methodology

Data regarding the soybean market were collected from a number of government and other sources. However, information regarding costs in the transportation and logistics sectors was not readily available, so a qualitative case study approach employing expert interviews was adopted for that portion of the study. A case study is a quantitative or qualitative method that relies on multiple sources of evidence as it "investigates a contemporary phenomenon in depth and within its real-life context" (Yin 2009, 18).

The study was conducted in three phases:

1. Data collection where possible, literature review, posing of the research objectives, creation of an interview guideline, and design of an organizational framework for a research trip through the selected regions.
2. On-site research in Brazil via interviews with researchers and experts who belonged to trading and transportation companies, as well as visits to logistics facilities and two farms in August–September 2012. In each county, at least one expert related to a transport company and one expert related to a trading company were interviewed.
3. Data processing and market and cost analysis: Information related to market size and trade flows was sourced from government data and associations. Market analysis was based on the approach used by Aaker (2005, 78). It included structure and size of the market, distribution systems, cost structure, and market trends, found in the case study regions.[1]

Regions Studied

The authors chose the deep-water port at Santos as a domestic destination port because of its importance in exporting soybeans, both nationally and specifically those from the farming regions in the study. *agri benchmark* farms in four counties with soybean production along the important Sorriso-Santos export corridor were used to illustrate costs and logistics: Sorriso-Mato Grosso (MT), 2,200 km; Rondonópolis-MT, 1,400 km; Rio Verde-Goiás (GO), 1,050 km; and Barretos-São Paulo (SP), 500 km (see fig. 1).

Cost Assumptions

A cost report was created from the point of view of the seller, based on information from Safras&Mercado (2012), market reports and the expert discussion with Prof. Dr. Lucilio Rogerio A. Alves (interview). It was assumed that the beans were sold free on board (fob) Santos, which implies that the seller is responsible for transportation from origin to destination and is liable for its costs. Risks of loss and damage to the goods are borne by the seller until traversing the ship's railing.

The major logistics cost centers are transportation, including transshipment costs, and port charges (Kussano and Batalha 2009, 31). Steps

Figure 1 Map of the Four Locations Studied Along Route to Santos. *Source:* Google Maps (2013), modified.

were taken to account for capital costs and depreciation of vehicles as well as variable costs based on fuel prices, distance traveled and tolls.[2]

Calculations

Beginning with the FOB price at the seaport and subtracting each cost along the commercial chain from vessel back to the farmer, a theoretical cost-based price received by the producer at his local warehouse was calculated. This is used as a benchmark for evaluation and comparison among regions.

In a second step, the authors compared these theoretical prices with spot prices actually paid to growers at each origin. The difference between the two prices indicates the degree to which other factors, such as local supply and demand dynamics, may have an influence.

Market Structure and Logistics

The shipping process starts at the farm gate, from which point the soybeans are transported by truck to a regional warehouse, where they are graded and inspected. Only small volumes are shipped directly from farm to seaport.

The national supply chain involves private service providers such as trading companies, brokers, and warehouse operators, as well as freight forwarders, transporters, and bankers on the one hand, and public agencies such as customs, port authorities, and transport regulators on the other.

An estimated 80 percent of Brazilian soybeans are purchased by commercial trading companies and 20 percent by cooperatives (Daniel Furlan Amaral, interview). Most soybeans are handled by the large "ABCD" trading companies—ADM, Bunge, Cargill, and Louis Dreyfus Commodities. The first three companies own large warehouses and crushing facilities in Brazil and operate port terminals. Their market position and size enable them to ship at very competitive freight rates (Charles L. Peeters, interview).

Modes of Transportation

The principal modes of transportation for oilseeds are road, rail, and water. Sixty percent of Brazilian soybeans move via road, 33 percent via rail, and only 7 percent on waterways. Most farms in Brazil have no direct access to rail terminals or inland ports, necessitating trucking at least to regional warehouses, if not the entire distance to port.

Less than one-seventh of the 1.6 million km of roads and only 2 percent of roads under municipal administration are paved. More than half are in average to poor condition, directly influencing operational costs and

Table 1/Comparison of Travel Time from Four Sites to Santos

Origin	Distance to Santos	Transit Time	Average Speed
Sorriso-MT	2,100 km	6 days	40 km/h
Rondonópolis-MT	1,400 km	5 days	40 km/h
Rio Verde-GO	1,050 km	3 days	45 km/h
Barretos-SP	500 km	0.75 days	n/d

Source: Based on expert interviews.

possibly causing longer transit times. Table 1 summarizes the transit time and average speeds from selected regions to Santos port.

At the time of research, the lack of local storage facilities, including on-farm storage, resulted in the need to compress farmers' sales and shipments at harvest. Peak export shipments occur from March to June (Nunes 2012), when soybean stocks in the United States—the primary competitor—generally are tightening and an ample supply of the Brazilian harvest floods the market. Exports fall off considerably by September, when demand shifts back to the northern hemisphere, as US soybean harvest begins.

During peak harvest season, local truck capacity in the largest soybean-producing state, Mato Grosso, is insufficient and the excessive demand must be satisfied by trucks from other states. This drives transport costs higher and causes road congestion. Typically, trucks that carry 37 t net cargo weight are used because not all intermodal terminals can handle the larger models with 50 t net cargo weight.

Rail

Only 10 percent of Brazil's rail network is fully utilized (Gregoire 2011, 7). Rail transport in Brazil is underutilized for several reasons:

> It is hampered by the lack of a standard gauge, although the Sorriso–Santos corridor runs on compatible, broad-gauge rails, allowing travel from Mato Grosso directly to Santos port. As a result, between 50 and 80 percent of the soybean exports from Mato Grosso travel via truck to the transshipment terminal and then via rail to the seaport.
>
> Because rail requires large quantities to be economical, mainly big trading companies use it.
>
> Train speeds often must be reduced, especially in urban areas and where rail infrastructure is old and less resilient. As a result, in some cases, trucks may be faster (Anonymous 4, interview).

Waterways

Waterway transport also requires transshipment and is mainly used by traders with large handling capacity due to high fixed costs and the need for large volumes to make it cost-effective. It rarely is used for beans grown in the Center-West and was disregarded in this study.

Ports

Although some 90 percent of Brazil's exports leave the country via seaports, port infrastructure also is deficient. At the port of Santos, more than half the grain and food products arrive via truck. Despite 24/7 operating hours, insufficient reception capacity, especially during peak harvest periods, leads to delays and demurrage costs for both ships and trucks.

For trucks, a free period of 24 hours typically is granted, after which demurrage fees of 0.40 R$/t/h, or 14.80 R$/truck/h are charged. Experts estimate the average wait-time for a truck to unload at Santos is approximately two days during peak harvest season if there are no other disruptions of the process (e.g., from weather) (interviews: Anonymous 2, Anonymous 6, Cicero Garcia da Silva, Diogo Parreira França, and Rogério Ferreira). But some experts (interviews: Anonymous 1 and Anonymous 2) reported truck waits of as much as 10–30 days at the port terminals.

During harvest, an average 150 to 250 rail cars are unloaded each day (Anonymous 1, 2012). Once a free unloading period of 18 hours for a train expires, a demurrage fee of 50 R$/railcar/h per railcar is charged to the exporter.

Hence, with estimated combined daily volume delivered to a terminal of 30,000 t during the peak of harvest, a halt in loading a vessel (e.g., because of rain) leads to high opportunity costs.

Port operational costs vary with the difference in volumes handled or a privileged access to the port terminal (i.e., a trading company running its own terminal). In the calculations, 11 US$/t (22 R$/t; based on the August 2012 exchange rate of 2.03 R$/US$) was used for the port fee, based on information given in interviews by Fábio França, Anonymous 1, and Mauro Osaki. Experts mentioned labor requirements and regulations, high rates of absence, and frequent strikes of employed syndicate members as factors that lead to elevated operational costs.

Findings

Cost Differences with Distance

Transportation is the major factor in total logistics costs. Total costs per route increase with the distance traveled, as do transportation costs as a

share of total cost, which ranges from 66 percent in Barretos to 86 percent in Sorriso. (See table 2.)

In the example calculation, 28 percent of the fob price of the Sorriso-originated beans at Santos port is attributed to logistics costs. This percentage drops when freight prices are comparatively lower and as the distance traveled decreases (Rondonópolis, 22%; Rio Verde, 19%; Barretos, 11%). As hypothesized, this usually results in lower farm prices in the remote regions of Mato Grosso.

The major cost factors for transportation from the trucker's perspective are fuel cost, driver's gross labor rate, and maintenance. These account for 63–70 percent of the total transport costs in the study. Sensitivity analysis showed that a change in fuel cost leads to a proportionate change in total transportation costs, which means an increasing effect on absolute transportation cost with increased mileage driven.

Furthermore, the cost of fuel usually is higher in the Center-West regions because it must be brought in from the eastern coastline where the fuel industry is located. Within the time scope of the analysis (export season 2011), fuel prices in Sorriso increased between March 2011 and September 2011 but remained constant or decreased slightly in the other regions.

Due to changes in local fuel costs, total costs for truck transport from Sorriso to Santos differed by 14.70 R$/km between March and April and by 11.55 R$/km between March and September. At Barretos, the absolute cost difference equaled 1.00 R$/km from March to April and 1.50 R$/km from March to September, with a change of 0.4 percent in the local diesel price. At Rio Verde, a slight decrease in diesel price from March to April and from March to September reduced costs by 12.08 R$/km and 16.28 R$/km respectively. In Rondonópolis there was no change in diesel prices and transport cost from March to April, but from March to September a change in diesel price resulted in a 4.50 R$/km change in total transport costs.

Table 2/Costs of Road Transportation by Location

Costs R$/km	Sorriso-MT	Rondonópolis-MT	Rio Verde-GO	Barretos-SP
Fixed	1.99	1.99	1.99	1.99
Variable	1.44	1.53	1.63	2.19
Total cost/km	3.42	3.52	3.61	4.18
Km to Santos	2,100	1,400	1,050	500
Total transport cost	7,182	4,928	3,791	2,090
% discount vs Sorriso		32	47	71

Further sensitivity analysis examined variations in maintenance costs, which generally increase with the age of the vehicle or with more distance driven on roads in poorer condition. A newer truck or driving on better roads might reduce such costs. A 10 percent variation of maintenance costs resulted in a 4 percent variation in fixed costs and 2 percent in total transport costs, or a change in total transport costs of 165.00 R$ from Sorriso and 37.50 R$/t from Barretos to Santos.

Analysis showed that distance magnified the impact of changes in a factor and any increase in transportation costs is reflected in lower local soybean prices paid to producers. Hence, changes that reduce transport costs would benefit producers in the Center-West more than those closer to the port, whereas increased transportation costs can offset the Center-West's competitive advantage, which is based on low production costs.

Differences by Season

Freight rates were highest in March due to strong seasonal demand for soybean and grain shipping, whereas those in September did not cover estimated trucking company costs in most cases (Diogo Parreira França, interview).

Comparing April and September prices and freight rates (illustrated in fig. 2) showed that freight rates fell 7 percent for Sorriso and Rondonópolis and 12 percent for Rio Verde from harvest to September. Freight rates in Barretos were unchanged, probably due to the low importance of the soybean crop versus other crops in that region and more level demand for transportation during the whole period.

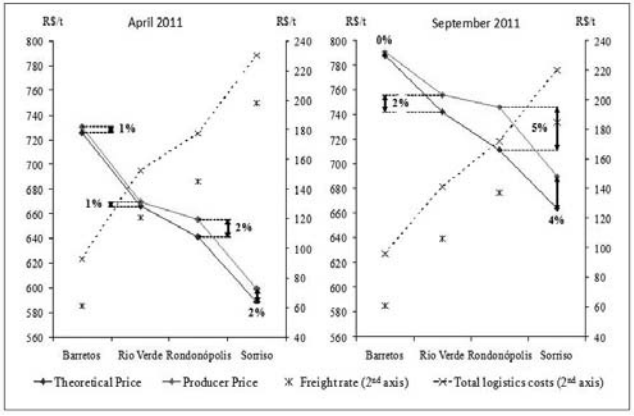

Figure 2 Comparison of Theoretical and Actual Producer Prices.

One would expect higher soybean prices when freight costs fall, and that is seen in figure 2. Soybean prices increased between April and September by 15 percent in Sorriso, 13 percent in Rondonópolis and Rio Verde, and 8 percent in Barretos, while freight prices were lower (–7% for Sorriso and Rondonópolis, –12% for Rio Verde, unchanged for Barretos).

Calculated versus Actual Prices

The price fob Santos for April 2011 was 818.53 R$/t. Deducting port export expenses of 31.86 R$/t left a port gate price of 786.67 R$/t. Table 3 shows the freight rate for each location and the resulting theoretical price at the regional warehouses.

Differences between the cost-based theoretical price and the local spot market price in April 2011 ranged from 0.56 percent (Rio Verde) to 2.2 percent (Rondonópolis). Because Rondonópolis is not the farthest site from the port, its largest price discrepancy implies something other than transportation is the cause. Some possible reasons include:

1. Market dynamics. Rondonópolis is a major trading center, and simplified logistics from that site may add value to supplies available there.
2. Values used in the study include monthly averages and estimates of experts, which may lack precision and congruence.
3. The spot market prices include the freight prices of self-employed drivers, whereas the theoretical prices do not. Age of trucks, labor costs and fierce competition may lead to lower trucking costs for self-employed drivers and thus may push down freight rates paid. This would be reflected in a stronger spot market price.

Table 3/Logistics Cost Calculation for Selected Regions Based on April 2011

Origin (km to Santos)	Sorriso-MT (2,200 km)	Rondonópolis-MT (1,400 km)	Rio Verde-GO (1,050 km)	Barretos-SP (500 km)
Truck freight rate	198.22	145.60	120.75	60.75
Total logistics costs	230.08	177.46	152.61	92.61
Price at warehouse	588.45	641.07	665.92	725.92
Local spot market price	599.17	655.17	669.67	730.50
= Difference of theoretical and spot price	10.71	14.09	3.74	4.58

Note: All costs, prices in R$/t.

Note that the differences between the theoretical and spot market prices were greater in September than during the peak of harvest, particularly in Rondonópolis and Sorriso, where the divergence was 5 percent and 4 percent, respectively, in September. As noted earlier, factors such as local changes in supply and demand may be the cause for the greater increase in actual price than predicted by the decrease in freight cost.

Conclusion

This study demonstrates a direct correlation between transport costs and farm gate prices in that changes in fob prices are almost "perfectly" transmitted to farm-gate prices. Domestic transportation costs for soybeans shipped out of Mato Grosso were equivalent to about a third of the 2012 fob price (app. 200 R$/t). This shows the challenge for remote, though highly productive, regions to efficiently compete on the world market.

It also illustrates the need for improvement in the Brazilian soybean transportation and logistics chain. The trucking industry is highly competitive but is hampered by poor infrastructure. The rail system is fragmented and the corridor from the soybean production regions in the Center-West to Santos is used almost exclusively by the major trading houses. Compression of shipping and insufficient port infrastructure lead to costly delays.

The high importance of transport cost implies that a strong impact would be seen from infrastructure improvements on the competitive advantage of producers in remote areas. This ultimately will help lower transportation costs, leading to comparatively higher farm-gate prices and increased return to land, thus promoting the expansion of agricultural production in remote areas and further encouraging sales of Center-West grown beans into export.

Given Brazil's natural resource abundance and rising investment, there is great potential for further conversion of grazing land to soybeans without touching the rainforest. In order to efficiently move the current volumes and be able to mobilize this potential of increased soybean production and grain flows, an efficient, integrated logistics system, supported by strategic investments and policies, is essential to reduce costs and ensure flow of product. In the end, a "trade supply chain is only as strong as its weakest link" (World Bank 2010).

Addendum

Recent Developments in Brazilian Transport and Logistics

In early 2018 the authors performed a literature review to determine whether more recent research was available that would indicate different conclusions from those reached based on their original research. In fact, relevant research indicates that investments are being made to address the shortfalls our article describes, but the issues have not yet been resolved.

For instance:

> Despite relevant public and private investments in infrastructure in the past two decades, Brazil has not yet developed a world-class infrastructure consistent with its needs or comparable to that of developed economies. This infrastructure bottleneck has an adverse impact on Brazilian productivity, competition and economic growth. (Enei 2017)

And:

> Brazilian primary transportation infrastructure faces many challenges. According to the World Economic Forum, Brazil ranks 107th out of 144 countries in level of infrastructure development. Roads and ports need to be upgraded. The most common method of cargo transportation is in trucks via roads due to a limited rail network. Despite the existence of several rivers, waterways are rarely used, except in the Amazon region where rivers are usually the only way to access many isolated points. Railroads are few and uncompetitive. The use of trains for long distance transportation of passengers is restricted to a few urban tourist routes, while cargo transportation is mostly restricted to raw minerals. (US Department of Commerce 2017)

Given these statements and other research and media accounts,[3] the authors regard their prior results as still relevant.

Notes

1. For the full explanation of the methodology, see Fliehr 2013.
2. For a discussion of all costs considered, see chapter 4.2, "Cost Analysis for Four Production Regions," beginning on page 72, in ibid.
3. See "New References" in ibid.

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