Brazil's Modal Shares for Corn and Soybeans: Updated Analysis from 2010-23

Thiago Guilherme Péra
University of Sao Paulo
Luiz de Queiroz College of Agriculture
ESALQ-LOG Group
Brazil

Delmy L. Salin
U.S. Department of Agriculture (USDA)
USA

Author Contact(s): Thiago Guilherme Péra, e-mail: thiago.pera@usp.br, phone number: +551934294580

USDA Contact: Delmy L. Salin, e-mail: delmy.salin@usda.gov, phone number 202-720-0833

Recommended Citation: Péra, Thiago G. and Delmy L. Salin. Brazil's Modal Share for Corn and Soybeans: Updated Analysis from 2010-23. University of São Paulo, Escola Superior de Agricultura "Luiz de Queiroz," Brazil (ESALQ/USP). 2024.
Web: https://esalqlog.esalq.usp.br/modalshareusdaesalq2024

Acknowledgements: This research was supported by Cooperative Agreement Numbers 20-TMTSD-BZ-0001 and 23-TMTSD-BZ-0003 with the U.S. Department of Agriculture, Agricultural Marketing Service.

EXECUTIVE SUMMARY

What Is the Issue?

Historically, grain exports from Brazil have relied heavily on road transportation to bridge long distances between major production regions and the Brazilian ports. However, in the last decade or so, exporting corn and soybeans became much more efficient, with the expansion and consolidation of new transport corridors, as well as the addition of new railways and waterways.

Over the past decade, Brazil has continuously increased grain production because of rising productivity. The country has also expanded cultivated areas and increased the number of harvests, particularly corn harvests. From 2010 to 2023, combined corn and soybean production more than doubled, from 124 million tons to 287 million tons.

Over the same period, booming production and exports led to congestion of traditional export corridors. The need to reduce congestion and cut transport costs spurred construction of new corridors. The rising demand for transportation infrastructure is especially pronounced in major agriculture-producing regions. As a result of this expansion, today's Brazilian transportation system is a more balanced system—markedly transformed from what it was in 2010. Similar to the U.S. system in its complexity, Brazil's system leverages all major modes (truck, barge, rail, and ocean vessel).

This study analyzes the most recent modal share changes for Brazil's corn and soybean exports and chronicles improvements in transportation infrastructure, from 2010 to 2023.

What Did the Study Find?

Despite Brazil's infrastructure advances, a number of challenges persist, including long distances from major production regions to barge and rail terminals, as well as a shortage of rail and inland waterway infrastructure capacity. While grappling with these challenges, Brazil continues to depend heavily on trucking to ship grain to major destinations.

Most corn and soybeans for domestic consumption are shipped by truck, with an average distance of 388 miles (625 km) from farms to any destination other than rail and barge terminals. As determined by the analysis, Brazilian soybeans and corn are trucked an average distance of 538 miles (865 km) (encompassing both domestic and export routes).

Because upgrades to Brazil's railway infrastructure did not keep pace with the rise in soybean and corn exports, shippers' reliance on trucking increased. If not for the growth of barge transportation (particularly in the northern region of the country), the dependence on trucking would have intensified even more. In the last decade, the use of barge transportation rose for shipping corn and soybean exports to major ports. On average, barged corn shipments travel 581 nautical miles (nm) and barged soybeans, 535 nm.

From 2010 to 2023

- Truck market shares for all corn movements (domestic and exports) declined by 8.0 percentage points (pp), from 84 to 76 percent; rail increased 1.5 pp, from 15 to 17 percent; and barge increased 7 pp, from 1 percent to 8 percent.

- Barge gained a significant market share for corn exports, rising from 3 percent to 16 percent—at the expense of rail, which fell from 78 percent to 39 percent. Truck also gained market share, rising from 20 to 45 percent.
- Brazil's increased reliance on trucks for exports is a result of the significant growth in corn exports.
- The ports of Paranaguá, Rio Grande, and São Luís significantly increased their reliance on trucks shipments, at the expense of rail. In 2023, of the ports evaluated, Santos had the lowest dependence on trucks—with 33 percent of shipments handled by truck and 67 percent by rail.

The main results for Brazilian *soybeans* are as follows:

In 2023

- Truck shipments of soybeans from the farm to major destinations accounted for 69 percent of total movements, followed by rail (22 percent) and barge (9 percent).
- Of all modes, trucks shipped the most soybeans to major export facilities. Trucks handled 54 percent of total soybean exports, followed by rail (34 percent) and barge (12 percent).
- Truck freight costs represented 15-40 percent of the product price delivered at port.

From 2010 to 2023

- Truck market shares declined 6 pp, from 75 to 69 percent; rail increased 2 pp, from 20 to 22 percent; and barge increased 4 pp from 5 to 9 percent.
- Barge and truck gained market share at the expense of rail, which fell 13 pp—from 47 percent in 2010 to 34 percent in 2023. Barge shipments increased 4 pp, from 8 percent to 12 percent. Truck shipments increased 9 pp, from 45 percent to 54 percent.
- For the port of Paranaguá, trucks' modal share rose from 76 percent to 78 percent. Even sharper increases occurred for the port of Rio Grande, where truck's share rose from 57 percent to 90 percent, and the port of São Luís, where trucks' share rose from 10 percent to 48 percent. Trucks' share declined only at the port of Santos, where rail's share rose from 52 percent to 57 percent.

How Was the Study Conducted?

The modal share study is a comprehensive logistics module that analyzes Brazil's infrastructure development in great detail. The study developed a longitudinal (2010-23) database that quantifies Brazil's corn and soybean movements by mode (rail, truck, and barge) from the production regions to export ports.

Furthermore, the study accounted for exports of corn and soybeans from a consolidated database that generated three modal indicators—truck, rail, and barge—related to corn and soybean transport movements in Brazil. We broke down the modal shares by total tonnage and by export and domestic market destinations. This study also incorporated secondary data from the Brazilian National Land Transport (ANTT); National Water Transport Agency (ANTAQ); National Supply Company (CONAB); COMEX-STAT; and the Ministry of Development, Industry, Trade and Services (MDIC).

1. INTRODUCTION

Over the past decade, Brazil's grain production has continuously increased with rising productivity, expanding farmland, and rising frequency of harvests (particularly, in the case of corn). Corn and soybean production grew from 124 million tons in 2010 to over 280 million tons in 2023—a 129-percent increase.

Historically, Brazil has always depended greatly on long-distance trucking for transporting freight, especially grains. Reduced efficiency in the trucking sector impairs the country's ability to supply grain in the domestic and export markets.

Numerous pressures have created a high demand for railways and inland waterways services has arisen from the high volume of corn and soybean production, Brazil's geographic vastness, and the difficulty accessing good-quality transportation infrastructure for most farms.

According to National Transport Confederation (CNT, 2023), the Brazilian transportation infrastructure includes:

- About 1 million miles (1.720 million kilometers (km)) of highways (13 percent are paved);
- 19,452 miles (31,299 km) of railways—one third in commercial operation; and
- Just over half of the 22,462 nautical miles (nm) (41,600 km) of inland navigable waterways that are commercially operating.

This profile of transportation infrastructure suggests that Brazil depends heavily on highways: around 61.1 percent of cargo is handled by highways; 20.7 percent, by railways; 13.6 percent, by barge; 4.2 percent, by pipelines; and 0.4 percent, by airways (CNT, 2019).

However, a number of factors have transformed Brazilian transportation infrastructure for grain in recent years:

- **Expansion of the Brazilian agricultural frontier.** This especially involves the states of Maranhão, Tocantins, Piauí, Bahia, and the northern region of Mato Grosso.
- **Construction of inland waterways in the northern region.** Following the establishment of the Ports Regulatory Framework in 2013, substantial private-sector investments have funded the construction of privately operated terminals (outside the traditional public port facilities).[1] Today, Brazil has roughly 200 privately operated terminals, which handle more than half of the country's export volume.
- **Expansion of railway capacity and establishment of new railroads for handling grain.** In 2021, Brazil enacted the Railways Law[2], which allows the private sector to develop railway infrastructure through an authorization process. The process provides an additional investment pathway to an industry that was previously limited to concessions.

[1] More detail about Ports Regulatory Framework: https://www.planalto.gov.br/cciviL_03////_Ato2011-2014/2013/Lei/L12815.htm
[2] More detail about Railways Law: https://www.planalto.gov.br/ccivil_03/_ato2019-2022/2021/lei/l14273.htm

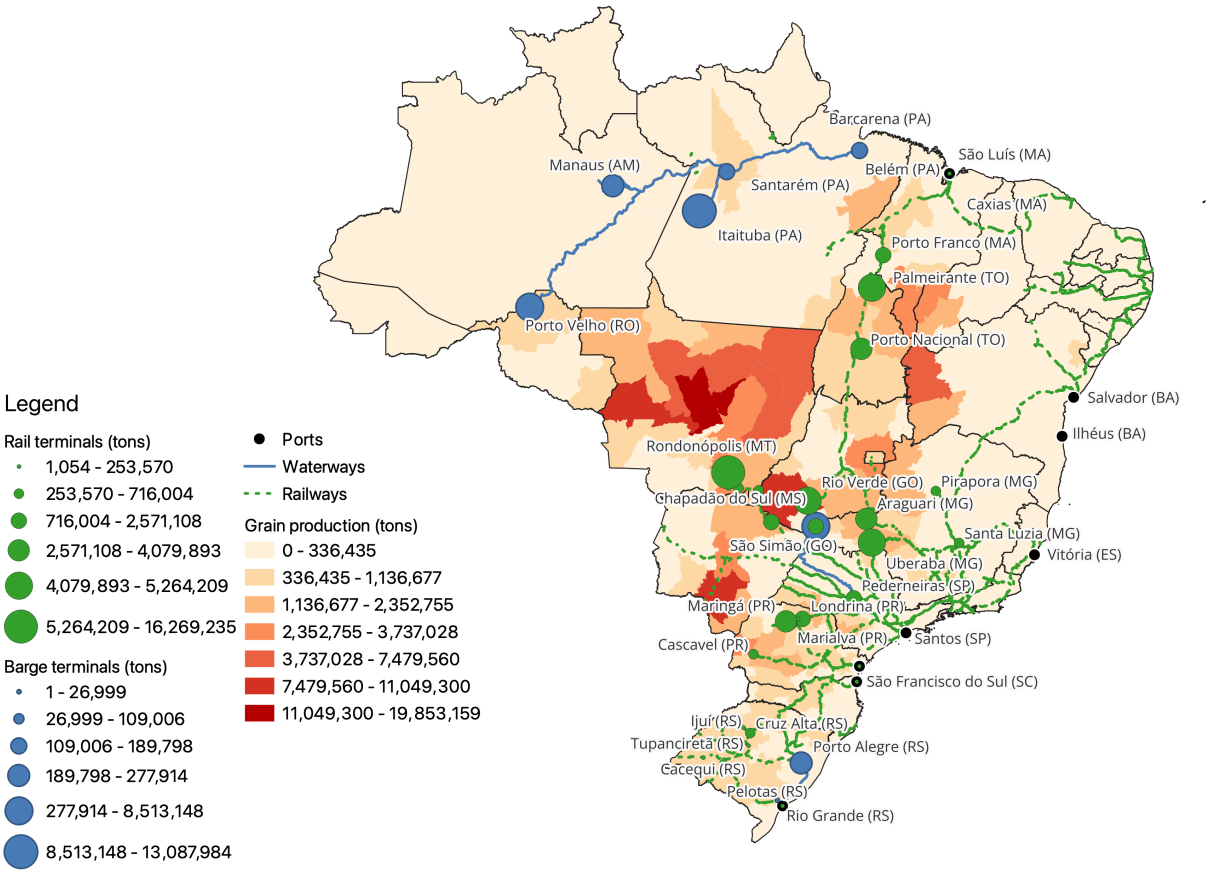
No one mode or type of infrastructure handles all grain movements in Brazil. Instead, movements involve multimodal integration across highways, waterways, and railways to connect origins, departure terminals, and destinations (ports, processing centers, or industries). Over time, the expansion of railways and inland waterways is expected to reduce congestion and lessen dependence on highways for long-distance (direct) transport, but to raise the demand on highways for short-distance transport directly to terminals.

This paper analyzes the changes in modal shares for soybean and corn movements in Brazil (2010-23), by building a detailed longitudinal database from various Brazilian government information sources. Furthermore, the paper develops transport indicators to evaluate Brazil's modal shares, broken down by various characteristics.

2. MAIN FINDINGS ON MODAL SHARES (BASED ON MODEL)

Utilizing the longitudinal database, figure 1 illustrates Brazil's corn and soybean transportation infrastructure in 2023, showing the main multimodal terminals and ports.

Figure 1. Corn and soybean logistics infrastructure, 2023



Source: Developed by the authors based on National Land Transport – ANTT (2024); National Water Transport Agency – ANTAQ (2024); and Brazilian Institute of Geography and Statistics – IBGE (2024).

The main results for Brazilian *corn*, are as follows:

In 2023

- Truck shipments from the farm to major destinations accounted for 76 percent of total movements, followed by rail (16 percent) and barge (8 percent).
- Of all the modes, trucks shipped the most corn to major export facilities. Trucking handled 45 percent of total corn exports, followed by rail (39 percent) and barge (16 percent).

From 2010 to 2023

- Truck market shares for all corn movements (domestic and exports) declined by 8.0 percentage points (pp), from 84 to 76 percent; rail increased 1.5 pp, from 15 to 17 percent; and barge increased 7 pp, from 1 percent to 8 percent.
- Barge gained a significant market share for corn exports, rising from 3 percent to 16 percent—at the expense of rail, which fell from 78 percent to 39 percent. Truck also gained market share, rising from 20 to 45 percent.
- Brazil's increased reliance on trucks for exports is a result of the significant growth in corn exports.
- The ports of Paranaguá, Rio Grande, and São Luís significantly increased their reliance on trucks shipments, at the expense of rail. In 2023, of the ports evaluated, Santos had the lowest dependence on trucks—with 33 percent of shipments handled by truck and 67 percent by rail.

The main results for Brazilian *soybeans* are as follows:

In 2023

- Truck shipments of soybeans from the farm to major destinations accounted for 69 percent of total movements, followed by rail (22 percent) and barge (9 percent).
- Of all modes, trucks shipped the most soybeans to major export facilities. Trucks handled 54 percent of total soybean exports, followed by rail (34 percent) and barge (12 percent).
- Truck freight costs represented 15-40 percent of the product price delivered at port.

From 2010 to 2023

- Truck market shares declined 6 pp, from 75 to 69 percent; rail increased 2 pp, from 20 to 22 percent; and barge increased 4 pp from 5 to 9 percent.
- Barge and truck gained market share at the expense of rail, which fell 13 pp—from 47 percent in 2010 to 34 percent in 2023. Barge shipments increased 4 pp, from 8 percent to 12 percent. Truck shipments increased 9 pp, from 45 percent to 54 percent.
- For the port of Paranaguá, trucks' modal share rose from 76 percent to 78 percent. Even sharper increases occurred for the port of Rio Grande, where truck's share rose from 57 percent to 90 percent, and the port of São Luís, where trucks' share rose from 10 percent to 48 percent. Trucks' share declined only at the port of Santos, where rail's share rose from 52 percent to 57 percent.

3. CORN MODAL SHARES

Table 1 shows Brazil's tonnages and modal shares indicators for corn for 2010-23.

Table 1. Tonnages and modal shares for corn, 2010-2023

Year	Truck		Short-haul truck*				Tonnage	
			Rail		Barge			
	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	
Total								
2010	46,882	83.8	8,441	15	694	1.2	56,017	Production Tonnage
2011	49,569	86.4	6,555	11.4	1,283	2.2	57,407	
2012	58,301	80	12,973	17.7	1,706	2.3	72,980	
2013	64,926	79.8	13,993	17.1	2,586	3.1	81,505	
2014	66,101	82.6	12,501	15.6	1,450	1.8	80,052	
2015	66,808	79	15,671	18.5	2,193	2.5	84,672	
2016	53,473	80.5	10,228	15.3	2,829	4.2	66,530	
2017	72,477	74.2	17,896	18.2	7,469	7.6	97,842	
2018	58,852	73	14,786	18.3	7,072	8.7	80,710	
2019	69,153	69	21,240	21.2	9,650	9.6	100,043	
2020	74,751	72.9	18,446	18.0	9,389	9.1	102,586	
2021	70,556	81.0	11,866	13.6	4,674	5.4	87,096	
2022	81,796	72.3	21,788	19.3	9,546	8.4	113,130	
2023	99,711	75.6	21,757	16.5	10,424	7.9	131,892	
Export								
2010	2,150	20	8,392	77.5	276	2.5	10,818	Export Tonnage
2011	2,176	23.1	6,504	68.5	802	8.4	9,482	
2012	6,003	30.4	12,895	65.1	903	4.5	19,801	
2013	11,068	41.6	13,927	52.3	1,629	6.1	26,624	
2014	6,785	32.9	12,420	60.1	1,450	7	20,655	
2015	11,206	38.9	15,525	53.6	2,193	7.5	28,924	
2016	9,635	44.1	9,566	43.7	2,672	12.2	21,873	
2017	4,824	16.6	17,852	60.9	6,590	22.5	29,266	
2018	1,981	8.7	14,606	63.6	6,378	27.7	22,965	
2019	13,220	31	21,193	49.5	8,339	19.5	42,752	
2020	7,494	21.8	18,443	53.6	8,495	24.6	34,432	
2021	4,101	20.1	11,815	57.8	4,514	22.1	20,430	
2022	12,514	29	21,772	50.4	8,904	20.6	43,190	
2023	24,969	44.7	21,751	38.9	9,178	16.4	55,898	
Domestic								
2010	44,732	99	49	0.1	418	0.9	45,199	Domestic Tonnage
2011	47,393	98.9	51	0.1	480	1	47,924	
2012	52,298	98.4	78	0.1	802	1.5	53,178	
2013	53,859	98.2	66	0.1	957	1.7	54,882	
2014	59,315	99.9	82	0.1	0	0	59,397	
2015	55,603	99.8	146	0.2	0	0	55,749	
2016	43,838	98.3	662	1.4	157	0.3	44,657	
2017	67,653	98.8	44	0	880	1.2	68,577	
2018	56,871	98.5	180	0.3	694	1.2	57,745	
2019	55,933	97.8	47	0.0	1,311	2.2	57,291	
2020	67,257	98.7	3	0.0	894	1.3	68,154	
2021	66,455	99.7	51	0.1	160	0.2	66,666	
2022	69,282	99.1	16	0	642	0.9	69,940	
2023	74,742	98.4	6	0	1,246	1.6	75,994	

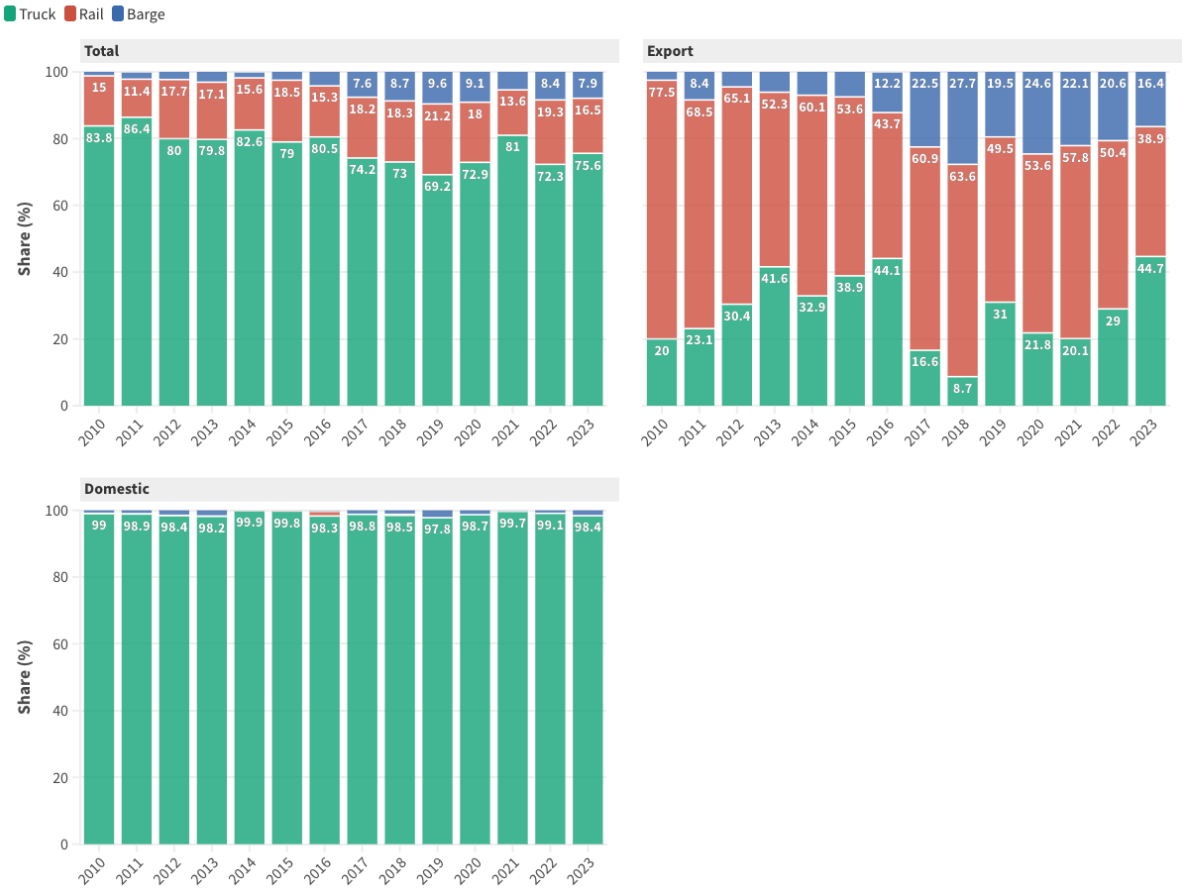
Note: Data compiled from the National Land Transport Agency (ANTT); National Land Transport Agency (ANTAQ); Comex-Stat; Ministry of Development Industry, Trade and Services; and National Supply Company (CONAB).

* Short-haul truck shipments refer to the average distance of 435 miles (701 kilometers (km)) from the farm to rail and barge terminals.
Source: Modal share analysis results—calculations by the University of São Paulo, Escola Superior de Agricultura "Luiz de Queiroz," Brazil (ESALQ/USP) and USDA, Agricultural Marketing Service.

Brazil's share of corn shipments by rail rose from 15 percent in 2010 to 16 percent in 2023. The barge share rose from 1 percent in 2010 to 8 percent in 2023.

According to figure 2, the trucking share declined from 84 percent in 2010 to 75 percent in 2023, marking less dependence on trucking for long-distance transportation.

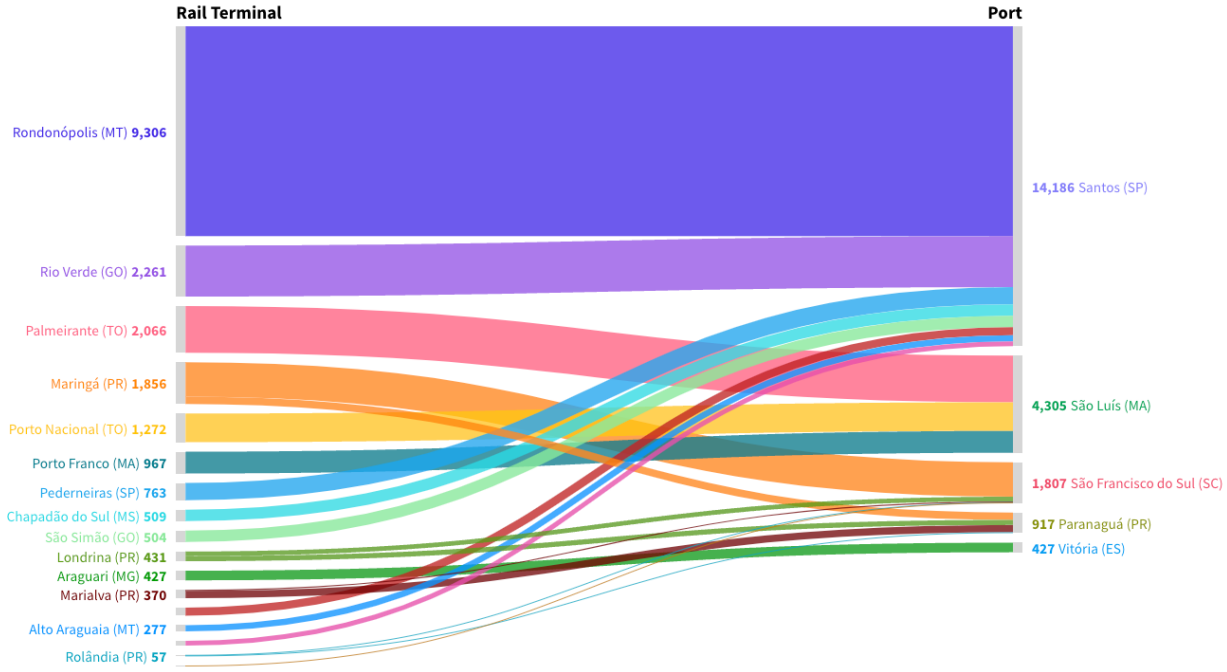
Figure 2. Corn modal shares, 2010-23



Source: Calculated by the authors based on table 1.

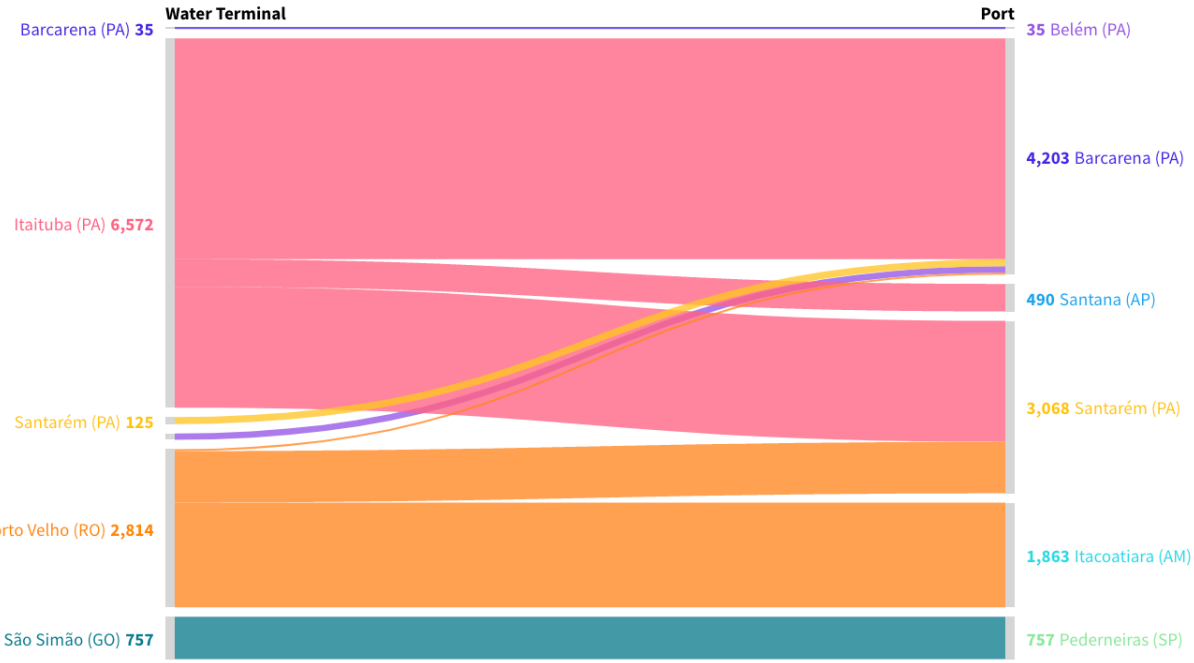
Brazil's corn-transport routes (origin-destination pairs) for rail and barge are shown in figures 3 and 4, respectively.

Figure 3: Distribution of corn rail routes, 2023 (1,000 tons)



Source: Calculated by the authors based on ANTT (2024).

Figure 4: Distribution of corn barge routes, 2023 (1,000 tons)



Source: Calculated by the authors based on ANTAQ (2024).

4. CORN MODAL SHARES BY PORT

Table 2 presents Brazil's corn and soybean tonnages to the main ports in 2010-2023, by truck and rail.

Table 2. Corn tonnages to main ports by truck and rail, 2010-23 (continues)

		Tonnage (1,000 tons)		Modal-Share (%)	
Port	**Year**	**Truck**	**Rail**	**Truck**	**Rail**
Paranaguá (PR)	2010	1,557	1,511	50.7	49.3
	2011	1,461	1,071	57.7	42.3
	2012	3,371	1,431	70.2	29.8
	2013	3,538	1,078	76.6	23.4
	2014	2,925	1,108	72.5	27.5
	2015	2,799	1,269	68.8	31.2
	2016	2,321	478	82.9	17.1
	2017	2,559	1,048	70.9	29.1
	2018	545	546	49.9	50.1
	2019	3,535	2,358	60	40
	2020	971	1,579	38.1	61.9
	2021	734	207	78	22
	2022	2,861	2,134	57.3	42.7
	2023	3,325	918	78.4	21.6
Rio Grande (RS)	2010	25	112	18.4	81.6
	2011	67	46	59.1	40.9
	2012	67	6	91.9	8.1
	2013	739	261	73.9	26.1
	2014	909	259	77.8	22.2
	2015	281	99	74	26
	2016	213	31	87.1	12.9
	2017	281	8	97.4	2.6
	2018	51	15	76.8	23.2
	2019	350	135	72.2	27.8
	2020	315	146	68.4	31.6
	2021	135	127	51.5	48.5
	2022	243	98	71.2	28.8
	2023	500	98	83.7	16.3
Santos (SP)	2010	366	5,159	6.6	93.4
	2011	601	4,222	12.5	87.5
	2012	1,976	7,186	21.6	78.4
	2013	4,468	7,442	37.5	62.5
	2014	1,693	6,732	20.1	79.9
	2015	4,210	9,030	31.8	68.2
	2016	5,038	6,246	44.6	55.4
	2017	1,288	12,417	9.4	90.6
	2018	2,003	11,242	15.1	84.9
	2019	4,262	14,227	23.1	76.9
	2020	2,380	12,220	16.3	83.7
	2021	0	8,701	0	100
	2022	2,257	13,679	14.2	85.8
	2023	7,165	14,186	33.6	66.4

(continues)

Table 2. Corn tonnages to main ports by truck and rail, 2010-23

		Tonnage (1,000 tons)		Modal-Share (%)	
Port	**Year**	**Truck**	**Rail**	**Truck**	**Rail**
São Luís (MA)	2010	0	0	0	0
	2011	0	37	0	100
	2012	0	360	0	100
	2013	44	327	11.7	88.3
	2014	0	558	0	100
	2015	808	1,237	39.5	60.5
	2016	405	366	52.5	47.5
	2017	208	1,696	10.9	89.1
	2018	0	775	0	100
	2019	782	2,304	25.3	74.7
	2020	1,254	2,473	33.6	66.4
	2021	727	2,184	25	75
	2022	2,356	3,931	37.5	62.5
	2023	2,986	4,314	40.9	59.1

(end)
Source: Calculated by the authors based on ANTT (2024), ANTAQ (2024) and COMEXSTAT (2024).

Figure 5 shows Brazil's corn movements to the main ports by truck and rail. This figure is derived from table 2.

Figure 5. Truck and rail shares of corn movements, by port, 2010-23

Source: Calculated by the authors based on table 2.

5. SOYBEAN MODAL SHARES

According to table 3, Brazil's share of soybean shipments by rail increased from 20 percent in 2010 to 22 percent in 2023. Barge increased from 5 percent in 2010 to 9 percent in 2023.

Table 3. Soybean tonnages and modal shares, 2010-2023

Year	Truck		Short-haul truck				Tonnage	
			Rail		Barge			
	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	
Total								
2010	51,218	74.7	13,908	20.2	3,562	5.1	68,688	Production Tonnage
2011	54,936	73	16,169	21.4	4,219	5.6	75,324	
2012	47,679	72	14,596	21.9	4,108	6.1	66,383	
2013	60,908	74.9	16,120	19.7	4,472	5.4	81,500	
2014	66,119	76.8	15,985	18.5	4,069	4.7	86,173	
2015	73,941	76.2	17,691	18.2	5,462	5.6	97,094	
2016	71,408	74.7	17,666	18.4	6,624	6.9	95,698	
2017	81,817	71.2	24,324	21.1	8,886	7.7	115,027	
2018	79,390	64.5	32,841	26.6	11,028	8.9	123,259	
2019	80,557	67.4	28,783	24	10,378	8.6	119,718	
2020	84,356	67.6	28,301	22.7	12,188	9.7	124,845	
2021	95,016	68.2	32,628	23.4	11,741	8.4	139,385	
2022	85,800	68.3	29,717	23.7	10,033	8	125,550	
2023	106,398	68.8	34,256	22.2	13,956	9	154,610	
Export								
2010	12,980	44.7	13,676	47	2,417	8.3	29,073	Export Tonnage
2011	13,964	42.4	15,960	48.4	3,051	9.2	32,975	
2012	15,396	46.9	14,462	43.9	3,048	9.2	32,906	
2013	23,492	55	15,997	37.3	3,307	7.7	42,796	
2014	26,320	57.7	15,796	34.5	3,577	7.8	45,693	
2015	31,406	57.9	17,456	32.1	5,462	10	54,324	
2016	28,165	54.7	17,393	33.7	6,024	11.6	51,582	
2017	36,323	53.4	24,017	35.2	7,815	11.4	68,155	
2018	40,975	49.3	32,565	39.1	9,718	11.6	83,258	
2019	36,225	49.1	28,442	38.3	9,406	12.6	74,073	
2020	43,446	52.4	28,092	33.9	11,435	13.7	82,973	
2021	43,161	50.1	32,376	37.6	10,573	12.3	86,110	
2022	39,569	50.3	29,589	37.6	9,572	12.1	78,730	
2023	55,254	54.2	34,037	33.4	12,579	12.4	101,870	
Domestic								
2010	38,239	96.7	232	0.5	1,145	2.8	39,616	Domestic Tonnage
2011	40,972	96.9	208	0.4	1,168	2.7	42,348	
2012	32,283	96.5	134	0.4	1,060	3.1	33,477	
2013	37,416	96.7	123	0.3	1,165	3	38,704	
2014	39,799	98.4	190	0.4	492	1.2	40,481	
2015	42,535	99.5	234	0.5	0	0	42,769	
2016	43,243	98.1	273	0.6	600	1.3	44,116	
2017	45,494	97.2	307	0.6	1,071	2.2	46,872	
2018	38,416	96.2	276	0.6	1,310	3.2	40,002	
2019	44,332	97.2	342	0.7	972	2.1	45,646	
2020	40,910	97.7	209	0.5	753	1.8	41,872	
2021	51,855	97.3	252	0.5	1,168	2.2	53,275	
2022	46,231	98.7	128	0.3	461	1	46,820	
2023	51,144	97	219	0.4	1,377	2.6	52,740	

Note: Data compiled from the National Land Transport Agency (ANTT); National Land Transport Agency (ANTAQ); Comex-Stat; Ministry of Development, Industry, Trade and Services; and National Supply Company (CONAB).
* Short-haul truck shipments refer to the average distance of 435 miles (701 kilometers (km)) from the farm to rail and barge terminals.
Source: The authors' modal share analysis based on calculations by the University of São Paulo, Escola Superior de Agricultura "Luiz de Queiroz"; Brazil (ESALQ/USP); and USDA, Agricultural Marketing Service.

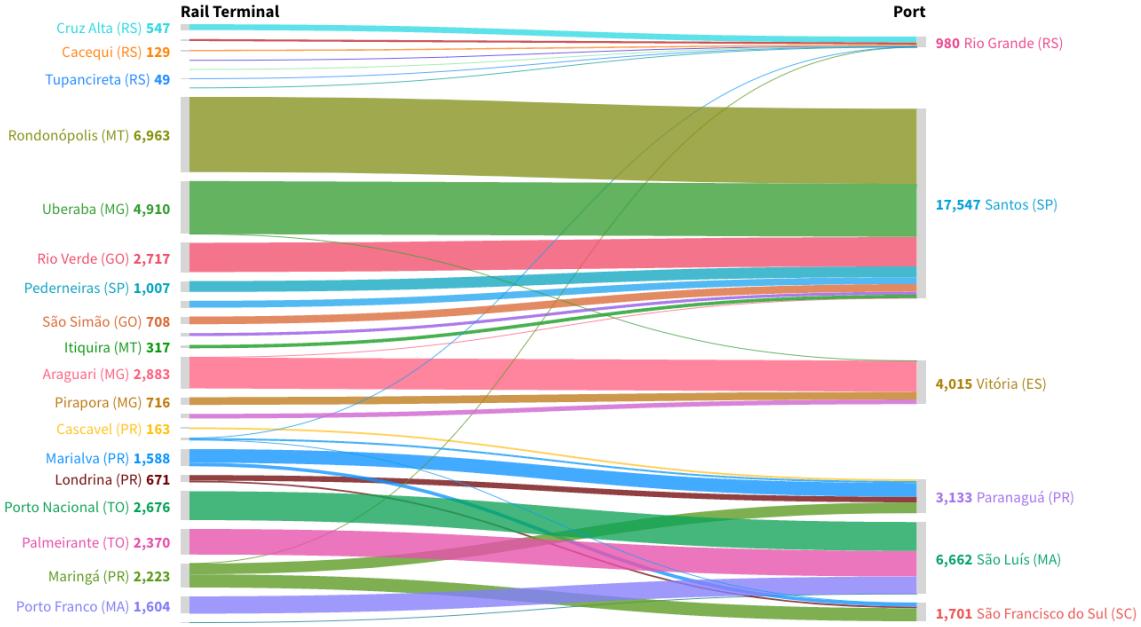
Figure 6 presents modal shares for transporting Brazilian soybeans, for 2010-23. Similar to the pattern for corn movements, the trucking market share dropped from 75 percent in 2010 to 69 percent in 2023, marking less dependence on trucking for long-distance transportation. Over the same period, rail rose from 20 percent to 22 percent, while barge (showing the most growth) rose from 5 percent to 9 percent.

Figure 6. Soybean modal shares, 2010-23

Source: Calculated by the authors based on table 3.

Rail and barge routes (origin-destination pairs) for soybeans in 2023 are shown in figures 7 and 8, respectively.

Figure 7. Distribution of soybean rail routes, 2023 (1,000 tons)



Source: Calculated by the authors based on ANTT (2024).

Figure 8. Distribution of soybean barge routes, 2023 (1,000 tons)

Source: Calculated by the authors based on ANTAQ (2024).

6. SOYBEAN MODAL SHARES BY PORT

Table 4 shows Brazil's soybean tonnages to the main ports in 2010-23, by mode of transportation.

Table 4: Soybean movements to main ports by truck and rail, 2010-23 (continues)

		Tonnage (1,000 tons)		Modal-Share (%)	
Port	**Year**	**Truck**	**Rail**	**Truck**	**Rail**
Paranaguá (PR)	2010	4,068	1,266	76.3	23.7
	2011	5,169	1,756	74.6	25.4
	2012	5,368	1,586	77.2	22.8
	2013	6,361	1,375	82.2	17.8
	2014	6,332	1,195	84.1	15.9
	2015	7,454	1,065	87.5	12.5
	2016	6,658	1,499	81.6	18.4
	2017	9,174	2,175	80.8	19.2
	2018	10,629	4,243	71.5	28.5
	2019	8,742	2,926	74.9	25.1
	2020	11,633	3,148	78.7	21.3
	2021	9,349	3,608	72.2	27.8
	2022	8,431	1,789	82.5	17.5
	2023	11,183	3,132	78.1	21.9
Rio Grande (RS)	2010	2,622	1,942	57.4	42.6
	2011	3,326	2,430	57.8	42.2
	2012	2,403	1,138	67.9	32.1
	2013	6,543	1,663	79.7	20.3
	2014	6,609	1,550	81	19
	2015	9,559	1,814	84	16
	2016	7,849	1,855	80.9	19.1
	2017	9,937	2,613	79.2	20.8
	2018	10,661	3,035	77.8	22.2
	2019	10,340	2,828	78.5	21.5
	2020	7,617	1,702	81.7	18.3
	2021	10,294	2,403	81.1	18.9
	2022	5,117	594	89.6	10.4
	2023	9,487	981	90.6	9.4
Santos (SP)	2010	3,915	4,312	47.6	52.4
	2011	3,468	5,762	37.6	62.4
	2012	4,655	5,741	44.8	55.2
	2013	7,195	5,698	55.8	44.2
	2014	6,954	5,765	54.7	45.3
	2015	7,224	5,808	55.4	44.6
	2016	7,583	6,893	52.4	47.6
	2017	7,592	8,997	45.8	54.2
	2018	8,119	12,595	39.2	60.8
	2019	5,779	11,307	33.8	66.2
	2020	9,500	11,633	45	55
	2021	8,720	14,273	37.9	62.1
	2022	9,744	15,992	37.9	62.1
	2023	13,015	17,546	42.6	57.4

(continues)

Table 4: Soybean movements to main ports by truck and rail, 2010-23

		Tonnage (1,000 tons)		Modal-Share (%)	
Port	Year	Truck	Rail	Truck	Rail
São Luís (MA)	2010	204	1,859	9.9	90.1
	2011	391	2,123	15.6	84.4
	2012	425	2,316	15.5	84.5
	2013	371	2,604	12.5	87.5
	2014	569	2,547	18.3	81.7
	2015	2,243	2,761	44.8	55.2
	2016	1,215	2,635	31.6	68.4
	2017	2,067	4,060	33.7	66.3
	2018	2,753	5,446	33.6	66.4
	2019	2,858	5,261	35.2	64.8
	2020	3,542	5,261	40.2	59.8
	2021	3,896	6,208	38.6	61.4
	2022	4,859	6,355	43.3	56.7
	2023	6,260	6,662	48.4	51.6

(end)
Source: elaborated by the authors based on ANTT (2024), ANTAQ (2024) and COMEXSTAT (2024).

As derived from table 4, figure 9 shows soybean tonnages to the main ports by truck and rail, in 2010-23.

Figure 9. Soybean truck and rail shares by port, 2010-23

Source: elaborated by the authors based on Table 4.

REFERENCES

Chang, Kuo-Liang, Peter Caffarelli, Jesse Gastelle, and Adam Sparger. (April 2019). *Transportation of U.S. Grains: A Modal Share Analysis*. U.S. Department of Agriculture, Agricultural Marketing Service. Available at: http://dx.doi.org/10.9752/TS049.04-2019.

COMEX-STAT, Ministry of Development, Industry, Trade and Services (MDIC) (2024). Export and Import Data. Available at: http://comexstat.mdic.gov.br/pt/home.

Freight Information System (SIFRECA). (2024). *Road Freight Price Indicators in Brazil.* Group of Research and Extension in Groindustrial Logistics – ESALQ-LOG, University of São Paulo, Piracicaba, Brazil. Available at: https://esalqlog.esalq.usp.br/en.

Henderson, Richard, Jesse Gastelle, and Peter Caffarelli. *Transportation of U.S. Grains: A Modal Share Analysis*. (August 2023). U.S. Dept. of Agriculture, Agricultural Marketing Service.
Web. <http://dx.doi.org/10.9752/TS049.08-2023>

National Land Transportation Agency (ANTT). (2024). Railway Data. Available at: www.antt.gov.br.

National Supply Company (CONAB). (2024). Agriculture Production Data. Available at: www.conab.gov.br.

National Transport Confederation (CNT). (2024). Boletins do transporte de cargas. Available at: https://www.cnt.org.br.

National Water Transportation Agency (ANTAQ). (2024). Anuario Data. Available at: www.antaq.gov.br.

APPENDICE

METHODOLOGY

In this study we followed Chang et al. (2019) and Henderson et al. (2023) approach to determine the modal shares. Chang et al. define the shares of total tonnage handled for each commodity and for each mode of transport (barge, rail, and truck), expressed as percentages, for the reference period.

This research's methodology depended on the consolidation of information from public and official sources and the development of a transporting soybeans and corn in Brazil from 2010 to 2023 database. The sources of the data are stated below:

- Rail movement data by origin, destination, period, and product: National Land Transport Agency (ANTT), period 2010-2023.
- Barge movement data by origin, destination, period, and product: National Water Transport Agency (ANTAQ), involving inland transportation, period 2010-2023.
- Soybean and corn production data: National Supply Company (CONAB), period 2010-2023.
- Export Data: COMEX-VIS, Ministry of Economy (Brazil), period 2010-2023.

The main parameters of estimating transport types were:

- **Production:** corresponds to the quantity of product produced in the reference year obtained from the National Supply Company (CONAB) 2024.
- **Export movements:** corresponds to the export quantities of the analyzed product for the reference year, obtained through COMEX-VIS from the Ministry of Economy (COMEX-VIS) 2024.
- **Domestic movements:** corresponds to the difference between production and export for the product and the reference period.

The types of transport and method employed are:

- **Total rail movement**: corresponds to the total rail movement of the analyzed product for the reference period, obtained from the National Land Transport Agency (ANTT) 2024.
- **Total barge movement**: corresponds to the total barge movement of the analyzed product for the reference period, obtained from the National Waterway Transport Agency (ANTAQ) 2024.
- **Total truck:** corresponds to trucks' movement from origin to destination (domestic and export). We estimate this movement as the difference between the quantity produced in the reference year and the sum of the amount handled by rail and barge. The average distance of this type of transport has been 538 miles (867 kilometers), according to SIFRECA (2024).
- **Export rail movement:** corresponds to the rail movement destined for the analyzed product ports for the reference period, obtained from the ANTT (2024).
- **Export barge movement:** corresponds to the barge movement destined for the analyzed product ports for the reference period, obtained from the ANTT (2024).
- **Export truck movement:** refers to a residual because there are no data available for the total truck export movement. We estimate this movement as the difference

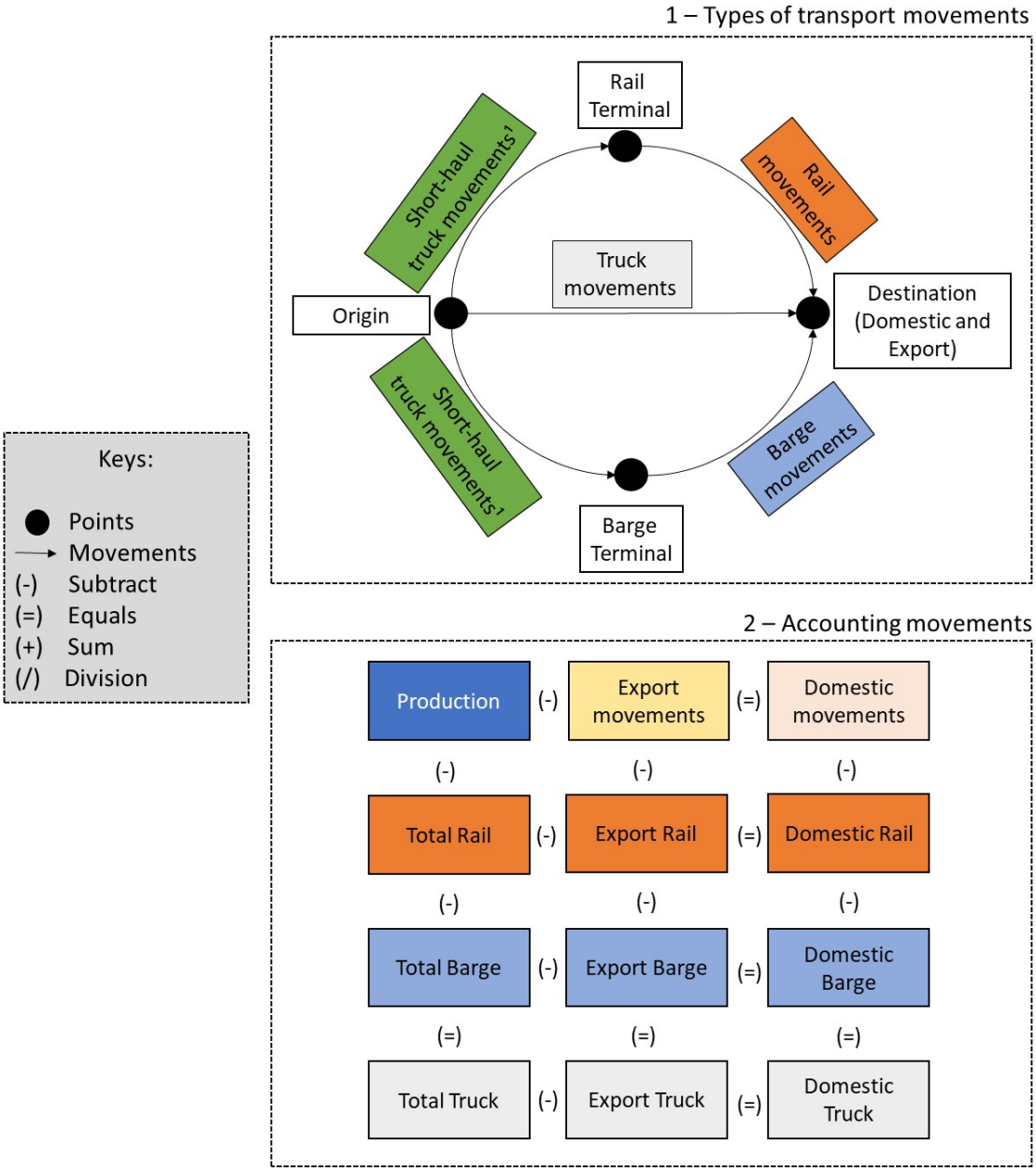
between total exports and the sum of the total tons handled by rail and barge movements for ports.

- **Domestic rail movement:** corresponds to the rail movement destined for the analyzed product's domestic market for the reference period, obtained from the difference between total rail movement and export rail movement.
- **Domestic barge movement:** corresponds to the barge movement destined for the analyzed product's domestic market for the reference period, obtained from the difference between total barge movement and export barge movement.
- **Domestic truck:** corresponds to the long-distance movement of trucks from the source to the domestic market destination. We estimate this movement as the difference between the domestic movement and the sum of the quantity handled by rail and barge for the domestic market in the reference year.

In this modal share analysis, we consider only the tonnage of the *long-haul trucks*, which it accounts for the long-distance movements from the production regions to destinations (ports or domestic market). More specifically, in Brazil, due to the country's vastness, low density of the rail and waterway networks, and low number of terminals, transportation from production regions to terminals occurs exclusively by trucks, which are also called *short-haul trucks*. In this study, short-haul truck shipments are not considered part of the modal share analysis to avoid double counting. Moreover, the short-haul trucks represent the shortest segment of a long route to reach the port or domestic markets. The short-haul refers to the averages distance of 388 miles (625 kilometers (km)) from the farm to rail and barge terminals. The average truck transportation distance for soybean and corn in Brazil, encompassing both domestic and export routes, is 538 miles (865 km).

Figure 10 presents a summary table illustrating the method used.

Figure 10: Framework approach for estimating modal tonnages and shares



[1]Short-haul truck corresponds to the movement between the producing regions and the terminals and is not counted in the modal share analysis.

Indicators of relationships between movements of rail and barge modes and production of the evaluated products were defined by equations (1) and (2).

$$\text{Ratio of rail shipments and production}_{p,t} = \frac{\text{Rail}_{p,t}}{\text{Production}_{p,t}} \quad (1)$$

$$\text{Ratio of barge shipments and production}_{p,t} = \frac{\text{Barge}_{p,t}}{\text{Production}_{p,t}} \quad (2)$$

Where:

- $\text{Ratio of rail shipments and production}_{p,t}$ is a ratio of rail shipments and production of product *p* at time *t*

- Ratio of barge shipments and production$_{p,t}$ is a ratio of barge shipments and production of product *p* at time *t*
- Rail$_{p,t}$ is a rail shipments of the product *p* at time t in tons
- Barge$_{p,t}$ is a barge shipment of the product *p* at time *t* in tons
- Production$_{p,t}$ is a production of product *p* at time *t* in tons

Equations (3) and (4) show the method of calculating the average annual distances traveled in Brazil for handling corn and soybeans in the Brazilian rail and barge.

$$\text{ARDISTANCE}_{p,t} = \frac{\left(\sum_o \sum_d \text{Rail}_{o,d,p,t} \text{ x Rail Distance}_{o,d,p,t}\right)}{\sum_o \sum_d \text{Rail}_{o,d,p,t}} \quad (3)$$

$$\text{AWDISTANCE}_{p,t} = \frac{\left(\sum_o \sum_d \text{Barge}_{o,d,p,t} \text{ x Barge Distance}_{o,d,p,t}\right)}{\sum_o \sum_d \text{Barge}_{o,d,p,t}} \quad (4)$$

Where:
- ARDISTANCE$_{p,t}$ is an average rail distance of product *p* at time *t* in miles
- AWDISTANCE$_{p,t}$ is an average barge distance of product *p* at time *t* in miles
- Rail$_{o,d,p,t}$ is a rail trip from terminal *o* to final terminal *d* of product *p* at time *t* in tons
- Rail Distance$_{o,d,p,t}$ is a rail distance from terminal *o* to final terminal *d* of product *p* at time *t* in miles
- Barge $_{o,d,p,t}$ is a barge trip from terminal *o* to final terminal *d* of product *p* at time *t* in tons
- Barge Distance$_{o,d,p,t}$ is a barge distance from terminal *o* to final terminal *d* of product *p* at time *t* in miles

Equations (5) to (8) show the receipt of movements in the two largest Brazilian corn and soybeans export ports, Santos (SP) and Paranaguá (PR). As previously noted, there is no option to use barge to move corn and soybeans products to these two seaports, so there are no barge movements for these ports.

$$\text{Rail to Port}_{k,p,t}(\%) = \frac{\text{Rail to Port}_{k,p,t}}{\text{Exports}_{k,p,t}} \quad (5)$$

$$\text{Truck to Port}_{k,p,t}(\%) = 1 - \frac{\text{Rail to Port}_{k,p,t}}{\text{Exports}_{k,p,t}} \quad (6)$$

Where:
- Rail to Port$_{k,p,t}$ (%) is a rail movement to Port *k* of product *p* at time t, in %
- Truck to Port$_{k,p,t}$ (%) is a truck movement to Port *k* of product *p* at time t, in %
- Rail to Port$_{k,p,t}$ is a rail movement to Port *k* of product *p* at time t, in tons
- Exports$_{k,p,t}$ is an Exports of port *k*, product *p* at time *t* in tons
- Santos Exports$_{p,t}$ is a Santos Exports of product *p* at time *t* in tons

In the modal share analysis, we account for only tonnages of long-haul truck movements, which cover the long distances between the production regions and destinations (ports or domestic market). More specifically, because of Brazil's vastness and the low density of the rail and waterway terminals, transportation from the production regions to the terminals occurs exclusively by short-haul trucks. Such movements represent the shortest segment of a long route to reach the port or domestic market, according to the method adopted by Chang et al. (2019). In this way, we estimated the modal share for corn and soybeans, based on three types of movements.

Rail transport's share in the modal is calculated by equation (7).

$$\text{Rail Share}_{p,t} = \frac{\text{Rail}_{p,t}}{\text{Tonnages}_{p,t}} \tag{7}$$

Equation (8) calculates a barge share:

$$\text{Barge Share}_{p,t} = \frac{\text{Barge}_{p,t}}{\text{Tonnages}_{p,t}} \tag{8}$$

Equation (9) accounts for truck as production less barge and rail movements. This equation refers to a residual because is no data available for the truck.

$$\text{Truck}_{p,t} = \text{Production}_{p,t} - \text{Rail}_{p,t} - \text{Barge}_{p,t} \tag{9}$$

Truck transport's share is calculated by expression (10).

$$\text{Truck Share}_{p,t} = \frac{\text{Truck}_{p,t}}{\text{Tonnages}_{p,t}} \tag{10}$$

The quantification of the total volume handled in the system, which is the denominator of the modal share calculation, is applicable by the expression (11).

$$\text{Tonnages}_{p,t} = \text{Rail}_{p,t} + \text{Barge}_{p,t} + \text{Truck}_{p,t} \tag{11}$$

Where:

- $\text{Rail Share}_{p,t}$ is rail transport's share in the modal share of product *p* at time *t*, in %
- $\text{Barge Share}_{p,t}$ is barge transport's share in the modal share of product *p* at time *t*, in %
- $\text{Truck Share}_{p,t}$ is truck transport's share in the modal share of product *p* at time *t*, in %
- $\text{Truck}_{p,t}$ is truck transport of product *p* at time *t*, in tons
- $\text{Tonnages}_{p,t}$ is total tonnage of product *p* at time *t*, in tons