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IMPACT OF SEASONALITY ON THE INBOUND AND OUTBOUND FREIGHT OF A GLOBAL FERTILIZER COMPANY

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ABSTRACT

The growing importance of agriculture in the Brazilian economy makes it essential that agricultural companies seek to increase their logistics competitiveness. This study aimed to compare and analyze the impact of seasonality of grain harvest and specific events, such as the 2018 Brazil truck drivers' strike, on the prices of inbound and outbound freight in a multinational company located in several Brazilian states. It focused on the CIF (Cost, Insurance, and Freight) routes of the company between 2015 and 2019 in Brazil, and the relationship between time of year and cost of transportation. These data were analyzed in a descriptive level after being treated by statistical analysis. This study showed that the costs of outbound freight suffered greater increases compared to the inbound freight due to the seasonality of grain harvest and the 2018 Brazil truck drivers' strike.

Keywords: logistics; fertilizers; Brazilian routes; strike

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1. INTRODUCTION

It is no longer a novelty to portray the importance of agriculture in the Brazilian economy. Zafalon (2020) reported that Brazil is among the leaders in the production of sugar, coffee, soy and corn. Soares and Caixeta Filho (1997) observed that there is a tremendous potential to increase the production of these products due to a large number of cropland areas in Brazil, the continuous techniques of production, and reduction of agricultural costs. The use of fertilizers in agriculture is one of the techniques to increase agricultural productivity (Reetz, 2017). This author also reinforces the need for fertilization in different agricultural crops, improving the product quality and economic returns. The price of agricultural products is regulated by the market and the oscillation price results in competitiveness (Globalfert, 2017).

Logistics is an essential way to improve the competitiveness in the agricultural sector that involves the fertilizer market (Silva, 2008). The location of fertilizer plants and units and the transport modes are important to make a decision. Only 23% of the Brazilian fertilizer demand is produced in Brazil (ANDA, 2018) and the transportation from the harbor to the up-country provides a considerable cost. To illustrate this issue it takes around 2000 km to transport the imported raw materials from the harbor to the Mato Grosso state that is the main agriculture region in Brazil (Buhler, 2016). Although the economic and political moment is encouraging the railway modal, the transport by trucks (road) is still predominant, and it represents 60% of the total for agricultural products in bulk such as fertilizer (Caixeta Filho & Péra, 2018). According to Caixeta-Filho and Gameiro (2001), the road should be used for transport only for distances lower than 500 km, railroads would be the best option for distance between 500 km and 1200 km, and for distance higher than 1200 km the waterways is recommended. Despite these recommendations, the main transport is by road in Brazilian agriculture.

The costs for the transport by road is calculated by the freight that is composed for (Péra et al. 2018):

a) Fixed cost: depreciation, capital cost, IPVA (tax on property of motor vehicles), insurance and labor;

b) Variable cost: tires, oil, fuel and maintenance;

c) Costs linked to the operational productivity: speed, loading / unloading time, queue time, travel time.

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This study will analyze the factors that influence the costs of operational productivity. It can be affected in terms of number and location by road competition (pulverized market), main freight / return, seasonality of transport demand and freight rates. The freight rates do not take account the particularities of each route with regard to operation productivity (Péra et al., 2018). For this study the company is a multinational in the NPK (nitrogen, phosphorus and potassium) fertilizer segment with more than 80% of the transport taking place by road.

The presence of harvest annually can affect the costs linked to the operational productivity, providing oscillation in prices on several road routes (Caixeta Filho & Soares, 1997). In addition, these moments characterize an extremely competitive market since the cargo supply is extensive and, therefore, offers to the transporters an opportunity to increase their bargaining power. However, this is where productivity factors, such as loading and unloading times, are essential to mitigate this pressure. There is a cost for the stopped vehicle at times of queuing at the loading / unloading due to queues and / or slow operations (Caixeta Filho and Soares, 1997).

There are other considerable factors, especially in Brazil, that affect the prices of road freight. In 2017, only 13.5% of the roads were paved, increasing the costs with diesel, maintenance and tires (Caixeta Filho & Péra, 2018). In 2018, year that occurred the 2018 Brazil truck drivers' strike, the Resolution number 5820 (30 May 2018) by the ANTT (National Land Transportation Agency in Brazil) stablished a minimum freight price according to the number of kilometers traveled, number of axles and types of cargo.

In the same year, the ANTT changed the Resolution (5820) with a new Resolution number 5821 (07 June 2018) that in specific situations the "Freight Table" would not be mandatory. There was a concern about rising road freight prices in the preliminary impacts (ANTT, 2018; Sifreca, 2018; Péra, 2018). The "Freight Table" increased 12% the road freight prices (on average) in industries in general (CNI, 2018), and an even more expressive increase was observed in two representative routes of the fertilizer sector (Péra, 2018).

Although the "Freight Table" is still in analysis under the responsibility of the Federal Supreme Court in Brazil (STF) (Pupo, 2020), such a tabulation of freight prices, in a mandatory way, is an action against free competition in the market (Barros, 2018). Because of this event and the possible approval of the "Freight Table", the market currently lives an uncertainty, and companies can have an impact of billions of Reais (R$ - Brazilian currency) by adopting prices that may increase by another 20% (Péra, 2018).

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Another hypothesis to be confirmed in this study is whether the volume of freight in the routes can be a pressure factor in the freight prices, increasing the bargaining power that suppliers have in the freight offer. It can be associated with the five forces that Porter (2013) mentions for the competitive advantage of a business. Carla (2013) observed that the greater the customer's participation in a market, the greater the supply of suppliers, and the tendency is that their negotiation power is considerable.

Understanding the oscillation costs and looking for alternatives to increase competitiveness in the demand for contracting road freight can mean a strategy to increase or maintain the market share in the fertilizer market. As a way of facilitating decision making at competitiveness, this research aims to analyze and compare the impact of seasonality of grain harvest or specific events, such as the 2018 Brazil truck drivers' strike, on the prices of inbound and outbound freight in a multinational company located in several Brazilian states. Some results expected in this work are indicators and graphs that present the seasonality for inbound and outbound freight, as well as their action in the company decisions and strategies.

2. METHODOLOGY

The internalization flux of the fertilizer originated by the import represents the transport from the harbor to the fertilizer company and it is called inbound flux. The way of the trucks with grain from the farm to the harbor is called outbound flux (Dos Santos, 2017). The term harvest is usually associated to the planting period of the main agricultural crops in Brazil (Baptistella, 2020) and occurs in the rainfall period (between September and October). However, for the context of our study, the term harvest will be related to the period of the intensification of fertilizer transport to the farm (between May and July) for planting.

Definitions of typologies for the intended objectives, work procedures and problem approach were based on the work of Raupp and Beren (2006). Our research brings a descriptive approach focusing on the description of occurrences related to the study, addressing the relationship between the variables involved and always looking for analytical techniques for data collection (Gil, 1999).

This research provides a more detailed study of some objects visualizing their application in loco being in the case study group (Gil, 1999). The research required some manipulations of the available information (periods of the year and economic events) with a study on the effects generated (Kerlinger, 1980). The qualitative typology was used to analyze the cause and effect and the relationship of the variables.

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The fertilizer company of this study has more than a thousand routes possibilities from the harbor or from the production units, and not all inbound and outbound freight are present in this research. To filter the data collected the freights were classified in CIF (Cost, Insurance and Freight) and FOB (Free On Board). These terms are used to define who is responsible to hire the freight (Wolffenbüttel, 2006). For data availability reasons, only CIF data were considered in this study.

The pricing and negotiation of freight were the sole responsibility of the company of our study. The fertilizer company does not have its own fleet of trucks and the freight is hired with transporters. There are two denominations for the truck routes: “closed-circuit route” and “viras route”. In the first, the truck can go with a product and go back with another product. The second has lower distance routes compared to the first, normally in the same city or neighboring cities and the same truck can make several transportations in the same day. The “viras routes” were not evaluated in this study because their freight costs are stable during the year.

Although the “closed-circuit route” has contracts, it includes clauses that allow the price changing throughout the year and it was used in this study to compare distant routes. The routes were chosen based on their representativeness in terms of volume and data availability. Routes that showed no movement in some months of year were excluded. As the volume is not one of the variables in this study, they were converted to base 100, with the route with the least volume among the selected routes being the reference.

The road freight data were collected for a five-year history (from 2015 to 2019). These information were generated for each cargo transported and recorded in the ERP (Enterprise Resource Planning) system of the company. The essential information extracted in the system was the transport cost in real per ton (R$ / t) for each month in the period of the study. The data were separated in CIF and FOB freight, and in inbound and outbound freight to analyze the relationship and statistic inferences in CIF freights for both inbound and outbound. For the inbound route, part of these freights is for the way back of the trucks that took grains for exportation and, according to Péra (2018) for not being the main freight; it has a price behavior below the main freight (Sifreca, 2018).

Data preparation and statistical analysis were performed to obtain the results. According to Raupp and Beuren (2006), this approach seeks to deal with a more general behavior of the events portrayed and it cannot always take place more deeply. It is necessary

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to understand the context in which the analysis of freight values was inserted, to the history of the collected data make sense. Some analyzes were performed for a general understanding of the data (average, standard deviation, graph as function of time).

Statistical analysis year by year, added to the study of economic conjuncture factors (strikes) were performed to analyze the impact in the strategy of the company. Statistical analyzes of averages, maximums and minimums were also applied to the data in order to understand the behavior of the freights when viewed in a set of years, reducing the influence of Outliers in specific years. All this evaluation will come from official information of the company, through its management system.

3. RESULTS AND DISCUSSION

3.1. Impact of seasonality on the outbound freight

The routes with outbound flux with higher volume are originated in Uberaba (Table 1), Minas Gerais state (MG), that is located the highest producing unit of the company. It is also located producing units in Araxá (MG) and Catalão, Goiás state (GO). The producing units in Araxá, Catalão and Uberaba have with destination the main market of the segment B2B (Business to Business) of the company that is located in Rondonópolis, state of Mato Grosso (MT), Rio Verde (GO) and Uberaba (MG).

Table 1: Volumes transported (%) on outbound routes in 2019.

Origen	Destination	2019 (Base volume 100)
Uberaba/MG	Rondonópolis/MT	311
Uberaba/MG	Rio Verde/GO	311
Araxá/MG	Rondonópolis/MT	139
Catalão/GO	Rio Verde/GO	136
Araxá/MG	Uberaba/MG	100

Mato Grosso state (MT) and Goiás have the highest market of fertilizer for this company, justifying the higher volumes to these routes. The flux from Araxá (MG) to Uberaba (MG), although continuous during the year, covers a few low-volume products.

It is evident that the freights had low intensity at the beginning and end of the year (Figure 1). In these periods, the grain exportation is low reducing the pressure for transport.

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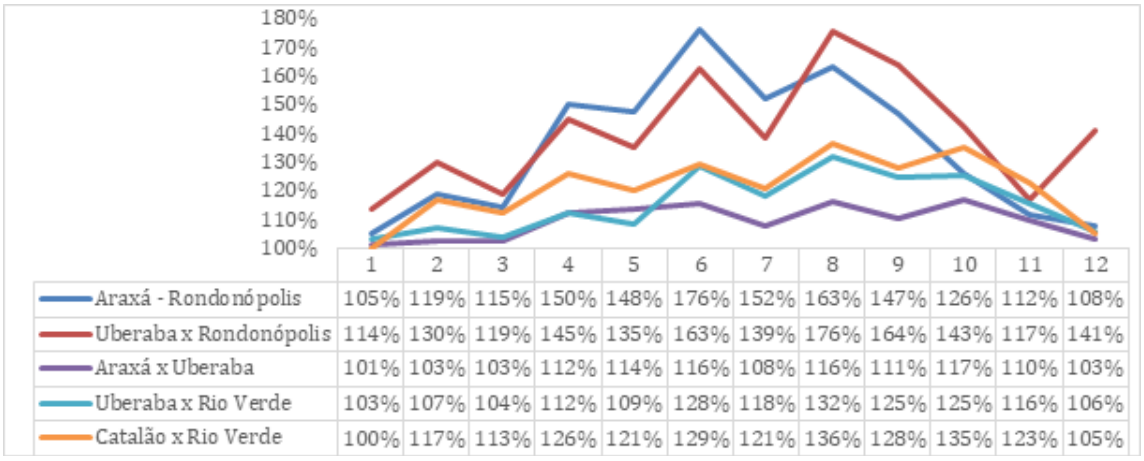
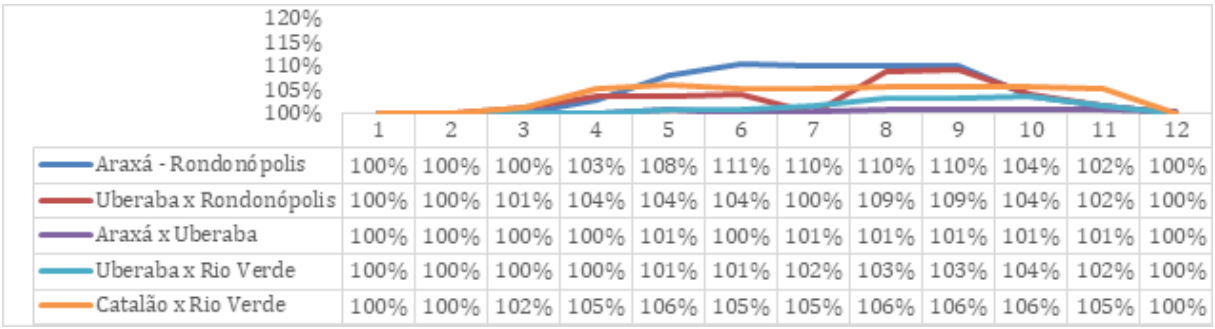


	1	2	3	4	5	6	7	8	9	10	11	12
Araxá - Rondonópolis	105%	119%	115%	150%	148%	176%	152%	163%	147%	126%	112%	108%
Uberaba x Rondonópolis	114%	130%	119%	145%	135%	163%	139%	176%	164%	143%	117%	141%
Araxá x Uberaba	101%	103%	103%	112%	114%	116%	108%	116%	111%	117%	110%	103%
Uberaba x Rio Verde	103%	107%	104%	112%	109%	128%	118%	132%	125%	125%	116%	106%
Catalão x Rio Verde	100%	117%	113%	126%	121%	129%	121%	136%	128%	135%	123%	105%

Figure 1: Monthly seasonality (%) on outbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

Uberaba, Araxá, and Catalão are geographic locations that can be used by the grain trucks in the way back to the Mato Grosso. It can justify the higher seasonality in intense periods of harvest (from May to September) with destination to Rondonópolis (MT).

Analyzing the minimum seasonality monthly (Figure 2), can be observed higher oscillation in the routes with destination to Mato Grosso. There was a delay in the oscillation in route from Uberaba to Rondonópolis. In the route with origin in Araxá the seasonality start at the beginning of harvest (May).



	1	2	3	4	5	6	7	8	9	10	11	12
Araxá - Rondonópolis	100%	100%	100%	103%	108%	111%	110%	110%	110%	104%	102%	100%
Uberaba x Rondonópolis	100%	100%	101%	104%	104%	104%	100%	109%	109%	104%	102%	100%
Araxá x Uberaba	100%	100%	100%	100%	101%	100%	101%	101%	101%	101%	101%	100%
Uberaba x Rio Verde	100%	100%	100%	100%	101%	101%	102%	103%	103%	104%	102%	100%
Catalão x Rio Verde	100%	100%	102%	105%	106%	105%	105%	106%	106%	106%	105%	100%

Figure 2: Minimum monthly seasonality (%) on outbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

The maximum seasonality monthly (Figure 3) had a similar behavior observed in Figures 1 and 2, characterizing higher costs after May and higher in the routes to Rondonópolis. It can also be observed that routes with lower distances and higher potential to perform the “closed-circuit route”, although there was an increase in the months in the middle of the year, the values tended to be more stable and lower compared with routes to Rondonópolis (MT). It was observed a high amplitude in the percentage (Figure 1, 2 and 3), especially in the routes to Rondonópolis (MT).

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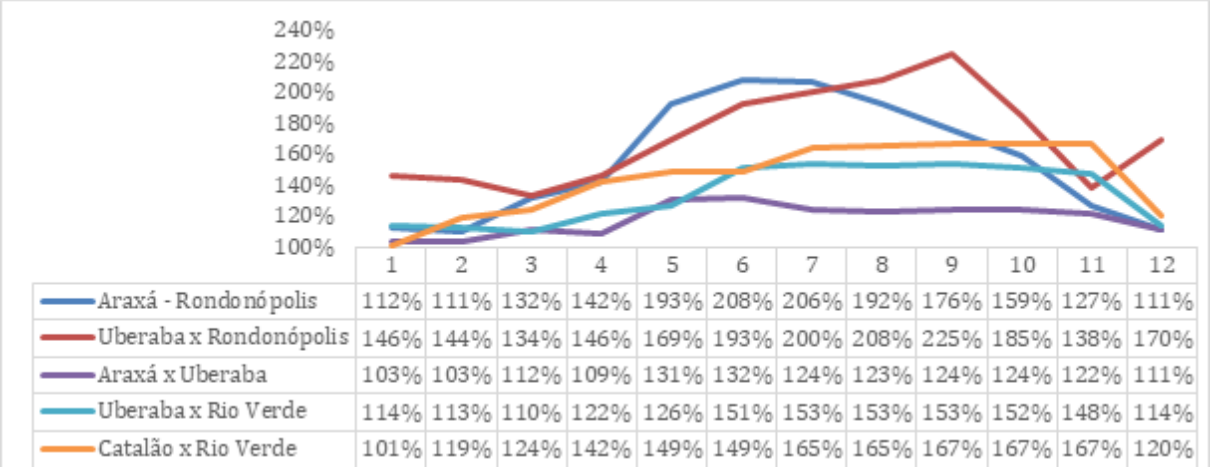

	1	2	3	4	5	6	7	8	9	10	11	12
Araxá - Rondonópolis	112%	111%	132%	142%	193%	208%	206%	192%	176%	159%	127%	111%
Uberaba x Rondonópolis	146%	144%	134%	146%	169%	193%	200%	208%	225%	185%	138%	170%
Araxá x Uberaba	103%	103%	112%	109%	131%	132%	124%	123%	124%	124%	122%	111%
Uberaba x Rio Verde	114%	113%	110%	122%	126%	151%	153%	153%	153%	152%	148%	114%
Catalão x Rio Verde	101%	119%	124%	142%	149%	149%	165%	165%	167%	167%	167%	120%

Figure 3: Maximum monthly seasonality (%) on outbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

The standard deviation monthly (Table 2) or yearly (Table 3) showed that the destination (especially Mato Grosso) and the period of harvest (May to June) are important factors that can influence the freight prices. In routes at the same state to supply the close mixing unit (Uberaba to Alfenas (MG); Araxá to Uberaba (MG); Catalão to Rio Verde (GO)) showed lower oscillation. In these cases, the flux is constant during the year, and it is easier to make contracts with transporters to mitigate the seasonality of prices. In 2017 and 2018 can be found higher standard deviation in the freights (Table 4), and there was the 2018 Brazil truck drivers' strike that can explain the variation in 2018.

Table 2: Monthly standard deviation (%) on outbound routes.

Routes	**Monthly standard deviation (%)**											
	Jan	Fev	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dez
Araxá - Rondonópolis	5	5	14	16	35	43	42	34	29	22	10	9
Uberaba - Rondonópolis	19	19	13	18	25	41	47	41	45	34	15	28
Araxá - Uberaba	1	1	5	4	11	13	9	9	9	10	8	9
Uberaba - Rio Verde	6	6	5	9	11	21	23	24	24	22	19	18
Catalão - Rio Verde	0	9	8	15	17	18	25	24	25	25	26	28
Average	6	8	9	13	20	27	29	26	26	23	16	18

Table 3: Yearly standard deviation (%) on routes outbound.

Routes	**Yearly standard deviation (%)**				
	2015	**2016**	**2017**	**2018**	**2019**
Araxá - Rondonópolis	9	7	31	40	25
Uberaba - Rondonópolis	10	7	28	36	35
Araxá - Uberaba	2	3	6	12	8
Uberaba - Rio Verde	5	2	16	23	5
Catalão - Rio Verde	9	4	12	27	7
Average	7	4	19	28	16

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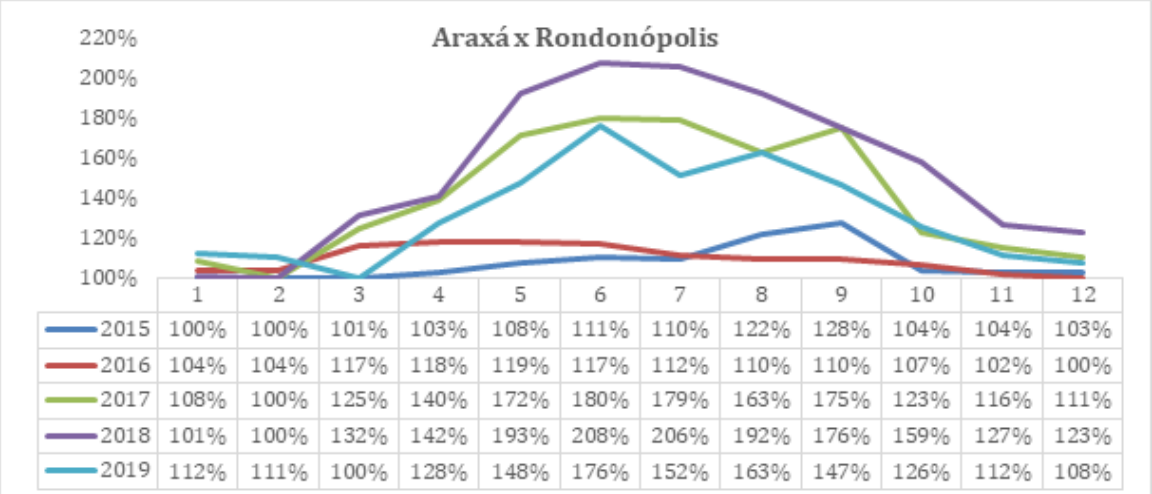
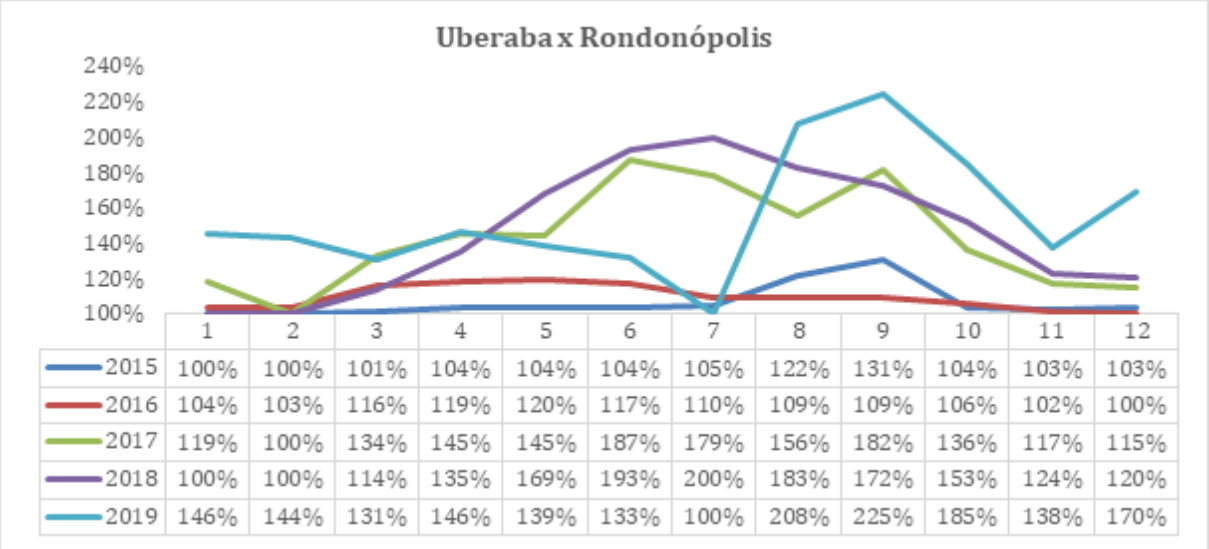
In the route from Araxá to Rondonópolis (Figure 4) the effects of seasonality provided an increase of freight in May and decreasing between September and October. In 2017, 2018 and 2019 were higher values compared to 2015 and 2016. The maximum seasonality among years (208 %) occurred exactly after one month after the 2018 Brazil truck drivers' strike.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	100%	100%	101%	103%	108%	111%	110%	122%	128%	104%	104%	103%
2016	104%	104%	117%	118%	119%	117%	112%	110%	110%	107%	102%	100%
2017	108%	100%	125%	140%	172%	180%	179%	163%	175%	123%	116%	111%
2018	101%	100%	132%	142%	193%	208%	206%	192%	176%	159%	127%	123%
2019	112%	111%	100%	128%	148%	176%	152%	163%	147%	126%	112%	108%

Figure 4: Yearly and monthly seasonality (%) on outbound routes from Araxá to Rondonópolis. Base volume 100. The number 1 to 12 represents the months January to December.

In the route from Uberaba to Rondonópolis (Figure 5), the behavior of seasonality is similar to the route from Araxá to Rondonópolis (Figure 4). It can be observed a more accentuated oscillation in 2019 (Figure 5), the effects of harvest occurred after June with maximum of 225% in September (2019) and it is higher than that in 2018.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	100%	100%	101%	104%	104%	104%	105%	122%	131%	104%	103%	103%
2016	104%	103%	116%	119%	120%	117%	110%	109%	109%	106%	102%	100%
2017	119%	100%	134%	145%	145%	187%	179%	156%	182%	136%	117%	115%
2018	100%	100%	114%	135%	169%	193%	200%	183%	172%	153%	124%	120%
2019	146%	144%	131%	146%	139%	133%	100%	208%	225%	185%	138%	170%

Figure 5: Yearly and monthly seasonality (%) on outbound routes from Uberaba to Rondonópolis. Base volume 100. The number 1 to 12 represents the months January to December.

In the route from Araxá to Uberaba (Figure 6), there is a "closed-circuit" with maximum of freights in the year and period of strike: 132% in June 2018. It is higher

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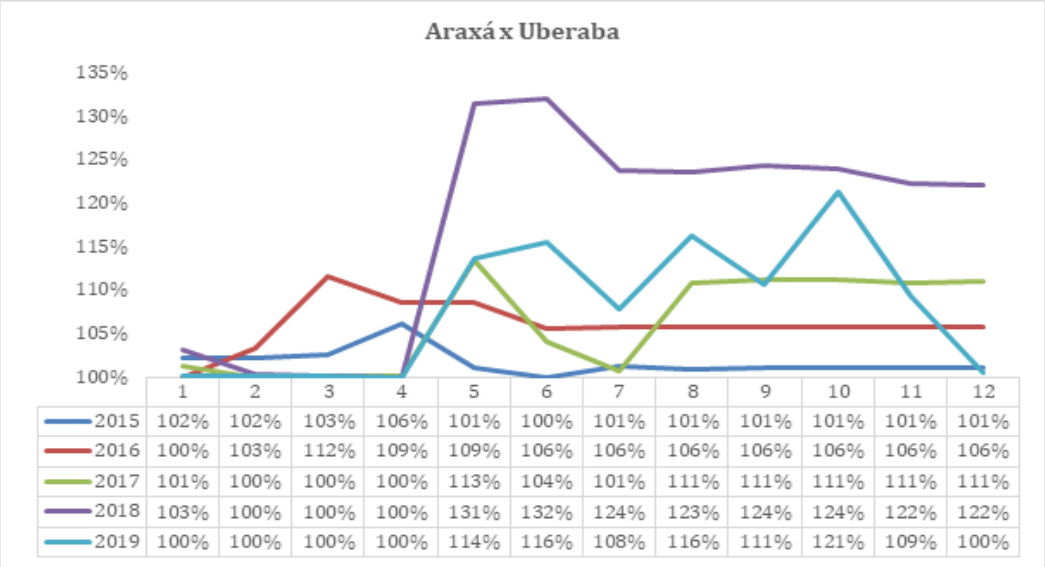
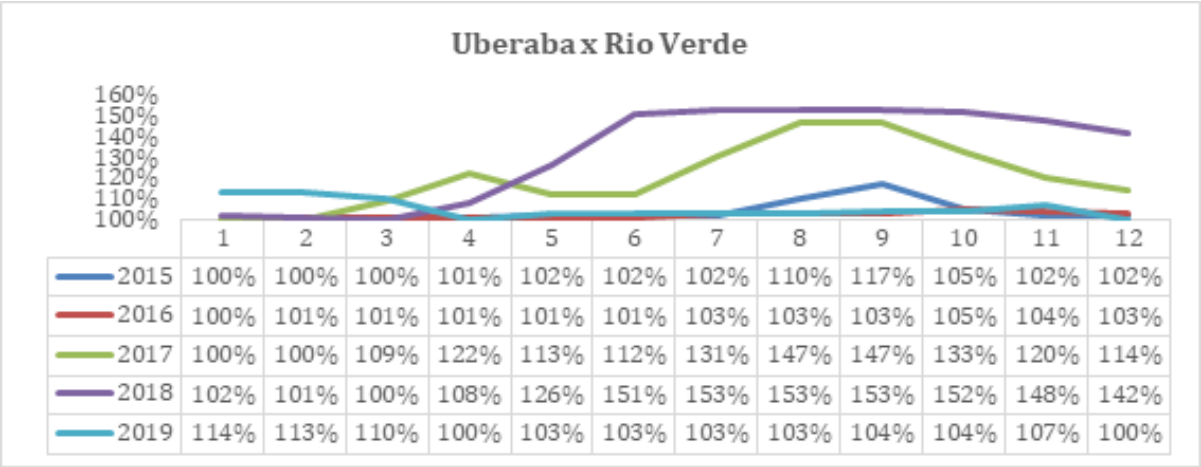
compare to the routes from Uberaba and Araxá to Rondonópolis. During the years the values are stable in some cases and it can be justified by contracts with transporters.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	102%	102%	103%	106%	101%	100%	101%	101%	101%	101%	101%	101%
2016	100%	103%	112%	109%	109%	106%	106%	106%	106%	106%	106%	106%
2017	101%	100%	100%	100%	113%	104%	101%	111%	111%	111%	111%	111%
2018	103%	100%	100%	100%	131%	132%	124%	123%	124%	124%	122%	122%
2019	100%	100%	100%	100%	114%	116%	108%	116%	111%	121%	109%	100%

Figure 6: Yearly and monthly seasonality (%) on outbound routes from Araxá to Uberaba. Base volume 100. The number 1 to 12 represents the months January to December.

In the route from Uberaba to Rio Verde (Figure 7) although the maximum was in June of 2018 with high value (153%) the stability of the values is more evident with oscillations just in 2017 and
2018.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	100%	100%	100%	101%	102%	102%	102%	110%	117%	105%	102%	102%
2016	100%	101%	101%	101%	101%	101%	103%	103%	103%	105%	104%	103%
2017	100%	100%	109%	122%	113%	112%	131%	147%	147%	133%	120%	114%
2018	102%	101%	100%	108%	126%	151%	153%	153%	153%	152%	148%	142%
2019	114%	113%	110%	100%	103%	103%	103%	103%	104%	104%	107%	100%

Figure 7: Yearly and monthly seasonality (%) on outbound routes from Uberaba to Rio Verde. Base volume 100. The number 1 to 12 represents the months January to December.

In the route from Catalão to Rio Verde (Figure 8), the oscillation is lower during the years and just in the strike in 2018 was higher than 140 % from June to December. The harvest did not increase the freight price during the years as observed in the strike in 2018.

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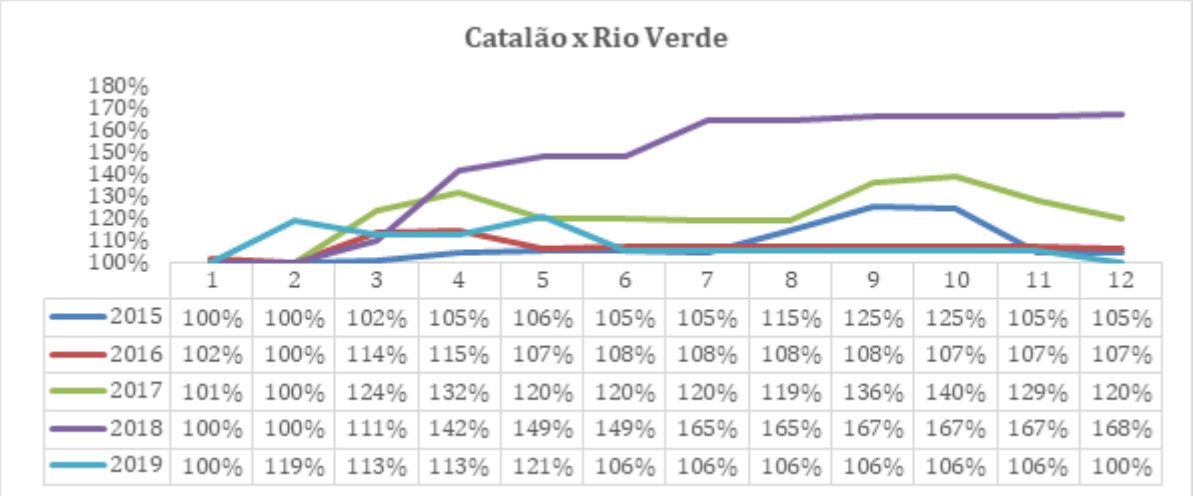

	1	2	3	4	5	6	7	8	9	10	11	12
2015	100%	100%	102%	105%	106%	105%	105%	115%	125%	125%	105%	105%
2016	102%	100%	114%	115%	107%	108%	108%	108%	108%	107%	107%	107%
2017	101%	100%	124%	132%	120%	120%	120%	119%	136%	140%	129%	120%
2018	100%	100%	111%	142%	149%	149%	165%	165%	167%	167%	167%	168%
2019	100%	119%	113%	113%	121%	106%	106%	106%	106%	106%	106%	100%

Figure 8: Yearly and monthly seasonality (%) on outbound routes from Catalão to Rio Verde. Base volume 100. The number 1 to 12 represents the months January to December.

Despite the influence of seasonality and the "Freight Table" have been confirmed in the outbound flux, there is no evident behavior of increases due to the "Freight Table" in the following year. In some of the routes, the year of 2019 provided the second higher seasonality of freight rates compared to the other years as observed in the routes from Araxá to Uberada and Uberaba to Rondonópolis. However, in the Table 3 can be observed that in 2017 the standard deviation values was higher compared to 2019 and there was no event in 2017 or before that can justify that.

3.2. Impact of seasonality on the inbound freight

The routes with inbound flux (Table 4) have origins in Paranaguá, Paraná state (PR), and in Santos, São Paulo state (SP), that is located the main harbors in Brazil. It represents the flux B2C (Business to Consumer) of the company.

Table 4: Volumes transported (%) on inbound routes in 2019.

Origen	Destination	2019 (Base volume 100)
Santos/SP	Uberaba/MG	210
Paranaguá/PR	Rondonópolis/MT	147
Santos/SP	Alfenas/MG	108
Paranaguá/PR	Rio Verde/GO	101
Paranaguá/PR	Sorriso/MT	100

In all destinations (Table 4) is located the company's fertilizer mixing units and it is also located the producing unit in Uberaba (MG). Consequently, the flux in Uberaba is the most intense (210%) and Santos is a cheaper option compared to the other origins. The destination in Goiás and Mato Grosso have an option of Santos and Paranaguá as an origin and because of that, these fluxes have low intensity.

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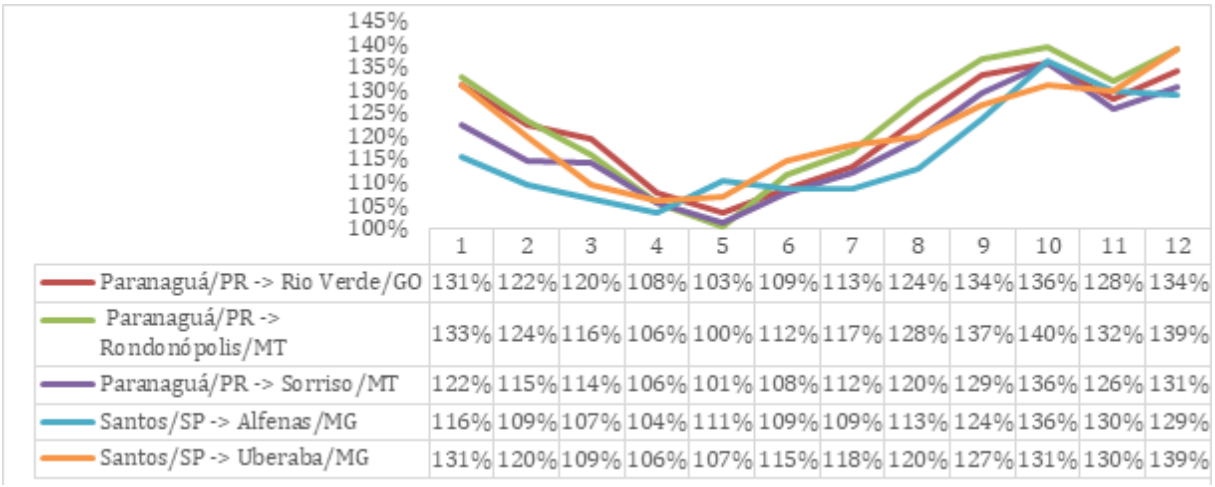
There are similarity in all the routes evaluated (Figure 9) with low values in the middle of the year and maximum in the last months of the year and there was no route that stood out.

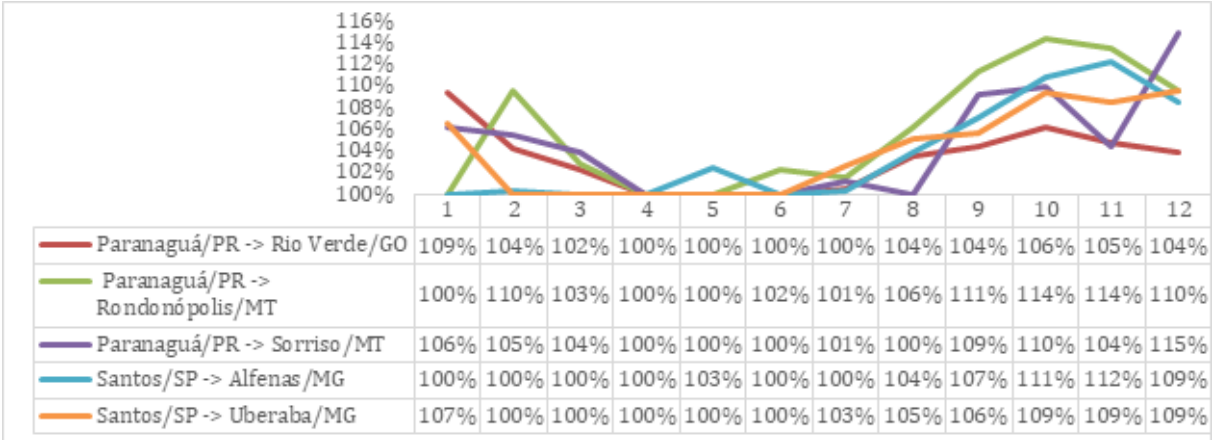


	1	2	3	4	5	6	7	8	9	10	11	12
Paranaguá/PR -> Rio Verde/GO	131%	122%	120%	108%	103%	109%	113%	124%	134%	136%	128%	134%
Paranaguá/PR -> Rondonópolis/MT	133%	124%	116%	106%	100%	112%	117%	128%	137%	140%	132%	139%
Paranaguá/PR -> Sorriso/MT	122%	115%	114%	106%	101%	108%	112%	120%	129%	136%	126%	131%
Santos/SP -> Alfenas/MG	116%	109%	107%	104%	111%	109%	109%	113%	124%	136%	130%	129%
Santos/SP -> Uberaba/MG	131%	120%	109%	106%	107%	115%	118%	120%	127%	131%	130%	139%

Figure 9: Monthly seasonality (%) on inbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

The routes from Paranaguá to Rio Verde and Rondonópolis provided percentage of seasonality a little higher during the year compared to the other routes, but in the outbound flux, the difference among routes is more evident. The maximum (176 %) that was observed in inbound routes (Figure 9) was lower than that observed in outbound routes (Figure 1).

There is a similarity in the minimum monthly seasonality during the year (Figure 10) with values between 100% and 105% in the months until August. In the end of the year the values reached 114% (between October and November) of seasonality in the route from Paranaguá to Rondonópolis. The outbound values reached 110% (Figure 2) in July.



	1	2	3	4	5	6	7	8	9	10	11	12
Paranaguá/PR -> Rio Verde/GO	109%	104%	102%	100%	100%	100%	100%	104%	104%	106%	105%	104%
Paranaguá/PR -> Rondonópolis/MT	100%	110%	103%	100%	100%	102%	101%	106%	111%	114%	114%	110%
Paranaguá/PR -> Sorriso/MT	106%	105%	104%	100%	100%	100%	101%	100%	109%	110%	104%	115%
Santos/SP -> Alfenas/MG	100%	100%	100%	100%	103%	100%	100%	104%	107%	111%	112%	109%
Santos/SP -> Uberaba/MG	107%	100%	100%	100%	100%	100%	103%	105%	106%	109%	109%	109%

Figure 10: Minimum monthly seasonality (%) on inbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

The Figure 11 confirmed again that routes that routes to Goiás and Mato Grosso are the main points of concern in relation to seasonality. The route from Paranaguá to Sorriso

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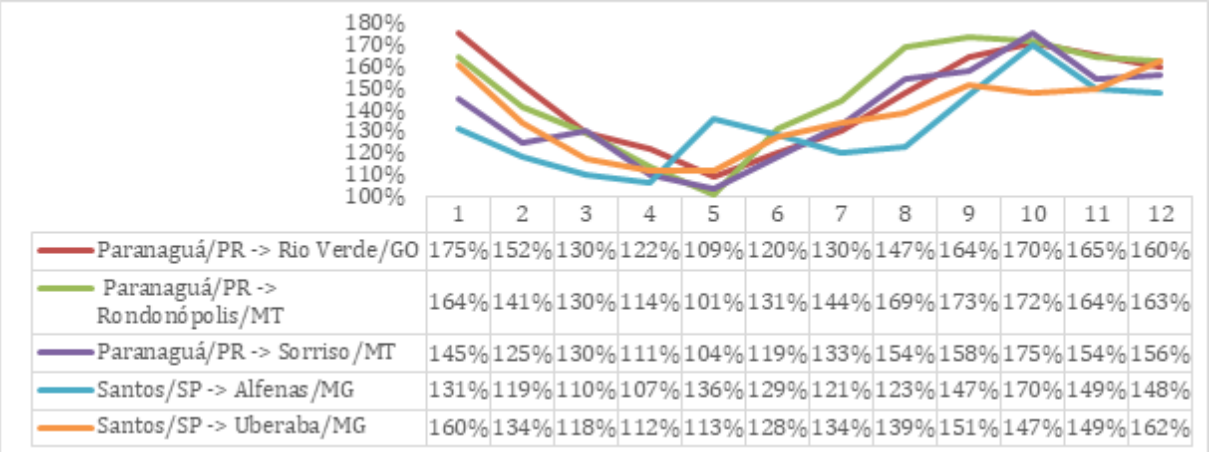
reached a maximum of 175% in October, and it is lower than 225% observed in September on the inbound route from Uberaba to Rondonópolis.

Despite differing in the intensity of the oscillation during the year, Figures 9, 10 and 11 have a very evident behavior. The inbound freight increases from the beginning of the harvest (from May to June), but unlike the outbound freight, the values did not decrease at the end of the grain planting period. The prices tended to remain high at the end of the following years and only in January started to decrease to the lowest values.



	1	2	3	4	5	6	7	8	9	10	11	12
Paranaguá/PR -> Rio Verde/GO	175%	152%	130%	122%	109%	120%	130%	147%	164%	170%	165%	160%
Paranaguá/PR -> Rondonópolis/MT	164%	141%	130%	114%	101%	131%	144%	169%	173%	172%	164%	163%
Paranaguá/PR -> Sorriso/MT	145%	125%	130%	111%	104%	119%	133%	154%	158%	175%	154%	156%
Santos/SP -> Alfenas/MG	131%	119%	110%	107%	136%	129%	121%	123%	147%	170%	149%	148%
Santos/SP -> Uberaba/MG	160%	134%	118%	112%	113%	128%	134%	139%	151%	147%	149%	162%

Figure 11: Maximum monthly seasonality (%) on inbound routes. Average of five years. Base volume 100. The number 1 to 12 represents the months January to December.

The harvest factor is evident in the seasonality that increased from June to October (Table 5) keeping a high price level until January corroborating with our hypothesis. However, in the second hypothesis, it is not possible guarantee that the seasonality are only due to the influence of the 2018 Brazil truck drivers' strike and "Freight Table". In 2016, a year with no similar event, the maximum of seasonality was the most intense in five years, having obtained the highest values in four routes of the five evaluated (Figure 6).

Table 5: Monthly standard deviation (%) on inbound routes.

Routes	**Monthly standard deviation (%)**											
	Jan	Fev	Mar	Ap	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Paranaguá - Rio Verde	27	18	11	9	4	10	14	21	25	28	24	24
Paranaguá - Rondonópolis	27	13	10	5	1	12	17	27	28	26	23	25
Paranaguá - Sorriso	16	10	11	4	2	8	14	23	22	28	20	17
Santos - Alfenas	12	7	4	3	14	13	9	10	18	24	16	17
Santos - Uberaba	20	13	7	5	6	10	11	13	19	16	16	20
Total	20	12	9	5	5	11	13	19	22	24	20	21

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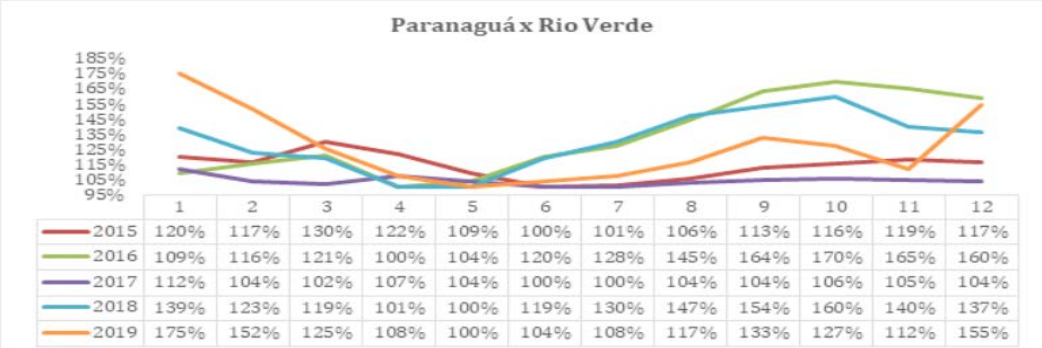
Table 6: Yearly standard deviation (%) on inbound routes.

Routes	**Yearly standard deviation (%)**				
	2015	**2016**	**2017**	**2018**	**2019**
Paranaguá - Rio Verde	9%	26%	3%	19%	23%
Paranaguá - Rondonópolis	8%	25%	7%	24%	20%
Paranaguá - Sorriso	7%	22%	6%	22%	15%
Santos - Alfenas	4%	18%	7%	22%	14%
Santos - Uberaba	9%	20%	8%	15%	17%
Total	**8%**	**20%**	**7%**	**19%**	**16%**

The inbound routes did not have an example of a "closed-circuit route" because of long distance between the destinations. There is an expectation that the influence of the harvest could be lower since the price increases are divided between the grain and fertilizer freight.

In 2016, the route from Paranaguá to Rio Verde (Figure 12) reached higher values than the other years including the values influenced by the "Freight Table". The "Freight Table" influenced the values in 2019 with high values until May. The harvest pressure also occurred and it extended to the beginning of next year's instead of finishing in September and October as in the outbound routes.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	120%	117%	130%	122%	109%	100%	101%	106%	113%	116%	119%	117%
2016	109%	116%	121%	100%	104%	120%	128%	145%	164%	170%	165%	160%
2017	112%	104%	102%	107%	104%	100%	100%	104%	104%	106%	105%	104%
2018	139%	123%	119%	101%	100%	119%	130%	147%	154%	160%	140%	137%
2019	175%	152%	125%	108%	100%	104%	108%	117%	133%	127%	112%	155%

Figure 12: Yearly and monthly seasonality (%) on inbound routes from Paranaguá to Rio Verde. Base volume 100. The number 1 to 12 represents the months January to December.

In 2016, the route from Paranaguá to Rondonópolis (Figure 13) also increased from May and had higher values in November and December compared to 2018 probably caused by a lower supply of vehicles. In 2019, it started with high freight prices and tended to normalize in February and March.

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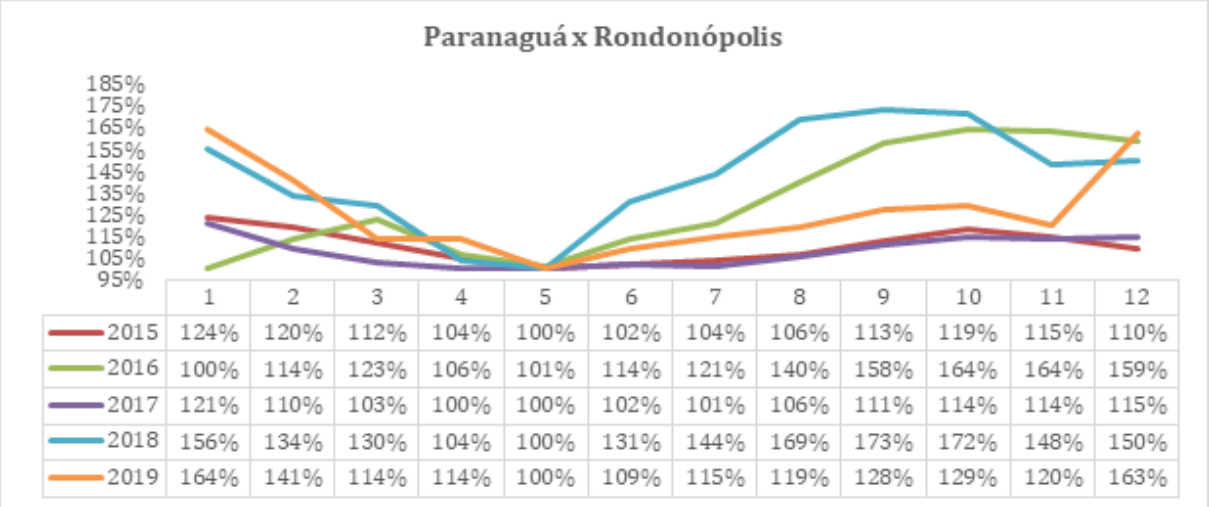
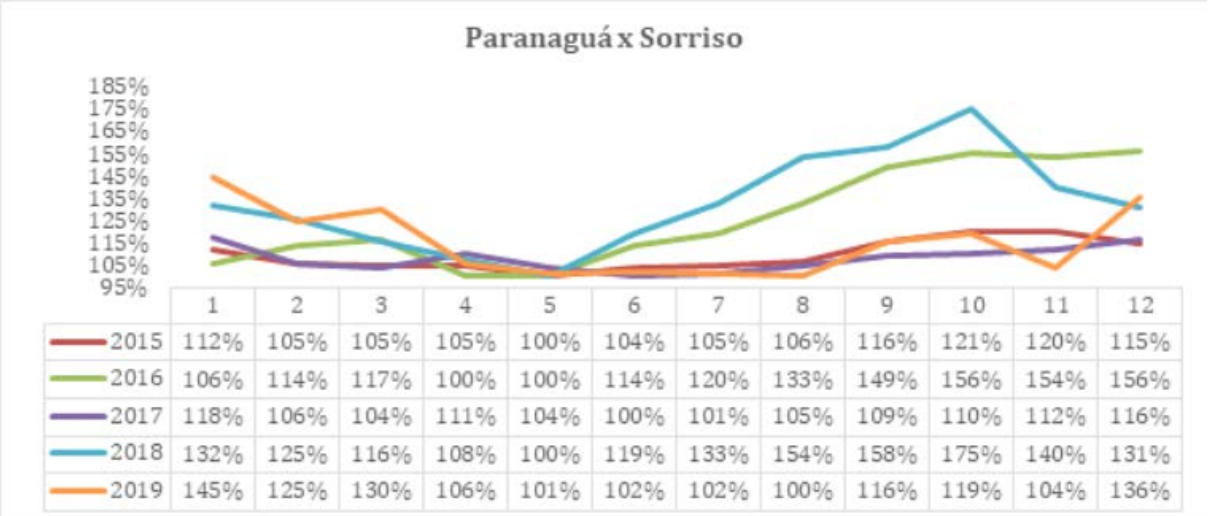


	1	2	3	4	5	6	7	8	9	10	11	12
2015	124%	120%	112%	104%	100%	102%	104%	106%	113%	119%	115%	110%
2016	100%	114%	123%	106%	101%	114%	121%	140%	158%	164%	164%	159%
2017	121%	110%	103%	100%	100%	102%	101%	106%	111%	114%	114%	115%
2018	156%	134%	130%	104%	100%	131%	144%	169%	173%	172%	148%	150%
2019	164%	141%	114%	114%	100%	109%	115%	119%	128%	129%	120%	163%

Figure 13: Yearly and monthly seasonality (%) on inbound routes from Paranaguá to Rondonópolis. Base volume 100. The number 1 to 12 represents the months January to December.

The route from Paranaguá to Sorriso (Figure 14) has similar seasonality behavior compared to the route from Paranaguá to Rondonópolis (Figure 13), and can be observed higher maximum that can be explained by the lower market of the company increasing the pressure to find transporters.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	112%	105%	105%	105%	100%	104%	105%	106%	116%	121%	120%	115%
2016	106%	114%	117%	100%	100%	114%	120%	133%	149%	156%	154%	156%
2017	118%	106%	104%	111%	104%	100%	101%	105%	109%	110%	112%	116%
2018	132%	125%	116%	108%	100%	119%	133%	154%	158%	175%	140%	131%
2019	145%	125%	130%	106%	101%	102%	102%	100%	116%	119%	104%	136%

Figure 14: Yearly and monthly seasonality (%) on inbound routes from Paranaguá to Sorriso. Base volume 100. The number 1 to 12 represents the months January to December.

The route from Santos to Alfenas (Figure 15) has smoother oscillation with just one value higher than 150%. The seasonality in 2018 and 2016 is higher than the other years from the beginning of harvest.

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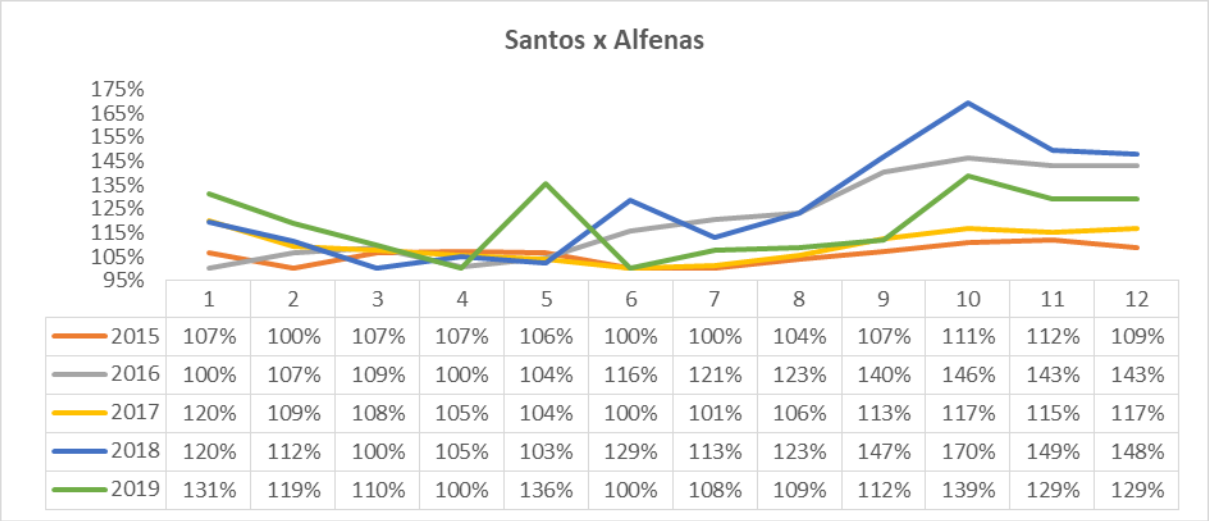
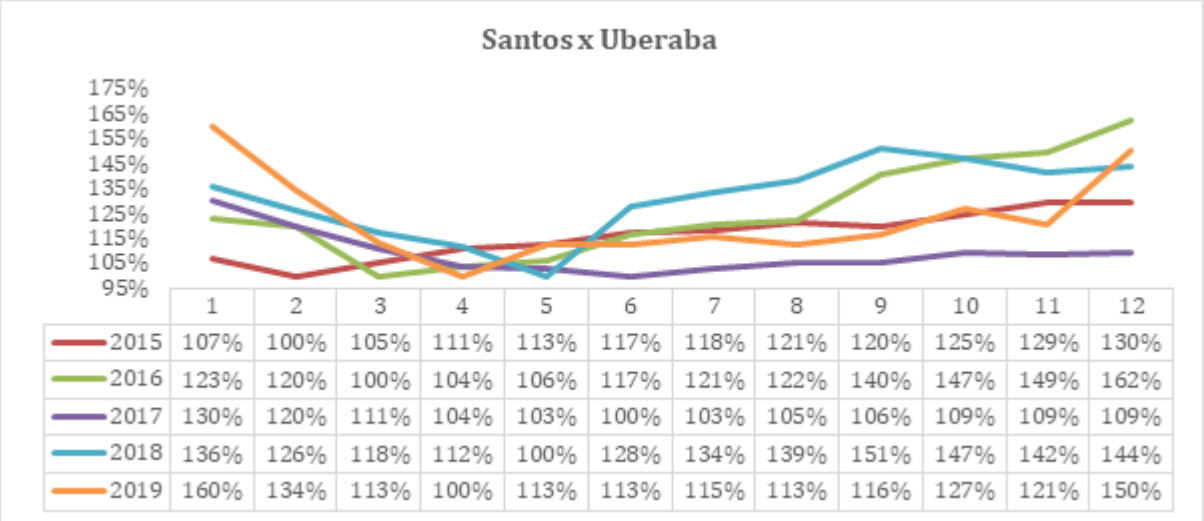


	1	2	3	4	5	6	7	8	9	10	11	12
2015	107%	100%	107%	107%	106%	100%	100%	104%	107%	111%	112%	109%
2016	100%	107%	109%	100%	104%	116%	121%	123%	140%	146%	143%	143%
2017	120%	109%	108%	105%	104%	100%	101%	106%	113%	117%	115%	117%
2018	120%	112%	100%	105%	103%	129%	113%	123%	147%	170%	149%	148%
2019	131%	119%	110%	100%	136%	100%	108%	109%	112%	139%	129%	129%

Figure 15: Yearly and monthly seasonality (%) on inbound routes from Santos to Alfenas. Base volume 100. The number 1 to 12 represents the months January to December.

The route from Santos to Uberaba (Figure 16), despite having the highest volume, it did not differ from previous behaviors, maintaining a strong influence of the "Freight Table" until the beginning of 2019, with the years 2018 and 2019 alternating with the highest prices.



	1	2	3	4	5	6	7	8	9	10	11	12
2015	107%	100%	105%	111%	113%	117%	118%	121%	120%	125%	129%	130%
2016	123%	120%	100%	104%	106%	117%	121%	122%	140%	147%	149%	162%
2017	130%	120%	111%	104%	103%	100%	103%	105%	106%	109%	109%	109%
2018	136%	126%	118%	112%	100%	128%	134%	139%	151%	147%	142%	144%
2019	160%	134%	113%	100%	113%	113%	115%	113%	116%	127%	121%	150%

Figure 16: Yearly and monthly seasonality (%) on inbound routes from Santos to Uberaba. Base volume 100. The number 1 to 12 represents the months January to December.

The company is more exposed with respect to the outbound routes compared to the inbound routes. Expanding the use of return freight will be an important factor to reduce freight oscillation. Another point is that the closer to the grain harvest, the more inflated the freight. Therefore, if there are opportunities to advance inbound volumes in less pressure times, the reflex will also tend to be positive.

For outbound routes, the use of return freight is difficult to perform because the origins (Araxá, Catalão, and Uberaba) are in the middle of the final destination (Mato

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Grosso) where trucks are loaded with grains. A partnership to use return route would bring benefits, especially during periods of pressure on freight. Another positive result for the company in the study was the practice of "closed-circuit route" and with the application of contracts can also mitigate part of the influence of seasonality, as observed in the route from Uberaba to Araxá, and can be used to reduce costs.

4. FINAL CONSIDERATIONS

This study in the fertilizer segment of Brazilian agribusiness represents very well the impact of seasonality on the prices of road freight during years. The grain harvest is a factor with high impact on the values, which can increase transport costs in 29% on average (Table 2). However, the impact of the grain harvest is more intense in the outbound routes that are less guaranteed to combine grain freight on the outward journey and fertilizers in the return as occurs in the inbound routes that have origins in the harbors.

The "closed-circuit route" can also mitigate part of the freight oscillation with a standard deviation maximum of 13% in the route from Uberaba to Araxá compared to 47% observed in the route from Uberaba to Rondonópolis. This study is also an applied example of the influence of the 2018 Brazil truck drivers' strike and the implementation of the "Freight Table" on the price of road transport.

These events increased the values in May and June of 2018 by a maximum of 208% and maintaining this high standard throughout the following months of the year in the outbound freight. It also influenced the inbound freight with simpler oscillation by a maximum of 131% in the route from Paranaguá to Rondonópolis. Despite the notorious influence of these events on the freights in 2018, there is no conclusive evidence that these effects were also reflected in 2019, since there are no well-established high price standards in that year, in the inbound flux.

Actions to mitigate the seasonality on the freights should be focused on long-distance routes and on outbound freight. Annual contracts and looking for new opportunities with return freights are responses practiced by the company and the intensification would reduce the freight oscillation that financially burdens the company. Aiming to avoid the pressure in the freight prices during the grain harvest the anticipation of the freight to Mato Grosso between February and May and stocking the products close to the final destination would be an alternative.

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Contracts are mechanisms that could be signed with companies for volume guarantee throughout the year and it can be a strategy for inbound and outbound freights depending on the success of negotiation. Thinking of the potential complements to enrich this work, a correlation of the results in this study with the duration of each grain harvest could increase the capacity to predict the behavior of the curves. As the focus of the work was in the fertilizer area, such volumes and dates for grains were not available.

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