Original Research Article

Wheat Grain Losses in Highway Transportation

ABSTRACT

Road transport is highlighted by its efficiency providing door-to-door services. It can be considered that 62.70% of the entire Brazilian cargo is handled by land transportation. In this context the transportation of wheat grains is very important. Wheat is an important cereal crop in Brazil and one of the main sources of carbohydrates for baking. The country produced approximately 5.42 million tons of wheat grains in the 2018 harvest. The objective of this study is to establish a percentage loss index, as well as to assess these quantitative losses during the transportation of grains of wheat in bulk. The work was developed through a partnership between the National Supply Company and the Nucleus of Storage Technology at the Federal University of Mato Grosso. It was established the evaluation of losses related to the transportation of grain wheat in bulk in the main waterways, and the research was carried out in BR-277/376 in the State of Paraná. After the choice of the highways evaluated, we performed research on the data of documents of the transport of wheat in bulk. The obtained data, through the documents, provided weight of origin, weight of destination, place of origin and place of destination, in this way, by difference was obtained the quantity of grains lost in the transport and the mileage traveled in each route. By means of these data it was possible to obtain three indices of losses, one in Kg / Km (kilogram per kilometer wheeled), another one in Kg / t (kilograms per tons transported), and also determined an index of loss in percentage of grains transported. With the indication of the indices it was possible to evaluate the losses. The Bitrem truck (7 axles) was used as the basis for calculating the losses, since during the interviews this was the type that had the most occurrences in BRs evaluated, with 39%. Based on the questionnaire, the load weight of 38,000 kg was adopted. For the study of losses of wheat grains in road transport, 10,279 data were analyzed for routs, 1,053,851 km, with an average of 102.52 km round trip. The amount of wheat grain transported was 222,494,228 kg. The total losses were 505,736 kg, averaging 49.20 kg of loss per trip. The loss per km was on average 0.479 kg. The percentage loss index for wheat (0.1708%) was determined. This percentage is lower than the adopted one that is of 0.25%, nevertheless, represent considerable losses for the economy. Based on the data obtained in the present study, it can be stated that it is possible to adopt, by the carriers, percentage loss indexes lower than 0.25% in the contracts. It is recommended to adopt the percentages of grain loss in road transport of 0.17% for wheat.

Keywords: highway, quantification, trucks, wheat grains.

1. INTRODUCTION

The road system is characterized by some specific characteristics, such as the door-to-door delivery process and the implementation of minimum inventories, through the use of pull (just in time) systems that allow faster turns [1 and 2]. It is worth mentioning that, in the context of supply chains, road transport is highlighted by its provision of door-to-door services [3]. According to [4], Brazilian road transport handled 58% of the country's total cargo volume, twice more than Australia and the US, with 30% and 28%, respectively, and three times more than China, with a percentage of 19%. More recently, it can be considered that 62.70% of the entire Brazilian cargo is handled by land transportation [5].

In context the transport of wheat grains is very important. Wheat is an important cereal crop in Brazil and one of the main sources of carbohydrates for baking. The country produced approximately 5.42 million tons of wheat grains in the 2018 harvest [6]. This production, although satisfactory, can still be larger, it is no longer a problem faced with a grain outflow logistics that loses part of the investment in relation to the infrastructure, with projects that only aim at the existing holes, without expanding and giving better quality to the and that there is no effect that diminishes the distance [7].

Thus, a portion of the grains is lost in transport to the ports, which represents about 0.25% of losses [8]. According to [9], the loss of grain is not responsible for the accumulation of waste on the highways, there is a flow of production to the warehouses, due to the precarious state of the roads that are bumpy, without the pavements causing breaks in the fleet as well as freight prices. For [10], it is precisely during the transportation of the granulation that it falls due to body shaking and unloading of the load. The result is a portion of grams that are used for the same and the flooring of the bodywork, which can be solved for the traditional outdoor plant. Another accessor is derived from the upper body of the manual, due to enlonation bad and non-uniform generated the activity manual that often requires speed. Obviously, those who are influenced by the quality of the paving for the truck travel, because the trepidation and the holes are decisive when there is no escape, when it is not completely sealed inside the body.

How the differences are a difference of weight between the origin and the destination. Shippers are available to handle loss of contracts with carriers. This loss or impediment of transport is calculated from an index of 0.25% per tonne of grain transported. This index is the tolerable agreed between the origin and the destination, when the units are carriers are analyzed and analyzed [11]. However, the studies have already shown average rates of under-paid losses and practiced the market, taking into account losses that can be further reduced by the new rates practiced by road transport [12].

In view of the above, this work results in an index of loss in percentage, as well as the value is disposable during the transport period of wheat grains.

2. MATERIAL AND METHODS

2.1. Experimental Site Description

The work was developed through a partnership between the National Supply Company (CONAB) and the Nucleus of Storage Technology, at the Federal University of Mato Grosso.

The evaluation of losses related to the transport of wheat grain in bulk in the main runways was established, being the research carried out in BR-277/376 in the State of Paraná (Table 1).

After the choice of the highways evaluated, we carried out research on the data of documents of the transport of wheat in bulk (Figures 1 and 2).

Table 1. Principal routes of grain yield of wheat in the BR-277/376 in the State of Paraná, Brazil.

Route	Distance (Km)	Highway (BR)
Porto de Paranaguá-PR a Ponta Grossa-PR	216	277/376

Source: Google Maps

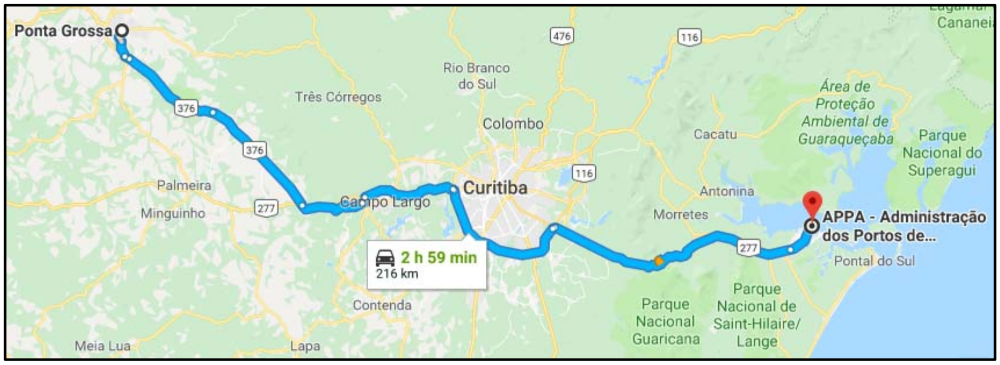

Fig. 1. Main route of wheat flow in the State of Paraná, BR-277/376, route from Porto de Paranaguá to Ponta Grossa, Paraná, Brazil. *Source: Google Maps 2019.*

2.2. Obtaining Data

The obtained data, through the documents, provided weight of origin, weight of destination, place of origin and place of destination, in this way, by difference was obtained the quantity of grains lost in the transport and the mileage traveled in each route. By means of these data it was possible to obtain three indices of losses, one in Kg/Km (kilogram per kilometer wheeled), another one in Kg/t (kilograms per tons transported), and also determined an index of loss in percentage of grains transported. With the indication of the indices it was possible to assess the losses.

The evaluated loads were separated by weight, in this way it was possible to carry out the classification by type of trucks. Rodotrem was considered to be the trucks that carried loads over 43 thousand kilos, Bitrem the trucks that carried loads between 33 thousand and 43 thousand kilos, and the trucks that carried loads weighing less than 33 thousand kilos, considering weight of scale. These classifications were made considering resolutions 210/06, which establishes the limits of weight and dimensions for vehicles that travel by land [13].

The Bitrem truck (7 axles) was used as the basis for calculating the losses, since during the interviews this was the type that had the most occurrences in BRs evaluated, with 39%. Therefore, based on the questionnaire, the load weight of 38.000 kg.

2.3. Calculation of the Indicators for the Determination of Losses

The calculation of the indicators involved the measurement of the frequency of travel and distance traveled, considering the repetition of trips. To determine the frequency was based on the number of times a passage was traveled. The total distance was calculated by multiplying the distance (Km) by the number of times the section was traveled. The loss per Km was calculated based on the expression:

$$\frac{\sum_{i=1}^{n} Losses}{\sum_{i=1}^{n} Distance\ (in\ km)}$$

For the calculation of the total loss losses were added per section. And the loss index was calculated according to the formula:

$$\frac{Average\ Losses\ \ (in\ Kg)}{Average\ Weight\ \ (departure)}$$

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To compare the loss index of 0.25%, a statistical test was performed based on the mean and standard deviation of the losses, sample size, at 1% significance.

The Z distribution was chosen according to the expressiveness of the sample (> 50). The hypotheses of the test were as follows:

H_O:μ≥0,0025 --□ Null hypothesis (this hypothesis, if it prevails, will indicate that, in fact, the average value of losses is greater than or equal to 0.0025).

H_a: μ<0,0025 --□ Alternative hypothesis (this hypothesis assumes that the mean value is less than 0.0025).

It was verified, by means of a cointegration model, what would be the long-term behavior of the estimated series. Being:

X_1= Initial weight, in kg, of grain to be transported.
X_2= Final weight in kg of grain to be transported.
Period analyzed: 2011 to 2017

The hypothesis that the problem of grain loss will last for a long period is assumed in the model.

The cointegration model is divided into.

Unitary Root Test: The unit root test is formally used to detect the presence or absence of stationarity in the series. The increased Dickey-Fuller and Dickey-Fuller methods are used more frequently in the detection of stationarity in time series.

The null hypothesis, according to the three methods, assumes that there is a unit root in the series, while the alternative assumes that there is no unit root and, consequently, the series is stationary, in the second hypothesis, and not stationary in the first.

The regression, according to the increased Dickey-Fuller method, is estimated according to equation 1. The regression format is similar to the first order auto regression process or AR (1).

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \varepsilon_t \qquad (1)$$

Being β_0 and β_1 the regression parameters and ε_t, the white noise.

If $(-1 < \beta_0 < 1)$. If $\beta_0 = 1, Y_t$ is a non-stationary series (a random path with an intercept), because if the process starts from some point, the variance of Y_t grows as a function of time to infinity. If the absolute value of the parameter is greater than one $(|\beta_0| > 1)$, a série é explosiva. The series is explosive. Consequently, the stationarity hypothesis must be tested to evaluate whether the absolute value of β_0 is strictly smaller than one. Both tests DFA and PP allow to evaluate the presence of a unit root as null hypothesis, that is, that: $H_0: \beta_0 = 1$ [14].

If the null hypothesis, which assumes the presence of unit root in the series, is not rejected, but when reestimated in its first difference, the test confirms the stationary nature of the model, it is concluded that the series is integrated of order 1 or $I\{1\}$. Conventionally, the original series is labeled random path.

If it is necessary to differentiate the original series twice, that is, to take the first difference from the first difference, before the series is converted to stationary, the original series is $I\{2\}$ or integrated order 2. In general, if a time series has to be differentiated n times, then it will be integrated order n or $I\{n\}$. But, if $= 0,$, the time series is stationary without differentiation or $I\{0\}$" [15].

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The Dickey-Fuller test for the presence of unit root in the series can be performed with intercept or without intercept, in the same way for the trend. Equations 2,3 and 4 illustrate the regression format for these situations.

$$\Delta Y_t = \theta Y_{t-1} + \varepsilon_t \qquad (2)$$
$$\Delta Y_t = \beta_i + \theta Y_{t-1} + \varepsilon_t \qquad (3)$$
$$\Delta Y_t = \beta_i + \beta_j t + \theta Y_{t-1} + \varepsilon_t \qquad (4)$$

The critical values do not belong to the t student distribution. The statistic used as a basis for comparison with the calculated value follows the distribution τ (tau).

The main objective of the cointegration tests is to verify if in a group of non-stationary time series there is at least one linear combination that is stationary, that is, if they are cointegrated [14].
The main objective of the cointegration tests is to verify if in a group of non-stationary time series there is at least one linear combination that is stationary, that is, if they are cointegrated.

$$X_T = \beta_0 + \beta_1 P_{st} + \varepsilon_t \qquad (5)$$

The residues resulting from this regression will be estimated in their first difference as a function of the same residuals lagged in the first order, as shown in equation 6.

$$\Delta e_t = \rho e_{t-1} + \lambda_1 \Delta e_{t-1} + \lambda_2 \Delta e_{t-2} + \ldots \lambda_q \Delta e_{t-q} + v_t \qquad (6)$$

If the calculated value of the statistic τ exceeds, in absolute terms, the critical values, it is concluded that the ε_t estimated is stationary, which means cointegration between the variables.

Johansen created a model without a constant in which the dependent variable is estimated as a function of it lagged up to the order $t-p$ and the independent variable not lagged.

This model is illustrated in equations 7 and 8, being Z_t a non-stationary series I{1}, Y_t a deterministic and ε_t a white noise.

$$Z_t = a_1 Z_{t-1} + a_2 Z_{t-2} + a_3 Z_{t-4} + \ldots\ldots a_p Z_{t-p} + bY_t + \varepsilon_t \qquad (7)$$
$$\Delta Z_t = a Z_{t-1} + \sum_{i=1}^{p-1} \lambda_i \Delta Z_{t-i} + bY_t + \varepsilon_t \qquad (8)$$

The cointegration is tested by the eigenvalues, generated by the likelihood ratio. Statistical tests, conventionally known as $\lambda_{traço}$[1] e λ_{max}[2], are compared with critical values [14].

$$\lambda_{traço}(r) = -T \sum_{i=1+r}^{k} \ln(1 - \hat{\lambda}_i) \qquad (9)$$
$$\lambda_{max}(r, r+1) = -T * \ln(1 - \hat{\lambda}_{r+1}) \qquad (10)$$

$\hat{\lambda}_i$ = i-th highest eigenvalue (or characteristic root)
T = number of usable observations
k = number of endogenous variables
r = rank of cointegration

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2.4. Statistical Analysis

The first statistic tests the null hypothesis that the number of distinct cointegration vectors is less than r against the generic alternative. The second statistic tests the null hypothesis that the number of cointegration vectors is equal to r against the alternative of r+1 vectors of cointegration. If the estimated value of the characteristic root (eigenvalue) is close to zero, then $\lambda_{\max}$ it will be inexpressive [16].

The null hypothesis assumes that there is no cointegration relation between the variables, while the alternative hypothesis assumes that there is at least one cointegration relation between the variables. The test is repeated until rejection of the null hypothesis is obtained.

$$\boldsymbol{H_0}: \boldsymbol{r} = \mathbf{0}$$

$$\boldsymbol{H_A}: \boldsymbol{r} > 0$$

The error term in the cointegration equation is treated as "equilibrium error", according to [15].This error term can be used as a link of the behavior, applying in the variables selected for the search, in the short term with its value in the long term. The error correction mechanism is the corrective component of imbalances in the short term. The equation of this mechanism is expressed in 11.

$$\Delta \boldsymbol{X_{1t}} = \boldsymbol{\alpha_0} + \boldsymbol{\alpha_1} \Delta \boldsymbol{X_{2t}} + \boldsymbol{\alpha_2 e_{t-1}} + \boldsymbol{u_t} \qquad (\mathbf{11})$$

If the error coefficient lagged in the first order ($\boldsymbol{\alpha_2}$) is statistically significant, this parameter informs in what proportion the imbalance in the data in one period is corrected in the following period.

The obtained data were submitted to descriptive statistics from where a breakdown frequency analysis was obtained. The statistical program used to perform the frequency analysis was the IBM SPSS Statistics Version 22.

3. RESULTS AND DISCUSSION

For the study of losses of wheat grains in road transport, 10,279 data were analyzed for routs, 1,053,851 km, with an average of 102.52 km rotated per trip. The amount of wheat grain transported was 222,494,228 kg. The total losses were 505,736 kg, averaging 49.20 kg of loss per trip. The loss per km was on average 0.499 kg.

In the first stage, the calculation of the indicatives involved the measurement of travel frequency, distance traveled and total loss, considering the repetition of trips in the transport of wheat grains (Figure 2).

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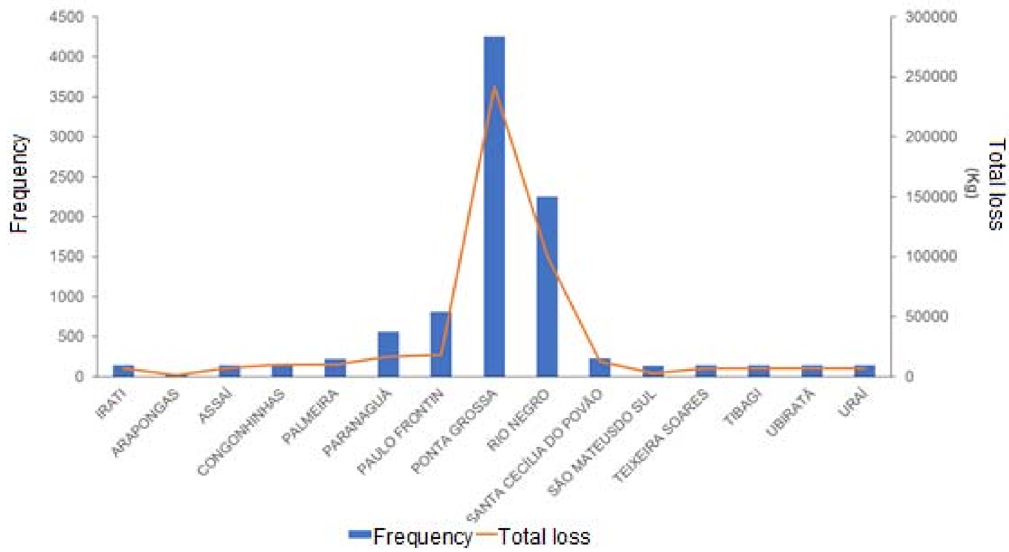

Fig. 2. Frequency of road transport and its respective total losses of wheat grains from the municipalities of origin to the final destination, Ponta Grossa, Paraná, Brazil, during the period from 2011 to 2017.

The frequency of trips and the total loss of wheat grains transported on the highways were determined through the documents (Figure 2). The Ponta Grossa destination - up to the mills near Ponta Grossa presented the highest total loss, even though it was a route with an average distance of 18 km, this result is explained by the high frequency (4207 trips) and the highest average of travel losses (57 kg). These high losses can be a consequence of the conservation of the trucks and the care in the moment of load that often are not observed, by the short distance that the trucks will go.

The Rio Negro - Ponta Grossa stretch (150 km) also obtained expressive frequency, with 2252 trips, and losses of 100.427 kg, but in a greater distance when compared to that of the previous section (18 km). During this research, it was possible to identify, through the documents, the frequency of the trips as well as the total loss in the transport of corn grains (Figure 2). [17] explain that due to poor road conditions, where the irregularities, and the large number of holes found cause the truck to shake, as a consequence of this trepidation the oscillation and displacement of these grains to the periphery occurs, and if the body does not is in good condition and well fenced, these grains fall down the highway. It should be considered that although producers and drivers are aware of this loss, they are not careful to take preventive measures, because they believe that they are insignificant and do not cause them any loss, but in the end there is a lot of waste [18]. According [19] with only 20% of road pavements and 1.7 million km of road surface, poor rural road conditions in Brazil create substantial bottlenecks due to intensive use during the soybean and corn harvest. According to [20], Brazilian law states that trailers may have a maximum weight of 45 or 57 tonnes (based on the total length of the trailer, [13], however the overload during transport of grain farm, for storage is common. The combined effects of poor road conditions and road maintenance, truck vibrations and overloads, and lack of maintenance of trailers on grains lost during transport were studied by [21 and 22].

According to the authors [23] the concession of highways has a direct impact. Understanding that the concession represents first the improvements, being in the pavement, signaling and geometry of the roads, secondly the consideration to the concessionaires will be given by toll collection of the public service user.

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The high total losses in the previous routes can be explained by the poor conservation of the roads and the non adoption of methods that could reduce the losses of grains in the transport, like wrapping of the bodies, training and awareness of the drivers.

In the second stage, the Hypothesis Test was performed to compare with the current loss index, which is 0.25% [11]. The test indicated that one should reject the null hypothesis, which states that the mean value of the losses is greater than or equal to 0.25%, and accept the alternative hypothesis, which states that the average value of losses is lower than the value of 0.25%. Later, the extreme values of the losses represented by the lower and upper limits were calculated using the confidence interval method (Table 2).

Thus, the percentage loss index for the wheat crop (0.1708%) was determined. This percentage is lower than the adopted one that is of 0.25%, nevertheless, represent considerable losses for the economy. According to [24], about 0.25% of the grains that are carried along the route. By contract, such loss, when greater than 0.2%, is banked by the carrier himself. But the economic impact is felt throughout the production chain until the final consumer, who ends up paying more for the product.

Table 2. Indices of wheat grain losses, upper and lower limits in BR-277/376 in the State of Paraná, Brazil.

Confidence interval (%)	
Inferior limit	Upper limit*
0,1678	0,1708

**The upper limit was adopted as the indicated index for the calculation of the losses.*

In the third step a cointegration model was applied, whose objective was to verify the behavior of the estimated series, in the case grain losses, for a long period (Table 3). This model uses the same statistical assumptions presented in the state distribution model, with the difference that the distribution occurs at the national level.

The variables of the estimation are as follows:

$Q_1 =$ Initial weight, in kg, of the product transported.

$Q_2 =$ Final weight, in kg, of the product transported.

The result of the applied statistical model showed a stable relationship of the cointegrated variables studied. It was verified through the models that grain losses can last for long periods if there is no effective intervention of the sectors involved, both privately and publicly.

Table 3. Cointegration model of the estimated series for the loss of wheat grains for a long period.

Auto value	Trace statistic	Critical value
0.5	47.34	15.5
0.26	14.26	3.84

With the application of the indexes, it is possible to calculate the amount lost in kilograms of grain transported by a bitrem truck with a capacity of 38 t, in addition to assessing this loss (Table 4).

The grain of wheat transported from Ponta Grossa-PR to the Port of Paranaguá-PR has losses of 64.90 kg. The loss index was estimated to be 0.1708%, representing a loss in values of R$39.06, with losses of R$ 0.18 per kilometer wheeled. The common tolerance between the carriers is 0.25% of the total load, this value that if extrapolated is the responsibility of the drivers.

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Table 4. Quantitative losses in road transport of wheat grains indicated by means of a percentage index

Route	Distance (Km)	Truck bitrem (kg)	Loss index (%)	Losses (Kg)	Price R$/60Kg	Losses Kg/Km	Losses R$/km	Losses Totals* R$
Ponta Grossa-PR a Porto de Paranaguá-PR	216	38,000	0.1708	64.90	36.17	0.300	0.1808	39.06

**Total Losses = Losses (R$/Km) x Distance*

It is possible to perceive how much is lost when comparing the difference between the percentage indices of losses found and the index of 0.25% practiced today (Table 5). It has been found that when transporting 38,000 kg of wheat grains, for example, it is allowed to lose up to 95 kg of that amount, using the current index which is 0.25%. However, using the index of 0.1708% indicated in this study, the acceptable loss would be approximately 64.90 kg, a value well below that practiced.

Table 5. Comparison between the percentages of losses found for road transport of wheat grains and the index practiced.

Route	Distance (Km)	Truck Bitrem (Kg)	Loss rate used	Loss index indicated
			0.25%*	**0.1708%***
Ponta Grossa-PR a Porto de Paranaguá-PR	216	38,000	95	64.90

** Values expressed in kg.*

What is lost holds great importance in the value of the product to the consumer, since the final price is influenced by the amount of product available. Thus, with demand continuing and with a percentage of grain being lost, the final price of the industrialized product will be more expensive at the consumer's table [25]. In addition to economic aspects, grain losses have a high social significance, as they result in a decrease in the supply of food to the population.

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4. CONCLUSION

Based on the data obtained in the present study, it can be stated that it is possible to adopt, by the carriers, percentage loss indexes lower than 0.25% in the contracts. It is recommended to adopt the percentage of loss of grain in road transport of 0.17% for wheat.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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REFERENCES

1. Barat, J. (2007). Logistics and transportation in the globalization process: opportunities for Brazil (225 p.). São Paulo: UNESP.

2. Janic, M. (2008). An assessment of the performance of the European long intermodal freight trains (LIFTS). Transportation Research Part A, Policy and Practice, 42 (10), 1326-1339. http://dx.doi.org/10.1016/j.tra.2008.06.008.

3. Singh, N., & Malik, P. (2016). Comprehensive analysis on cement and crumbed rubber mixed fly ash in India. International Journal of All Research Education and Scientific Methods, 4 (7), 211-216.

4. Severo Filho, J. (2006). Integrated logistics management: materials, PCP and marketing. Rio de Janeiro: E-papers. 310.

5. Logistics and Supply Chain Institute. (2010). Logistics costs in Brazil. Rio de Janeiro.

6. CONAB - NATIONAL COMPANY OF SUPPLY. Acomp. crop breeding grains, v. 6 Safra 2018/19 - Fourth survey, Brasília, p. 1-118 February 2019. Available at: <https://www.conab.gov.br/info-agro/safras/graos/boletim-da-safra-de-graos>. Accessed on: 27 May. 2019.

7. Silva, M. P. da & Marujo, L. G. Analysis of the intermodal model for the flow of soybean production in central-western Brazil. Journal of Transport Literature, Vol. 6, n. 3, pp. 90-106, Jul. 2012.

8. ASSOCIATION OF SOYBEAN PRODUCERS - APROSOJA. Aprosoja launches booklet to minimize losses, CUIABÁ-MT, 2016.

9. PASQUA, D. D .; LIMA, J. (2004). Time to face challenges. Special Topics. Safra Agency. 2004, p. 03. Available at: <http://www.safras.com.br>. Accessed on May 25, 2019.

10. CARVALHO, D. C .; TONIAL, E .; VACHIA, G. D .; POSTAL, R .; CARVALHO, A. P. Logistic Analysis of Grain Transport Networks in the Brazilian Territory. International

Congress of Administration. 2012. Strategic Management: Entrepreneurship and Sustainability. Available at: <http://www.admpg.com.br/2012/down.php?id=2718&q=1>. Accessed on May 23, 2019.

11. ANES, C. E. R. Effect of transport and storage quality on the cost of soybean in the mission region of Rio Grande do Sul. Dissertation in Agribusiness, interinstitutional modality UFRGS / URI. 2003.

12. SEMPREBOM, P. A. Losses in agricultural transport. XIV Cycle of Policy and Strategy Studies, Londrina. Anais ... 2009.

13. Resolution No 210. Establishes the limits of weight and dimensions for vehicles that transit by land and other measures. Ministry of Cities, National Traffic Council, Brazil, 2006.

14. SANTANA, A.C. Quantitative Methods in Economics: elements and applications. Belém: UFRA, 2003.

15. GUJARATI, D.N. Basic Econometrics. São Paulo: Pearson Education, 2000.

16. ENDERS, W. Applied econometric time series. New York: John Wiley & Sons, 2004.

17. NEVES, Renato Ramirez Viana; PELLEGRINI, Sérgio de Paula; TSILOUFAS, Stergios Pericles; FREIRE, Cesar Monzu; KAMINSKI, Paulo Carlos. Automated wrapping system - a solution for superior body wrapping. Anais ... São Paulo: ABCR, 2011.

18. ARRUDA, L. G. de; DENADAI, M. S. Losses in grain outflow in Brazil. 5th FATEC Scientific and Technological Conference of Botucatu, Annals ... 2016.

19. Bartosik, R., 2010. Challenges and characteristics of the South American grain and oilseed postharvest system. In: 10th International Working Conference on Stored Product Protection, pp. 57-62. http://dx.doi.org/10.5073/jka.2010.425.302, 2010.

20. Danao, Mary-Grace C .; Zandonadi, Rodrigo S .; Gates, Richard S. Development of a grain monitoring probe to measure temperature, relative humidity, carbon dioxide levels and logistical information during handling and transportation of soybeans. Computers and Electronics in Agriculture, v. 119, p. 74-82, 2015.

21. Fernandes, J.L., Widmer, J.A., and Soria, M.H.A. Economic impacts of axle load limits and heavy vehicle configurations on the performance of pavements in Brazil. In: Road Transport Tech., Vol. 4. University of Michigan, Ann Arbor, Mich., Pp. 47-53, 1995.

22. Caixeta-Filho, J.V. The determinants of transport costs in Brazil's agribusiness. Presented at the Latin America / Caribbean and Asia / Pacific Economics and Business Association (LAEBA) Fourth Annual Meeting, Lima, Peru, 2008.

23. Torres, Osmar et al. Impact of the Implantation of the Cost of the Toll in the BR-163 in Relation to the Transport of the State of Mato Grosso. Journal of Economics and Rural Sociology. Brasília, v. 55, n. 3, p. 533-550, set. 2017. Available at: <. Accessed on: 22 May 2019.

24. MATO GROSSENSE INSTITUTE OF AGRICULTURAL ECONOMY (IMEA). Weekly bulletin of the corn No. 240, São Paulo, February 15. 2013. Available at:

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<http://www.imea.com.br/upload/publicacoes/arquivos/R403_2013_02_15_BSMilho.pdf>. Accessed: May 18, 2019.

25. NASCIMENTO, Q .; MARQUES, J. C .; MIRANDA, L. M .; ZAMBRA, E. M. Quantitative losses in the short transport of maize grains (Zea Mays L.) as a function of post-harvest germination in the northern state of Mato Grosso. Navus Journal of Management and Technology. Florianópolis, SC, v.6, no. 1, p. 60-71, Jan / Mar 2016.

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