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Forecasting Corn Storage Capacity in Santos Port Terminal in Brazil
Pronóstico de capacidad de almacenamiento de maíz en la terminal portuaria de Santos en Brasil
Previsão da capacidade de armazenamento de milho no terminal do porto de Santos no Brasil

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Abstract: *Brazil, an important player in the international commodities trade, is currently the third largest exporter of corn, which is one of the main inputs in several food supply chains. In this study, we investigated the capability of the Port of Santos, the major port of Latin America, to deal with the growing demand for Brazilian corn exportation. To do so, we used forecast models to estimate corn exports from both Brazil and the Port of Santos for the 2017–2021 period. Next, we used data from the main grain export terminal of the Port of Santos to determine its storage capacity for accommodating a sufficient flow of corn to meet new export demands via Santos. The results show that corn exports along this route may increase by 115%, which necessitates investment in the port and terminal to avoid logistical bottlenecks*.

Keywords. *Corn Production, Brazil's Corn Export, Agricultural Product, Food Supply Chains.*

Resumen: *Brasil, un actor importante en el comercio internacional de productos básicos, es actualmente el tercer mayor exportador de maíz, que es uno de los principales insumos en varias cadenas de suministro de alimentos. En este estudio, investigamos la capacidad del Puerto de Santos, el principal puerto de América Latina, para hacer frente a la creciente demanda de exportaciones brasileñas de maíz. Para ello, utilizamos modelos de previsión para estimar las exportaciones de maíz desde Brasil y el Puerto de Santos para el período 2017-2021. A continuación, utilizamos datos de la principal terminal de exportación de granos del Puerto de Santos para determinar su capacidad de almacenamiento para acomodar un flujo suficiente de maíz para satisfacer las nuevas demandas de exportación a través de Santos. Los resultados muestran que las exportaciones de maíz a lo largo de esta ruta pueden aumentar en un 115%, lo que requiere inversiones en el puerto y la terminal para evitar cuellos de botella logísticos*

Palabras Clave. *Producción de Maíz, Las Exportaciones Brasileñas de Maíz, Productos Agrícolas, Cadenas de Suministro de Alimentos.*

Resumo*: O Brasil, um importante player no comércio internacional de commodities, é atualmente o terceiro maior exportador de milho, que é um dos principais insumos em várias cadeias de abastecimento de alimentos. Neste estudo, investigamos a capacidade do Porto de Santos, o principal porto da América Latina, de lidar com a crescente demanda pela exportação brasileira de milho. Para isso, usamos modelos de previsão para estimar as exportações de milho do Brasil e do Porto de Santos para o período 2017-2021. Em seguida, utilizámos dados do principal terminal de exportação de grãos do Porto de Santos para determinar a sua capacidade de armazenamento para acomodar um fluxo suficiente de milho para atender às novas demandas de exportação via Santos. Os resultados mostram que as exportações de milho ao longo desta rota podem aumentar em 115%, o que exige investimentos no porto e terminal para evitar gargalos logísticos*

Palavras-chave. *Produção de Milho, Exportações Brasileiras de Milho, Produtos Agrícolas, Cadeias de Abastecimento Alimentar.*

1 Introdução

Corn is one of the most important in the food supply chain. The United Nations has reported that corn was the most widely grown cereal grain in 2016, with a world production of 968 million tons (USDA, 2018). Moreover, corn is used in the United States to produce ethanol, and this production more than doubled from 6.5 billion gallons in 2007 to 13.2 billion gallons in 2012 Chen & Khanna (2018), which directly affects global demand.

In Brazil, corn plays a key role in foreign trade commodities, ranking third in global production, and is the second-most exported product (CONAB, 2017; FIESP, 2017; MDIC, 2017). Despite its economic importance to the country, logistical bottlenecks often occur due to poor transportation infrastructures, limited storage capabilities, and the sharing of logistic systems with soybeans, which directly affect the exportation of corn and its supply to international markets (LOPES et al., 2017).

The global demand for corn by 2020 is expected to reach 138% of that in 1995 (MUSUNDIRE et al., 2018). Brazil's corn production is 67 million tons, behind China's 224 million tons and United States' 345 million tons, of which 21 million tons is designated for international markets (FIESP, 2017; MDIC, 2017; USDA, 2018). Therefore, Brazil has a strategic role in meeting this increasing demand.

Although Brazil's agricultural corn production for national markets has reached levels of excellence, its competitiveness is compromised with respect to the international marketplace. Generally, agricultural commodities are characterized by high volatility, low value-added products, and tight margins. For these reasons, effective logistic systems are essential for ensuring competitiveness and profitability in agribusiness supply chains. One of the critical infrastructures of these systems is the cargo port. In 2016, Brazilian ports moved 998 million tons of goods (ANTAQ, 2016).

Brazil is a coastal country, had its development linked to port infrastructure, and, in recent years, port development has been strongly influenced by institutional and governance changes (GALVÃO et al., 2017). They are divided into two categories, with 37 main ports and 122 secondary ports (MT, 2018). Of the 37 main ports, Santos is the main logistic platform. In 2016, it accounted for 28.5% of the Brazilian trade balance, which exceeded US$ 92 billion in free on board (FOB) value (CODESP, 2017). Although in recent decades the Brazilian port system has made significant improvements that have resulted in greater efficiencies in the flow of commodities Farranha et al. (2015), operational bottlenecks continue to interfere in Brazil's capacity to provide outstanding levels of service. Brazil commodities production areas are located far from the ports, thus, the storage, transport and port infrastructure is an essential factor in the exportation (LIMA et al., 2018)

Among the various logistical issues experienced by the Port of Santos, the most important constraint is the storage area. Historically, the infrastructure for the exportation of soybeans and corn has been shared and is operated by the same companies and transport operators, who coordinate their activities once the soybeans are harvested in Brazil between January and March. Therefore, sharing this infrastructure becomes a logistical challenge to companies who maintain the operation of their facilities throughout the year. However, when trading companies must sell more corn or keep the soybeans in storage to obtain better prices, conflicts arise.

Furthermore, the largest soybean production and the largest producer of corn in the second Brazilian crop is Mato Grosso state that there is an average distance from Port of Santos between 1000 and 2000 km that obligate companies retain a storage area to avoid a stockout (ECKERT et al., 2018). So, if the indications are clear that the demand for corn is increasing and Brazil intends to increase its supply to this market, it becomes necessary to ensure that the country has the capacity to respond to these increased flows.

Our aims in this study were to forecast the future demand for Brazilian corn exports and investigate whether the Port of Santos has the capacity to meet the requirements of these flows, based on its storage capacity and ability to maintain flow to cargo ships. We used secondary data to perform this forecast analysis and evaluated the associated logistical bottlenecks based on data from the main grain terminal of the Port of Santos.

The remainder of the paper is structured as follows. In section we discuss forecast models. Section 3 describes the methodological steps. Results are presented in Section 4. Discussion and conclusions are showed in Section 5.

2 Forecast Models

Forecasting are essential for decision-makers, both at individual level and for the government policies (NALBAN, 2018). Product forecasts, for instance, are a critical input into production, logistics, and marketing decisions (ARVAN et al., 2018). Forecast models are used to predict uncertain future scenarios related to a subject of interest, which, in our case, is the demand for Brazilian corn exportation. The uncertainties are described with the aid of scenarios that represent coherent future pathways based on different sets of assumptions (MAIER et al., 2016).

According to Correa (2010), there are several options with respect to demand forecast methods:

- **Qualitative:** use of subjective and essential data when there is low availability of historical data
- **Time series:** use of historic demand to make predictions
- **Cause:** forecasts that are directly related to certain environmental factors
- **Simulation:** a projection of consumer choices that may also be combined with temporal and causal series methods

To choose the most appropriate technique, researchers must understand the dimensions of each prediction and may choose different methods with respect to specific dimensions. In certain situations, the combined use of several methods can be more effective than using any one method alone. Chopra & Meindl (2015) state that the general procedure in demand forecasting is as follows:

1. Understand the object of the forecast
2. Allow the integration of demand planning and supply chain forecasting
3. Understand the customer segments
4. Identify the major factors influencing the demand forecasts
5. Determine the appropriate forecasting technique
6. Establish performance measures and determine the prediction error

Forecast methods may be classified into two categories Correa (2010) (Table 1): a) quantitative forecasting methods are based on data series and predict future behavior patterns. Quantitative models have been developed and applied to generate and improve forecasts Arvan et al. (2018); and b) qualitative analysis methods involve subjective judgment and intuition.

This subjective method is used for long-term forecasts, as historical data can have little relevance for understanding the future. An analysis using qualitative information can provide insights about both the process of preparing forecasts and the variables that informed that process (STEKLER & SYMINGTON, 2016)

There are no predefined or specific rules for the use of forecasting techniques. Each case must be individually evaluated regarding the projection trends in the short, medium, and long term, as well as the characteristics of each company and its market.

Several works have been using forecast models to study maritime and port issues (LYRIDIS et al., 2004; CHEN et al., 2012; LEE et al., 2017; MUNIM & SCHRAMM, 2017; FARHAN & ONG, 2018; RASHED et al., 2018; ZENG et al., 2016). Lyridis at al. (2004) attempts to uncover the benefits of using Artificial Neural Networks in forecasting VLCC spot freight rates.

Chen et al. (2012) in the same sense makes a forecast of spot rates at main routes for three types of dry bulk vessels. Lee et al. (2017) provided a practical method for forecasting potential container cargo volume on a container transport network by combining port choice and an autoregressive integrated moving average model. Munim & Schramm (2017) introduced a state-of-the-art volatility forecasting method for container shipping freight rates. Farham & Ong (2018) as Lee et al. (2017) use seasonal autoregressive integrated moving average models to provide reliable seasonal forecasts of container throughput at a given container port. Zeng et al. (2016) created a method based on empirical mode decomposition and artificial neural networks to establish the Baltic Dry Index forecasting. Finally, Rashed et al. (2018) develop an instrument which assists the ports' infrastructure investment-decision-making based on an annual time series (1995–2017) for the total container throughput measured in twenty-foot equivalent units for the main ports within the Hamburg-Le Havre (H-LH).

Most statistical prediction methods identify parameters for the analysis of historical data in time series. These parameters appear in the data sets as quantitative variables that influenced events that occurred in the past and have been observed over time (BRUNI, 2011; DOANE, 2014).

The objective in time series model analyses is to predict future behaviors based on previous data, which can be expressed as follows (Equation 1):

$$Y_{t+1} = f\,(Y_1, Y_{t-1}, Y_{t-2}, \ldots) \qquad (1)$$

The predicted value Y is obtained by the analysis of historical data.

→ y is the value of the time series for the period t;
→ t is the index that identifies the period ($t = 1, 2, \ldots, n$);
→ n is the number of periods;
→ $y_1, y_2, y_3, \ldots, y_n$ is a set of data for analysis.

Table 1: Predictive information processing methods. Source: Correa (2010)

Qualitative		**Quantitative**
Intrinsic	**Extrinsic**	
Moving averages	Simple regression	Delphi methods
Exponential smoothing	Multiple regression	Jury of executives
Projection of trends		Sales forces
Decomposition		Market research
		Historical Analogy

When evaluating the relationship between variables over a period of time, a function is used to characterize the behavior of a time series. To determine the function that expresses the relationship between time series variables, regression analysis is used. Various regression models can be adopted to represent the behavior of a time series and to estimate future values, which can be useful for strategic decision-making. The main models Chagas et al. (2010) Costa Neto (2002) Escolano & Espin (2016) used in this work are as follows:

- **Linear:** simple model, where the function is represented by a line in the Cartesian plane that expresses the relationship between two variables.
- **Exponential:** a weighted average that attributes larger weights to the latest observations; shows steady growth. Useful in situations in which the dependent variable varies at a constant rate.
- **Logarithmic:** a reverse exponential function.
- **Polynomial:** a polynomial regression function in which the relationship between variables is expressed as a parabola in the Cartesian plane.
- **Power:** involves constant elasticity, useful for demonstrating a learning curve.

3 Methodology

Our method was split into two steps: (1) First, we carefully examined the predictions of forecast models regarding the volume of corn exported from Brazil and the Port of Santos in the 2017–2021 period. (2) Next, we investigated the ability of the major grain terminal of the Port of Santos to deal with an increasing volume of corn exports, based on its current operations.

3.1 Data Collection

To study the potential for forecasting corn export demand for the 2017–2021 period, we conducted exploratory and quantitative research (CERVO et al., 2006). In a quantitative study, the researcher will need to identity the population; people or objects McLiesh et al. (2018), in this case, we obtain the volume of corn exported from Brazil and specifically from the Port of Santos using the database provided by the Ministry of Industry and Foreign Trade of Brazil (MDIC, 2017).

We then compared these figures with the capacity of the grain terminal at the Port of Santos, which we obtained directly from documents and an interview with the port manager.

3.2 Grain Terminal

The grain terminal is a logistic platform located on the left bank of the Port of Santos. It has an area of more than 300,000 m² where three distinct payloads are handled: soybeans, soybean meal, and corn. The Port's infrastructure comprises the road access, gates, rail hoppers, facilities for unloading of trucks, pier for mooring ships, conveyor belt and two carriers, and two warehouses with static capacities of 108,000 (t) each. Roughly 80% of the cargo that arrives at this terminal is transported by train and 20% by truck, usually from the state of Mato Grosso.

3.3 Data Analysis

Using Microsoft Excel 16 software, we organized the data obtained from Brazil's Ministry of Industry and Foreign Trade in tables. We performed forecasting simulations using this software, based on two variables: volume "y" and period "x." We determined the volume of Brazil's corn exports based on those of the past 16 years (2001–2016) (Table 2). We chose this period because when we conducted this study, the last crop year result available was 2016. We conducted this research in the second half of 2017. To evaluate the predictive capability of the models, we determined their average absolute errors and mean square errors (ESCOLANO & ESPIN, 2016). In addition, we calculated the average percentages and average absolute percentages, which we extracted from the differences between the predicted values for each period and the original demand values.

Having established our forecasting method and predicted the volume of Brazilian corn exports, we performed a comparative study of the Brazilian forecast, the Port of Santos forecast, and the capacity of the grains terminal to meet new operational demand.

Table 2: Function Models

Model	Equation
Exponential	$y = 2.067.189,661e^{0,162x}$
Linear	$y = 1.653.787,64x - 2.503.562,23$
Logarithmic	$y = 8.197.025,22\ln(x) - 4.159.992,95$
Polynomial	$y = 125.217,47x^2 - 474.909,39x + 3.882.528,87$
Power	$y = 1.720.347,75x^{0,82}$

x = periods, y = prediction.

4 Results

4.1 Regression Analysis

Figure 1 shows the results of our regression analysis and the forecasting trend lines. The predictions were made by the calculation of the above classic functions (Table 2), based on the volume of exports from Brazil over the last 16 years (2001–2016).

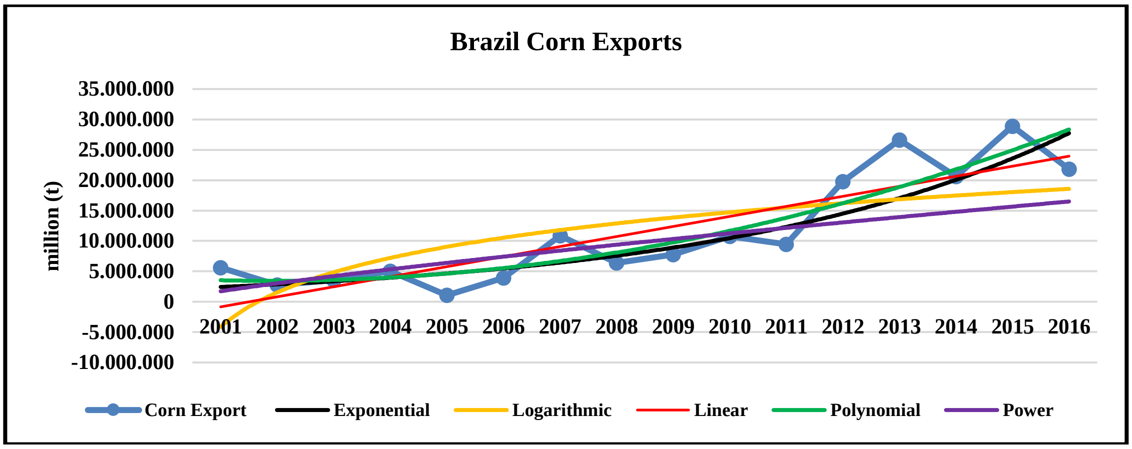

Figure 1: Brazil Corn Annual Export (2001–2016)

As we can see in the historical series in Figure 1, the corn exports in 2001 reached 5.6 million tons, followed by a significant drop in 2005, with just 1.6 million tons exported. By 2007, that total had reached 10.8 million tons and from the year 2011, the trend line has shown exponential growth.

Despite some fluctuations in 2014 and 2016, in 2013 the volume of corn exported was 26.6 million tons; in 2014, it was 20.6 million tons, and it reached 28.8 million and 21.8 million tons in 2015 and 2016, respectively. We also note that national corn production has registered a growth of 246% (CONAB, 2017).

We applied the same methodology to export volumes from the Port of Santos (Figure 2).

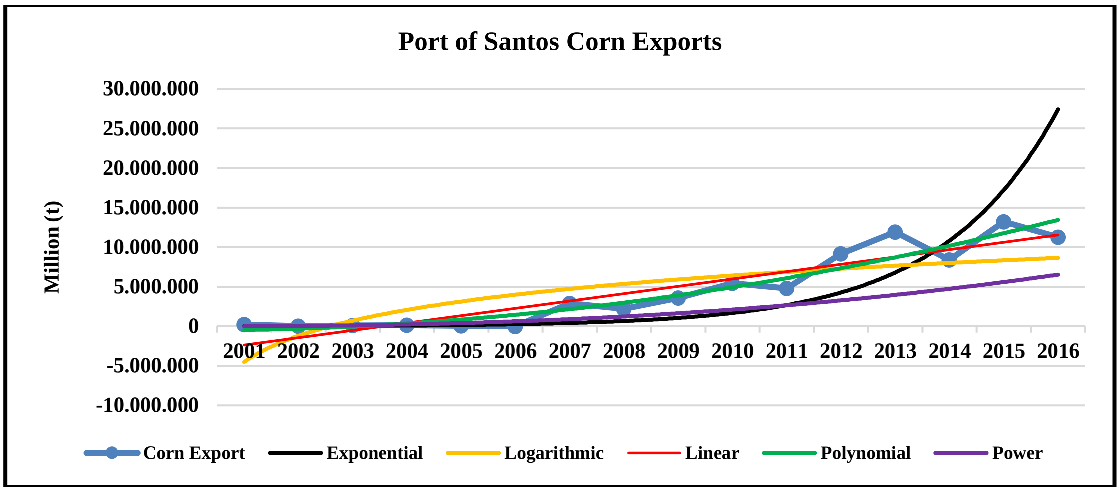

Figure 2: Santos Corn Annual Export (2001–2016)

As in the above historical series analysis of the grain exports by Brazil (Figure 1), we also see a growth trend in exports by the Port of Santos complex (Figure. 2).

There has been significant growth since 2007, when the port exported 2.8 million tons, which represents an increase of nearly 1000% from that of 2001, when just 230,000 tons were exported. Another milestone was reached in 2013, when the Port of Santos exported 13.2 million tons. This means that more than 50% of the corn exported by Brazil was moved by the Port of Santos.

4.2 Fitting the Forecasting Models

We then determined the measurement errors of different models with respect to the time series. After calculating the top five average errors for each model, we ranked the average errors based on the Likert scale, where A= 5, B = 4, C = 3, D = 2, and E = 1 (Table 3).

Table 3: Average Error Calculation

Model	**AAE**	**MSE**	**APE**	**AAPE**	**Ranking**	**Score**
Exponential	2,890,470.0 (A)	15,005,085,241,874.3 (A)	-16.5 (B)	42.8 (B)	1º	18
Linear	3,607,661.0 (C)	17,940,285,569,050.5 (C)	-28.3 (C)	67.7 (D)	2º	11
Logarithmic	5,195,693.6 (E)	36,829,762,682,418.6 (E)	-59.4 (E)	102.0 (E)	4º	4
Polynomial	2,820,861.2 (B)	12,342,734,260,983.8 (B)	-24.5 (A)	44.1(A)	1º	18
Power	4,313,423.7 (D)	33,069,689,679,034.0 (D)	-29.3 (D)	63.4 (C)	3º	9

AAE **(average absolute error),** MSE **(mean squared error),** APE **(average percentage error),** AAPE **(average absolute percentage error**

As we can see in Table 3, the two best models, which scored 18 points each, were the exponential and polynomial models.

Using the same methodology, we calculated the lowest average errors for the Port of Santos (Table 4). In this case, we identified one best model the polynomial model.

Table 4: Average Error Calculation

Model	AAE	MSE	APE	AAPE	Ranking	Score
Exponential	2,852,968.1 (E)	22,931,638,495,397.0 (E)	-12.8 (A)	12.9 (A)	2º	12
Linear	1,467,169.4 (B)	2,935,517,512,914.5 (B)	-110.9(D)	111.7 (D)	2º	12
Logarithmic	2,497,224.9 (C)	8,113,755,512,434.8 (C)	-195.8 (E)	196.6 (E)	3º	8
Polynomial	1,105,017.8 (A)	1,881,109,201,258.9 (A)	-71.2 (C)	71.4 (C)	1º	16
Power	2,596,564.1 (D)	13,548,289,679,424.9 (D)	-30.4 (B)	30.5 (B)	2º	12

AAE (average absolute error), **MSE** (mean squared error), **APE** (average percentage error), **AAPE** (average absolute percentage error).

4.2 Estimating Volume of Corn Exports

Having determined that the better models for predicting Brazil’s corn exports were the exponential and polynomial models, we could then use the Microsoft Excel 16 software to predict the export values. Table 5 shows the predictions for corn exports by Brazil for the 2017–2021 period. Based on our calculations of the error (Table 4), we conclude that the exponential and polynomial models yield the best predictions.

Table 5: Estimated Forecast

Predicted values (Tons)						
Model	Ranking	2017	2018	2019	2020	2021
Exponential	1º	32,631,890	38,382,055	45,145,474	53,100,696	62,457,732
Polynomial	1º	31,996,918	35,904,620	40,062,757	44,471,329	49,130,336

Table 6 shows the forecasts for corn exports from the Port of Santos for the 2017–2021 period. We can see that the best prediction model is the polynomial, which is consistent with the application of statistical methods for mitigating errors (Table 4).

Table 6. Estimated Forecast

Predicted values (Tons)						
Model	Ranking	2017	2018	2019	2020	2021
Polynomial	1º	15,245,662	17,151,686	19,166,403	21,289,813	23,521,915

5 Discussion

Our results show that the volume of corn exported from the Port of Santos should increase by roughly 55% by 2021. Considering this forecast, here, we discuss the logistical bottlenecks that will be driven by the increased demand of the international market.

The flow of corn through the Port of Santos depends on the services of its grains terminal. Currently, the port has five terminals that handle corn and soybean grains. Here, we refer to the main terminal as Terminal A, which is a logistic platform located on the left bank of the Port of Santos in the city of Guaruja. This terminal covers an area of more than 300,000 m² and handles three distinct payloads: soybeans, soybean meal, and corn.

The terminal infrastructure comprises an access road and gates; rail hoppers; and facilities for unloading trucks, a pier for mooring ships, a conveyor belt and two carriers, and warehouses with astatic capacity of 108,000 (t) each. Corn represents 75% of the terminal’s total required static capacity162,000 (t) as shown in Table 7.

Table 7: Terminal corn storage capacity

Static capacity	Storage demand (3/4)	Monthly handling (4)	Peak demand (Jul-Nov)	Dynamic capacity (year)	Dynamic capacity avalaible (year)
216,000 (t)	162,000 (t)	648,000 (t)	5 months	3,240 million (t)	4.050 million (t)

As we can see in Table 7, around three quarters of the static capacity (162,000) is dedicated to corn flow. Annually, the terminal grain movement reaches 3.2 million (t) a year. However, the Terminal A warehouses have the dynamic capacity to store 4 million (t).

Understanding the importance of this terminal, we compared the Port of Santos and Brazil volume exports from 2007 to 2016, as shown in Figure 3

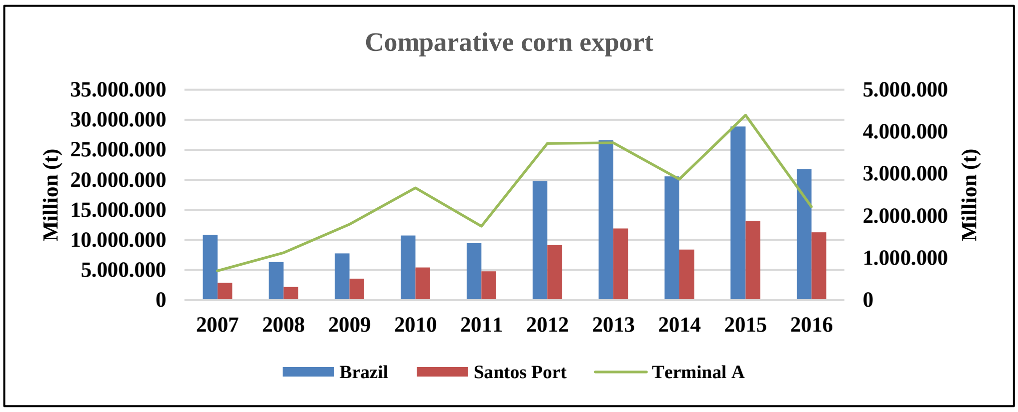

Figure 3: Comparative corn export Brazil, Santos and Terminal A. Source: Adapted MDIC (2017)

Note that in 2007, Terminal A recorded a movement of 696,000 (t) of grain, which represents about 24% of all movement by the Port of Santos. In addition, the Port of Santos closed the same year having handled 2.8 million (t), which represents 26% of the total volume exported by Brazil.

Another important aspect in Figure 3 occurred in 2016, where we can see that 52% of all Brazilian corn exported was moved through the Port of Santos. Of this sum, 11.2 million (t) was handled at Terminal A, which represents about 20% of the total corn volume, or approximately 2.2 million (t).

Considering the forecast period for Terminal A, from 2017 to 2021, we considered the historical average for the last nine years of corn movement and compared these figures with those for the Port of Santos, the results of which are shown in Table 8.

Table 8: Corn demand forecast in millions (t)

Polynomial Model	2017	2018	2019	2020	2021
Port of Santos	15,245,662	17,151,686	19,166,403	21,289,813	23,521,915
Terminal A	5,640,894	6,346,123	7,091,569	7,877,230	8,703,108

As we can see in the table, Terminal A will be responsible for 37% of the corn volume to be moved through the Port of Santos.

Using the polynomial model, which has the best predictive evaluation function with the least error (Table 8), estimates of demand for Terminal A will increase by 16%. Thus, it is possible to project a deficit of storage capacity in Terminal A.

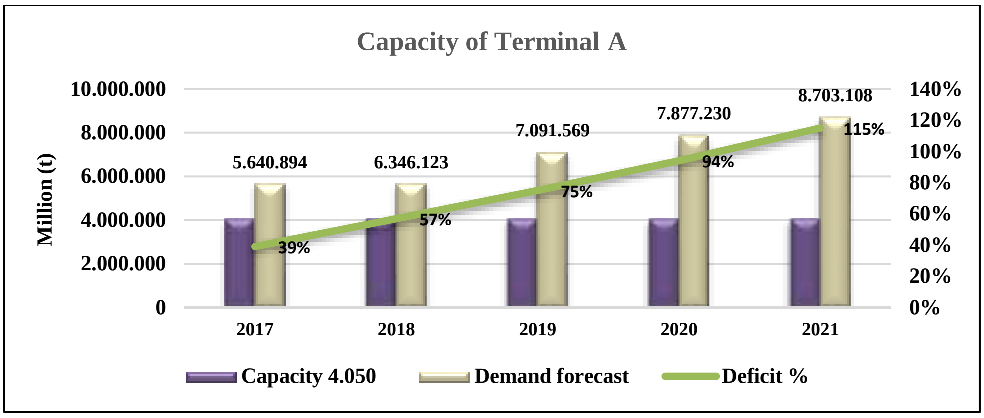

Figure 4: Operational Capacity of Terminal A

Although Terminal A is responsible for 37% of all grain movement through the Port of Santos (Table 8), the dynamic capacity for corn storage remains about 4 million (t), Table 7. So, we can conclude that there is a deficit in the storage capacity of Terminal A, Figure 4.

Our forecast shows that in 2017, more than 1.5 million (t) of grain will occupy the terminal, which represents about 39% of the operational capacity of the terminal storage. Following this trend, in 2021, with a demand for corn exports of approximately 8.7 million (t), the required storage occupancy of Terminal A will be 115% above its capacity.

As such, the corn operations in Terminal A will impact the movement of other goods (soybeans and soybean meal) and create bottlenecks that may affect the logistical service level of the terminal. Furthermore, the creation of bottlenecks at the Port of Santos will affect the competitiveness of Brazil's grain production.

6 Conclusions

Brazil is experiencing increases in its production and external demand for corn. In this paper, we estimated the corn exports for the 2017–2021 period from Brazil, the Port of Santos, and the main Santos grain terminal.

The results indicate that in 2021, exports of Brazilian corn will total somewhere in the range of 49 to 62 million tons. The Port of Santos will be able to handle 37% to 47% of this total, depending on the estimations. Accordingly, Terminal A will move 37% of the corn volume through the Port of Santos, which is 16% higher than its current volume of 24%.

Given this forecast, we can conclude that the volume of corn to be exported will create a bottleneck at the Port of Santos. The study results shown an initial 39% deficit in the first year (2017), followed by 57%, 75%, 94%, and 115% in subsequent years (2018, 2019, 2020, 2021, respectively). Therefore, investments are necessary to facilitate the increased movement of grains.

The limitations of this study are the errors of the forecasting models. However, these errors do not invalidate the research outcome, as estimation error is an inherent aspect of any prediction model. These models have a vital role in creating future scenarios to help organizations predict their requirements and respond effectively to future demand.

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References

ANTAQ (2016) **Anuário Estatístico Aquaviário 2016.** Brasilia: Agência Nacional de Transporte Aquaviários.

ARVAN, M.; FAHIMNIA, B.; REISI, M.; SIEMSEN, E. (2018) Integrating human judgement into quantitative forecasting methods: A review. **Omega,** v. 86, p. 237-252.

BRUNI, A.L. (2011) **Estatística aplicada à gestão empresarial.** São Paulo: Atlas.

CERVO, A.L.; BERVIAN, P.A.; SILVA, R. DA (2006) **Metodologia Científica.** São Paulo: Pearson.

CHAGAS, E.S.; RUSSO, S.L.; SIMON, V.H. (2010) Geração de Perfil Sônico Sintético em Poços de Petróleo Através dos Modelos de Regressão Não Lineares Usando a Profundidade como Variável Regressora. **Sci. Plena**, v.6, p. 1–21.

CHEN, S.; MEERSMAN, H.; VOORDE, E. van de (2012) Forecasting spot rates at main routes in the dry bulk market. **Marit. Econ. Logist.**, v. 14, p. 498–537. https://doi.org/10.1057/mel.2012.18

CHEN, X.; KHANNA, M. (2018) Effect of corn ethanol production on Conservation Reserve Program acres in the US. **Appl. Energy** v. 225, p. 124–134. https://doi.org/10.1016/j.apenergy.2018.04.104

CHOPRA, S.; MEINDL, P. (2015) **Supply Chain Management:** Strategy, Planning, and Operation. Boston: Prentice Hall.

CODESP (2017) **Análise do Movimento Físico do Porto de Santos.** Santos: Codesp.

CONAB (2017) **Portal de informações agropecuárias.** Available: https://portaldeinformacoes.conab.gov.br/index.php/safras/safra-serie-historica. Acess: 29 August, 2018.

CORREA, H.L. (2010) **Gestão de redes de suprimentos:** Integrando cadeias de suprimentos no mundo globalizado. São Paulo: Atlas.

COSTA NETO, P.L. DE O. (2002) **Estatística.** São Paulo: Blucher.

FIESP (2017) **Balança Comercial Brasileira do Agronegócio**: Consolidado 2016. São Paulo: FIESP.

DOANE, D.P. (2014) **Estatística aplicada à administração e economia.** São Paulo: AMGH.

ECKERT, C.T.; FRIGO, E.P.; ALBRECHT, L.P.; ALBRECHT, A.J.P.; CHRIST, D., SANTOS, W.G.; BERKEMBROCK, E.; EGEWARTH, V.A. (2018). Maize ethanol production in Brazil: Characteristics and perspectives. **Renew. Sustain. Energy Rev.**, v. 82, p. 3907–3912.

ESCOLANO, N.R.; ESPIN, J.J.L. (2016) **Econometría:** Series temporales y modelos de ecuaciones simultáneas. Alacant: Editorial UMH.

FARHAN, J.; ONG, G.P. (2018) Forecasting seasonal container throughput at international ports using SARIMA models. **Marit. Econ. Logist.**, v. 20, p. 131–148.

FARRANHA, A.C.; FREZZA, C. DA S.; BARBOSA, F. DE O. (2015) Nova Lei dos Portos: Desafios Jurídicos e Perspectivas de Investimentos. **Rev. Direito GV**, v. 11, p. 89–116.

GALVÃO, C.B.; ROBLES, L.T.; GUERISE, L.C. (2017) 20 years of port reform in Brazil: Insights into the reform process. **Res. Transp. Bus. Manag.**, Revisiting Port Governance and Port Reform: A Multi-country Examination, v. 22, p. 153–160.

LEE, S.-Y.; LIM, H.; KIM, H.-J. (2017) Forecasting container port volume: implications for dredging. **Marit.**

Econ. Logist., v. 19, p. 296–314.

LIMA, D.P.; Fioriolli, J.C.; Padula, A.D.; Pumi, G. (2018) The impact of Chinese imports of soybean on port infrastructure in Brazil: A study based on the concept of the “Bullwhip Effect.” **J. Commod. Mark**., v. 9, p. 55–76.

LOPES, H. DOS S.; LIMA, R. DA S.; LEAL, F.; NELSON, A. DE C. (2017) Scenario analysis of Brazilian soybean exports via discrete event simulation applied to soybean transportation: The case of Mato Grosso State. **Res. Transp. Bus. Manag.**, New developments in the Global Transport of Commodity Products, v. 25, p. 66–75.

LYRIDIS, D.V.; ZACHARIOUDAKIS, P.; MITROU, P.; MYLONAS, A. (2004) Forecasting Tanker Market Using Artificial Neural Networks. **Marit. Econ. Logist.**, v. 6, p. 93–108.

MAIER, H.R.; GUILLAUME, J.H.A.; VAN DELDEN, H.; RIDDELL, G.A.; HAASNOOT, M.; KWAKKEL, J.H. (2016) An uncertain future, deep uncertainty, scenarios, robustness and adaptation: How do they fit together? **Environ. Model. Softw.**, v. 81, p. 154–164.

MCLIESH, P.; RASMUSSEN, P.; SCHULTZ, T. (2018) Quantitative research in orthopaedic and trauma nursing. **Int. J. Orthop. Trauma Nurs.**, v. 30, p. 39–43.

MDIC (2017) **Séries Históricas**: Balança Comercial Brasileira 1989-2017. Brasilia: MDIC.

MT (2018) **Sistema Portuário Nacional:** Secretaria Nacional de Portos. Available: http://www.portosdobrasil.gov.br/assuntos-1/sistema-portuario-nacional. Acess: 29th August, 2018.

MDIC (2017) **Séries Históricas**. Available: http://www.mdic.gov.br/comercio-exterior/estatisticas-de-comercio-exterior/series-historicas. Acess: 08th December, 2017.

MUNIM, Z.H.; SCHRAMM, H. J. (2017) Forecasting container shipping freight rates for the Far East – Northern Europe trade lane. **Marit. Econ. Logist.**, v. 19, p. 106–125.

MUSUNDIRE, L.; DARI, S.; MACROBERTS, J.; YANG, H.S.; DERERA, J.; TONGOONA, P. (2018) Effect of Male Planting Date and Female Plant Population on Hybrid Maize Yield and Evaluation of Use of Hybrid-Maize Simulation Model for Grain Yield Estimation in Hybrid Maize Seed Production. **J. Agric. Sci.**, v. 10, p. 333–343.

NALBAN, V. (2018) Forecasting with DSGE models: What frictions are important? **Econ. Model.**, v. 68, p. 190–204.

RASHED, Y.; MEERSMAN, H.; SYS, C.; VAN DE VOORDE, E.; VANELSLANDER, T. (2018) A combined approach to forecast container throughput demand: Scenarios for the Hamburg-Le Havre range of ports. **Transp. Res. Part Policy Pract.**, v. 117, p. 127–141.

STEKLER, H.; SYMINGTON, H. (2016) Evaluating qualitative forecasts: The FOMC minutes, 2006–2010. **Int. J. Forecast.,** v. 32, p. 559–570.

USDA (2018) **World Agricultural Supply and Demand Estimates**. Available: https://www.usda.gov/oce/commodity/wasde/. Acess: 28th August 2018.

ZENG, Q.; QU, C.; NG, A.K.Y.; ZHAO, X. (2016) A new approach for Baltic Dry Index forecasting based on empirical mode decomposition and neural networks. **Marit. Econ. Logist.**, v. 18, p. 192–210.