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Evolution of sugar exports in two centuries

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ABSTRACT

The research showed the trajectory of Brazilian exports and sugar prices between 1821 and 2020 (two centuries). The hypothesis of the research was that exporters' price forecasting errors affected their export forecasting errors in the period evaluated. The data were obtained from the Ministry of Development, Industry and Trade (MIDIC). Sugar prices were translated to 2020 Brazilian currency values (R$) and then to US dollars using the 2020 (R$/USD) average conversion rate. Autoregressive integrated moving average (ARIMA) models were used to forecast sugar exports and prices over the entire period. Geometric growth rates of exports and prices were estimated for each quartile using trend evaluation models. Dummy variables were used to test whether there were differences between the elasticities measuring the forecast errors of exports as a function of the forecast errors of sugar prices in each quartile. The estimated models proved to be parsimonious and robust from a statistical point of view. The hypotheses that prices and export quantities expanded at different rates in the four quartiles were confirmed and the estimated elasticities were shown to be statistically different suggesting that export forecasting errors are likely to be related to sugar price forecasts.

Contribution/Originality: The originality of the research lies in quantifying the responses that price forecast errors have affected the forecasts of exported quantities of sugar as well as showing how these variables have evolved in the historical periods of the trajectory of exports of Brazilian commodities.

1. INTRODUCTION

The first sugarcane seedlings were introduced to Brazil from the Madeira Islands around 1500 marking the beginning of sugarcane's significant economic contribution to Brazil (Furtado, 2005). Since the colonial era, the sugar-alcohol industry has played a significant historical, economic and social role in Brazil and has produced significant advantages including the development of industrial parks, money and jobs (Furtado, 2005; Prado Junior, 1978). In general, sugarcane production significantly affects the country's economy during each harvest. Sugar is a significant export for the nation and ethanol is a clean fuel extracted from sugar cane.

According to Graziano Neto (1982), when sugar production increased in the Serto, it influenced nearby industries such as livestock farming (which provided meat, transportation, energy for the mills, tallow and fuel). The production grew in the 17th century to include the states of Pará, Amazônia, Ceará, Piau, and Rio Grande do Norte. The plantation's objectives included the production of sugar for export as well as the occupation and colonization of Brazilian territory.

Brazil became a net exporter of sugar cane in the 18th century as a result of the development of the crop. In the last decade of that period, sugar prices in foreign markets experienced a considerable reduction which lasted until the beginning of the next century, when the Brazilian product faced strong competition in the European market from products coming from the English, French, Spanish and Dutch colonies as well as from other Latin American countries (Lemos, 1983).

Early in the nineteenth century, the redistribution warehouse in Lisbon served as the primary trading centre for Brazilian sugar exports. Small quantities of sugar, molasses and brandy were sold in the United States of America (Fernandes & Prado Junior, 2005).

In the early nineteenth century two facts occurred that contributed to the expansion of the sugar industry in Brazil. The first was the introduction of a new variety of sugar cane that substituted the sweet and creole varieties that had been cultivated since the time of the discovery (Dé Carli, 1936). The second fact was the increase in the external prices of sugar caused by the reduction of international stocks, attributed both to the disorganization of production in the Spanish and English colonies and to the Napoleonic wars.

The Brazilian exports of sugar grew from 1837 to 1846 in Alagoas, Bahia, Paraíba and Pernambuco (Dé Carli, 1936; Lemos, 1983). The expansion of industrial sugar production was stimulated by the concession of credit for the creation of central mills. The measure of this incentive can be evaluated by the law promulgated by the Imperial Government in November 1885 which reserved the amount of thirty thousand contos de réis for the support of the industry and granted the guarantee of subsidized interest to investments for the installation of new mills (Dé Carli, 1936; Prado Junior, 1978; Simonsen, 2005).

According to EMBAPA (2020), the adaptation of sugar cane to Brazilian climatic conditions was good. The crop can be produced for an average of four to six years is perennial and is relatively simple to plant and maintain. Sugarcane requires high temperatures, a high solar radiation index and a lot of water which is the primary ingredient in the juice that will be used to extract sugar and alcohol. Major changes have occurred in sugar cane production in Brazil throughout the years including the establishment of the National Alcohol Programme Proalcool in the 1970s and an increase in production capacity. There was an increase in production as a response to the increase in production capacity from the mid- 1970s to the end of the 1980s. The growth in production was focused mostly on the international market following the Real Plan's implementation and the stabilisation of the economy (Cortez, 2016).

Brazil is considered the world's largest producer of sugarcane followed by India and China (CONAB, 2021). Data from the 2021 harvest show that the country was responsible for the production of 654.5 million tons of sugarcane. An increase of 1.8% in relation to 2020, 45% went to sugar production and 55% to ethanol production. The Southeast region is the largest producer in the country responsible for 65% of all production in 2020. São Paulo is the largest producer accounting for 54.1% of te production in the 2020-21 harvest and being responsible for the production of 48.4% of ethanol (14.3 billion liters) and 63.2% of sugar (26.0 million tons).

According to IBGE (2017), sugarcane production is mostly present in the Southeast region of the country (92%) while the North/Northeast regions produce only 8% of all production. This difference is related to the climatic disadvantages of these regions, soil and relief (IBGE, 2017).

This research seeks to describe the trajectory of sugar exports and prices from 1821-2020, (the year that the first official records of these variables are available). Therefore, 200 years of evaluation of this culture has a very relevant role in the economic formation of Brazil (Fernandes & Prado Junior, 2005).

To do this description, we chose to divide the historical series of two hundred (200) years into four series of 50 years that will be called quartiles from now on, considering that the 200-year series were divided into smaller series of 50 years which represent a quarter of the entire period. In each of these periods, there were historical, environmental and natural events that must have impacted exports and prices of this commodity which is one of the most important to the Brazilian economy.

In the first quartile, between 1821 and 1970, the political regime in Brazil was a monarchy and a large part of the workforce employed in all activities including sugar cane cultivation and sugar production were slaves. At the beginning of this period, Brazil was dominant in the production and export of this commodity (Dé Carli, 1936; Furtado, 2005).

In the following quarter (1871 - 1920) there was a political change in Brazil which ceased to be a monarchy and became a republic in November 1889. In 1888, the slaves were freed and the first great world conflict occurred (from 1914 to 1918) that impacted the production and exports of sugar (Furtado, 1883; Pereira, Alves, Alves, & Meireles, 2014).

The third quartile starts in 1921 and ends in 1970. In this period, the 1929 crisis had a great impact on the world economy especially the American economy. It also happened during the Second World War between 1939 and 1945 and in 1947 began the "Cold War" which was mainly ideological and put on one side the Western economies led by the United States of America and on the other side the Eastern European economies led by the Union of Soviet Socialist Republics (Romer, 1988).

The fourth quartile begins in 1971 practically starting with a crisis that would directly affect the sugar market. In 1973, a few oil exporting countries cartelized within the Organization of Petroleum Exporting Countries (OPEC) reducing the supply of this commodity and as a result raising its prices. In this period, the country was much more dependent on oil imports. The National Alcohol Program was created in November 1975 as a joint initiative of the automobile industry. The objective was to use sugar cane production for the production of alcohol. In fact, the sugar cane production was transferred to alcohol production (Cortez, 2016; Galveas, 1985; Modiano & Lopes, 1981).

This was a time of intense political turbulence when the first civilian administration succeeded the military which had seized control in 1964. In this period, the automobile industry experienced great advances in the evolution of fuel from sugar cane (Galveas, 1985; Modiano & Lopes, 1981).

There were differences in how Brazilian sugar exporters formed assumptions about the costs and demand for this commodity. Demand and prices were impacted by these historical facts and must have caused errors in exporters' forecasts.

Sugar's price is influenced by various factors that are worth discussing such as sugar production in competing countries. It is significant that developed countries that grow sugar beetroot have influence on how much sugar is priced (Ferreira, Teixeira, & Souza, 2009).

It is well known that exchange rates fluctuated during the 200-year period studied with a considerable part of that time being set as a result of governmental controls that were frequently political in nature. Instabilities in input pricing are caused by these variables. These elements may have contributed to errors in the formation of sugar price expectations which led to errors in the export forecasts. This research seeks to answer the following questions based on these scenarios from almost two centuries: 1) Do the forecast errors of sugar prices affect the forecast errors of its exports differently in the four periods of 50 years in which the series studied were divided? 2) How have exports and observed prices of sugar evolved over these four periods?

The objectives of the study are as follows: a) to estimate forecast models of sugar exports and prices from 1821 to 2020; b) to assess whether price forecast errors influence Brazilian sugar exports in the four quarters of the century in which this study was classified; c) to estimate the annual growth rates of sugar prices and exports in each of these periods.

2. METHODOLOGY

The data used in the research was collected from the DECEX website of the Ministry of Development Industry and Commerce (MIDIC, 2022). According to the Brazilian Central Bank, in this period, there were nine (9) different types of currencies in Brazil (BACEN, 2007).

The variables used in the research were: Brazil's sugar exports and prices were examined between 1821 and 2020. All values were updated to Brazilian reais of 2020 using the General Price Index, Domestic Availability of the Getúlio Vargas Foundation. Then, the entire price series has been converted into 2020 US dollars using the average exchange rate.

The entire series (1821-2020) is used to achieve the first objective of build the forecast models of exports and sugar prices. We divided the 200 years of observation (1821-2020) into four periods called quartiles in order to achieve the study goals. These time periods are long enough to capture changes in the trajectories of exported quantities and sugar prices. Additionally, it is assumed that the behaviours assessed in this research varied across the quartiles.

2.1. Theoretical Framework

The consider time series is represented by the random variable Y_t. Its predicted value (Y_P) will differ from its observed value (Yt) due to random factors (ξt) that occur along its trajectory. This information can be summarized by Equation 1. In this research, the values of Y_P are estimated using the Autoregressive Integrated Moving Average (ARIMA) model developed by Box and Jenkins (1976).

$$Y_t - Y_P = \xi_t \qquad (1)$$

2.2. A Brief Overview of the ARIMA Model as it Applies to this Study

The series must be stationary or move randomly around a constant mean over time with homoscedastic and non-autoregressive residuals in order to use the ARIMA model to make forecasts (Box & Jenkins, 1976; Gujarati & Porter, 2011; Wooldridge, 2015).

Initially, a visual examination of the graph representing the trajectory is carried out to determine whether the Yt series is stationary. The autocorrelation function is evaluated. If it stabilizes with the first lag around the null value, one can be sure that the series is stationary.

The unit root test is carried out to definitively verify if the series is stationary. Several tests are applied to determine the series integration order. If the integrated series is of order zero, no modification will be necessary to apply the regression. However, if the null hypothesis is rejected, differentiation should be performed in order to obtain the stationarity process given the criterion and the number of lags. In general, one needs no more than three differentiations to turn a non-stationary series into a stationary one (Enders, 2009).

There are different ways to do the unit root (UR) test. Some of them are the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests. Since the series has a unit root and is not stationary, the null hypothesis in the majority of tests is as follows: H_0 : Yt has a unit root (is not stationary); H_1: Yt has no unit root (is stationary) . It is worth noting that in the KPSS test, the lack of a unit root represents the null hypothesis.

Unit Root Test (RU): ADF Approach

Suppose there is a time series Yt and you want to estimate the following autoregressive (AR) model for this series:

$$Y_t = \rho Y_{t-1} + \epsilon_t \qquad (2)$$

In Equation 2, the random term ϵ_t is white noise by hypothesis. The following limitation must be followed for the series Yt to be stationary: $|\rho| < 1$. Thus, the hypotheses of the test to confirm whether Y_t is stationary convert to: H_0: $\rho = 1$; Y_t is not stationary; H_1: $|\rho| < 1$, Y_t is stationary.

Equation 2 is transformed to obtain the outcomes shown in Equation 3.

$$Y_t - Y_{t-1} = \Delta Y_t = (\rho - 1)Y_{t-1} + \varepsilon_t = \pi Y_{t-1} + \varepsilon_t ; \quad \pi = (\rho - 1) \quad (3)$$

And one tests the following hypothesis: $H_0 : \pi = 0$, Y_t is not stationary. H_1: $\pi < 0$, Y_t is stationary.In practice, it is not always possible to use just an AR(1) to identify the existence of a unit root. Some series have a more complex structure and a simple AR(1) is not enough to capture it. Therefore, according to Dickey-Fuller, 3 approaches should be considered to perform the unit root test considering H_0: $\pi = 0$. The ADF and PP tests circumvent this problem. In this case the AR(1) structure will be extended to accommodate a more general ARMA(P,Q) structure. This extension is known as "augmented Dickey-Fuller (ADF).

The test considering only the AR(1) model is the standard Dickey-Fuller test which can be treated as a particular case of the ADF test when P = 1. In this case, the statistic of interest is: $\tau_i = (\rho - 1)/ S\rho$ where $S\rho$ is the standard deviation of ρ. Although similar to the student's t-distribution, the distributions for τi are obtained through Monte-Carlo simulations (Gujarati & Porter, 2011).

Four steps must be followed to apply the ARIMA model to a time series:

Step 1: identify the number P of autoregressive parameters. Identify the number D of times that the series must be divide to become stationary. In general, $D \leq 3$, identify the number Q of moving average parameters and the model is said to be ARIMA (P.D.Q).

Step 2: Estimate the autoregressive and moving average parameters that best fit the model.

Step 3: Diagnose the adequacy of the fitted model, always favoring the most parsimonious and evaluate the residuals that need to be white noise.

Step 4: Make forecasts from the fitted model.

2.3. A Brief Overview of the ARIMA Model as it Applies to the Research

Consider that a stationary time series Y_t can be represented as follows:

$$Y_t = \theta_0 - \theta_1 Y_{t-1} - \theta_2 Y_{t-2} - \ldots \theta_p Y_{t-p} + \varepsilon_t \quad (4)$$

Where θ_0 , θ_1,..., θ_p are parameters. The model described in the above equation is identified as an autoregressive model of order P. The AR(P) process has as a fundamental characteristic the idea of correlation between an observation in time t and an observation in period t-p. The parameter estimation procedure is performed through the Ordinary Least Squares (OLS) method and the goodness of fit tests consist of checking whether the autocorrelation function of the residuals is white noise. In general, a time series can be written as follows in Equation 5:

$$\{Y_1, Y_{2,\ldots,} Y_T\} \text{or} \{Yt\}, t = 1, 2, \ldots, T \quad (5)$$

In the moving average model, the Y_t series results from combining the white noise ε_t of the current period with previous periods. Thus, a Q-order moving average model or MA(Q) is given by:

$$Y_t = \varepsilon_t - \theta_1 \varepsilon_{t-1} + \theta_2 \xi_{t-2} + \ldots \theta_q \varepsilon_{t-q} \quad (6)$$

Where θ_i is the parameter that describes how Y_t relates to the value ε_t - i for i = 1, 2,..., q. In some cases, it is necessary to combine AR model parameters with MA models, thus generating an ARMA model as shown in Equation 7:

$$Y_t = c + \emptyset_1 Y_{t-1} - \emptyset_2 Y_{t-2} - \ldots \emptyset_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots \theta_q \varepsilon_{t-q} \quad (7)$$

Y_t is not stationary, it is necessary to stationarize it. Among the transformations, the most common one consists in taking, generally, one, two or three successive differences from the original series so that the series becomes stationary (Toloi & Morettin, 1987). The number D of differences required for the series to become stationary is called the integration order (Box & Jenkins, 1976). By including integration order, the ARIMA (P,D and Q) models can be used:

$$w_t = \varnothing_1 w_{t-1} + \ldots + \varnothing_p Y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{t-1} - \ldots - \theta_q \varepsilon_{t-q} \qquad (8)$$

where $w_t = \Delta^D Y_t$.

Thus, in this study, the models were previously tested in order to evaluate the best fits including considering the integration levels to turn nonstationary series into stationary ones. The residuals (t) generated are checked to see if they are white noise in addition to the series integration test. The following conditions must be met for it to satisfy this assumption:

$$\varepsilon_t \sim N(0; \sigma^2) \qquad (9)$$

The following presumptions must be met in order for the conditions given in Equation 9 to be true: 1 – $E(\varepsilon_t) = 0$;2 – $E(\varepsilon_t, \varepsilon_{t-j}) = Cov(\varepsilon_t, \varepsilon_{t-j}) < \infty$; 3 - $Var(\varepsilon_t) = Var(\varepsilon_t \mid \varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) = \sigma^2$; and this value is constant (Gujarati & Porter, 2011).

The first and second conditions establish the absence of any autocorrelation between the residuals or any predictability. The third condition establishes conditional homoscedasticity or constant conditional variance (Cochrane, 1997).

One criterion for selecting statistically adequate formulations is to search for models with fewer regressors because this will improve the model's fit. Five (5) other criteria were used to evaluate the adequacy of the adjusted models to the objectives sought in the research, namely: 1)determination coefficient (R^2). The higher this coefficient, the better the adjustment. 2) Percentage of the mean absolute error (MAPE) in which the lower its value, the better the adjustment obtained. 3) Ljung-Box test to verify the hypothesis that the residuals generated in the model are white noise. 5) Correlation coefficient between the observed values in the series and their predicted values. The closer this coefficient is to one, the better the fit (Box, Jenkins, Reinsel, & Ljung, 2015; Box & Jenkins, 1976; Camelo, Lucio, Leal Junior, & Carvalho, 2018; Clement, 2014; Makridakis, Wheelwright, & Hyndman, 1998; Wooldridge, 2015).

2.4. Effects of the Price Forecast Errors on Sugar Export Forecast Errors

As it was already mentioned in earlier sections of this study, forecast errors are created during the analysis of the quantity and export prices of sugar.To estimate the impacts of the absolute errors generated in forecasting export prices (ε_t) on the absolute errors generated in the forecasting process of the quantity exported (ϵ_t), the log-linear model presented in Equation 10.

$$|\epsilon_t| = \beta_{0.}|\varepsilon_t|\beta^1 e^{\theta t} \qquad (10)$$

In Equation 10, the random terms (ϵt; εt) are estimated at positive and negative values. The research seeks to assess the magnitudes of the impacts of these deviations on sugar exports and prices, regardless of the signs. For this reason, their absolute values are taken. The coefficient $\beta 0$ is the log-linear parameter of the equation. The constant "e" constitutes the base of natural logarithms, υt is the random term associated with Equation 11. The coefficient $\beta 1$ is defined as follows:

$$\beta_1 = (\alpha_0 + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3) \qquad (11)$$

Where D1 = 1 consists of the years in the first quartile of the 200-year period (1821 to 1870). D1 = 0 consists of the remaining periods. D2 = 1 represents the years in the second quartile (1871 to 1920). D2 = 0 represents the remaining periods. D3 = 1 in the third quartile (1921-1970). D3 = 0 in the remaining quartiles. D1 = D2 = D3 = 0 represents the years in the fourth quartile (1971 - 2020). Applying the natural logarithm, Equation 11 can be rewritten as shown in Equations 11a and 11b:

$$\ln(|\epsilon_t|) = \ln(\beta_0) + [(\alpha_0 + \alpha_1 D_1 + \alpha_2 D_2 + \alpha_3 D_3)]\ln(|\varepsilon_t|) + \theta_t \qquad (11a)$$

The coefficients α_0; α_1, α_2 and α_3 measure the sensitivity of the forecast errors of the quantities of sugar exported in response to the forecast errors of the respective prices in quartiles 1, 2, 3, and α_0 measure the sensitivity of the forecast errors of the quantity 4 of sugar exported in response to the forecast errors in that quartile.

2.5. Geometric Growth Rates (GGR) of Sugar Exports and Prices.

In general, the instantaneous geometric growth rate (GGR), or acceleration/deceleration rate of a continuous random variable (Y_t) is expressed by the following equation:

$$Y_t = \rho_0 . e^{(\rho 1 \, T + \lambda t)} \qquad (11b)$$

In Equation 11b, "e" is the base of natural logarithms, d[log(Yt)]/dT = ρ1 multiplied by 100 is the instantaneous GGR associated with the variable (Y_t), t = 0, 1, 2, ...,n. Its values will be defined in each of the periods in which the trajectories of exports and sugar prices are studied. The random term (λ_t) is also assumed to be white noise (Wooldridge, 2015). In this study, it is assumed that the instantaneous geometric growth rates will differ across the four periods into which the export and sugar price trajectories have been divided. Thus, the following equation to define the GGR is written as follows:

$$Y_t = \beta_0 . e^{(\beta 1 T + \lambda t)} \qquad (12)$$

Where β_1 is defined as in Equation 12. Thus, Equation 13 becomes:

$$Y_t = \beta_0 . e^{T(\alpha 0 + \alpha 1 D1 + \alpha 2 D2 + \lambda t)} \qquad (13)$$

3. RESULTS AND DISCUSSION

3.1. Results Found in the Estimation of ARIMA Models for Forecasting

Table 1 shows the findings from the forecast model parameter estimations. The evidence presented suggests that the series of exported quantities of sugar as well as its prices were not stationary but it was possible to make them stationary by means of a difference. The best fitted models had the variables in their respective natural logarithms. The coefficients of determination (R^2) had values above 90%. The mean absolute percentage errors (MAPE) as well as the BIC/SIC statistics showed low values. The estimated heats for the Ljung-Box statistics suggest that the residuals generated in the models are white noise. Finally, the Pearson correlation coefficients examined the adherence between the observed values and the corresponding values in the two series. These values were 0.991 and 0.997, respectively.

Table 1. Models fitted to forecast sugar exports and prices from 1821 to 2020.

Fitted models	LN(Sugar exportations) (Ton)	LN(Sugar price) (USD 2020)
	ARIMA (0.1.1)	ARIMA (0.1.1)
MA lag1	0.484*	0.255*
R^2	0.933	0.905
Ljung box	17.467 ^{NS}	12.699^{NS}
MAPE	36.303	21.364
BIC	24.376	-1.701
R Pearson	0.991	0.997

Note: * Significant at 1%. NS = not significant at least with 12% error.
Source: MIDIC (2022).

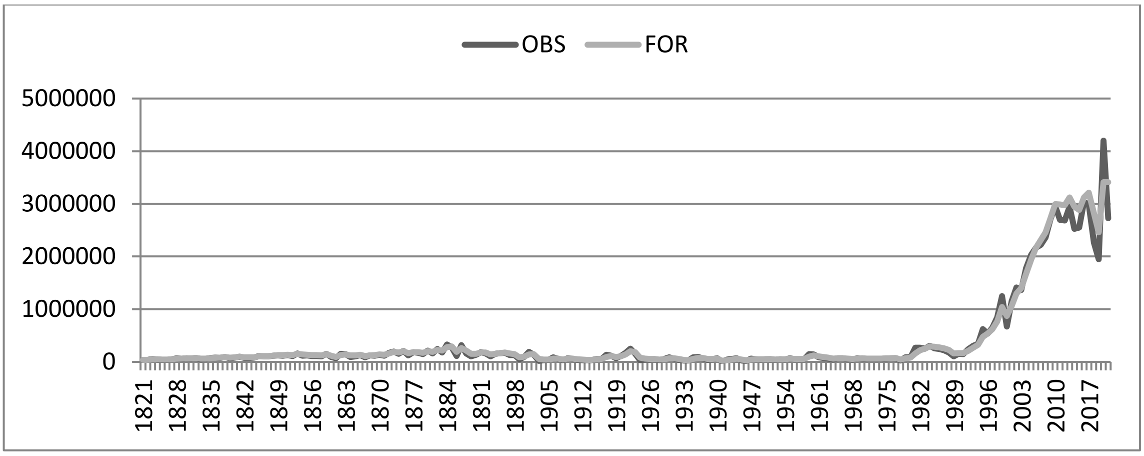

Figure 1. Trajectories of observed (OBS) and forecast (FOR) quantities of sugar exports in Brazil between 1821 and 2020.
Source: MIDIC (2022).

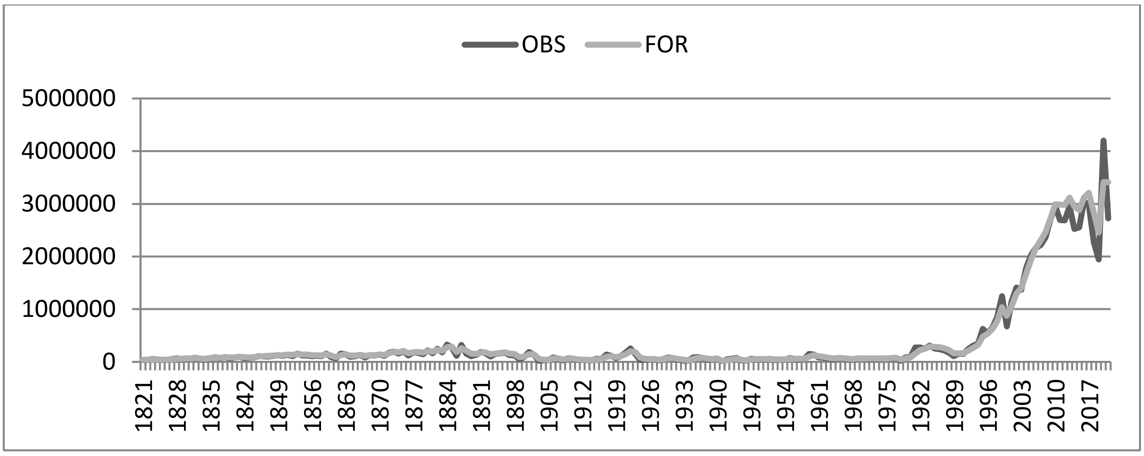

Figure 2. Trajectories of observed and forecast (POR) sugar prices in Brazil between 1821 and 2020.
Source: MIDIC (2022).

3.2. Elasticities of the Forecast Errors in Exports as a Result of Forecast Errors in Sugar Prices Over the Periods Studied

The findings of the study reveal that the assumptions made when this study was planned were correct. These results are shown in Tables 2 and 3. In fact, the evidence shows that the forecasting errors for sugar prices affected the forecasting errors of exports in a differentiated way including from a statistical perspective with a maximum error of 8.5 % in the four quartiles of 50 years in which the series of exports and sugar prices were divided between the years 1821 and 2020. It is also observed that all forecasting price errors had a negative and inelastic influence on export forecast errors and the highest estimated elasticity occurred in the fourth quartile (1971 to 2020) exactly when the oil crisis occurred in the 1970s. Therefore, there was an official stimulus with the creation of the Fuel Alcohol Program (PROÁLCOOL) that stimulated the production of sugarcane. In this period, the estimated elasticity was -0.51 (see Table 2).

Table 2. Estimates of the elasticities of forecast errors of sugar exports in response to price forecast errors.

Variables/period	Coeficient	Sign.	Elasticity
Constant	8.649	0.000	-
ln(|ε_t|)xD1 (1821-1870)	0.473	0.081	-0.037
ln(|ε_t|)xD2 (1871-1820)	0.327	0.067	-0.183
ln(|ε_t|)xD3 (1921 – 1970)	0.398	0.064	-0.112
ln(|ε_t|)/(1971-2020)	-0.510	0.085	-0.510
R^2 Ajustado	0.556		

Source: MIDIC (2022).

In Table 3, one can see that Brazilian exports of sugar expanded at the highest geometric rate (GCGR = 9.6% p.a.) in 1971-2020. In this period, the prices had a negative GGR (-2.1% p.a.). This result is corroborated by research conducted by Ferreira et al. (2009) who argue that sugar is a commodity that presents enormous volatility in its prices due to policies. Protectionist production and price controls in developed countries that produce sugar using sugar beet as a raw material.

Table 3. Geometric growth rates (GER) of exports and sugar prices in the four quartiles studied.

Periods	Results for the GGR of sugar exports			Results for the GGR of sugar prices		
	Adj R^2.	Const	Regr.coef.	Adj R^2.	Const	Regr.coef.
Quarto 1 (1821-1870)	0.680	10.771 (0.000)	0.024 (0.000)	0.840	1.797 (0.000)	-0.037 (0.000)
Quarto 2 (1871-1820)	0.431	12.336 (0.000)	-0.031 (0.000)	0.401	-0.412 (0.000)	-0.018 (0.000)
Quarto 3 (1921-1970)	0.021	10.911 (0.000)	0.001 (0.940)	0.565	-1.790 (0.000)	0.032 (0.000)
Quarto 4 (1971-2020)	0.907	10.776 (0.000)	0.096 (0.000)	0.456	-0.236 (0.167)	-0.021 (0.000)

Note: The values in parentheses are the significance levels associated with the estimated values.
Source: MIDIC (2022).

4. CONCLUSION

The evidence found in the research showed that good models were achieved for forecasting sugar exports and prices for the 200 years period beginning in 1921 and ending in 2020.

The assumptions that guided the decision to undertake the research were confirmed. In fact, different behaviours were observed in the growth rates of exports and sugar prices in the four quartiles of fifty years each in which the long series was divided both in terms of magnitude and statistical perspectives. Many factors have affected Brazil's history since the 1920s. The cultivation of sugar cane for the production of sugar is part of the economic formation of Brazil.

The results of the research also confirmed the hypothesis that errors in sugar price forecasts by exporters had an influence on export forecast errors. This was also shown quite differently in the four quartiles into which the survey was divided.

In the first quartile, it was observed that prices had experienced their greatest deceleration while exports showed a positive growth rate but a lower rate than that observed for the fall in prices. In this period, when Brazil was hegemonic in the export of sugar, the smallest absolute error in the forecast of exports occurred as a result of the forecast errors of prices.

In the second quartile (1871-1920), it was observed that both sugar exports and their prices presented negative TGC. During this period, slaves were freed affected the availability of labor for work in the sugarcane fields and mills and the First World War which cooled the demand for sugar. In this period, the responses to export forecast errors as a result of price forecast errors were the lowest observed in the four quartiles studied.

In the third quartile which covers the period from 1921 to 1970, it was observed that there were several factors in the world that may have influenced the demand for and prices of sugar exported by Brazilians. Some of these factors were the 1929 crisis, the Second World War and the "cold war". During this period, sugar exports were stagnant, even though prices showed positive growth.

The research showed that in the last quartile (1971 - 2020), there was a real "explosion" in the growth rate of sugar exports, a clear reflection of the facts that have happened over the last fifty years of Brazil's economic history which began with the rise in oil prices that led the military governments to create the alcohol program that encouraged the expansion of sugar cane planting. In this period, sugar prices had negative growth influenced also by the exchange rate variations, the high rates of inflation that the country experienced from the 1960s on and only culminated in 1994. The exchange rate regime which was fixed and frozen (with the Brazilian currency overvalued) between 1994 and 1999.

The general conclusion of the research is that the answers that motivated its construction have been achieved. In fact, the elasticities that measure the responses of forecast errors of exports as a result of forecast errors of prices were statistically different from zero and presented different magnitudes in the four historical periods in which the series of exports and sugar prices were divided.

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