IOSR Journal Of Humanities And Social Science (IOSR-JHSS)
Volume 28, Issue 7, Series 8 (July, 2023) 21-30
e-ISSN: 2279-0837, p-ISSN: 2279-0845.
www.iosrjournals.org

Instabilities In Prices And Exports Of Brazilian Cocoa In Two Centuries: 1821-2020

José de Jesus Sousa Lemos[1], Antonia Leudiane Mariano Ipolito[2]; Ana Cecília Vasconcelos Loayza[3]; Alexandra Pedrosa Monteiro[4]; Erika Costa Sousa[5]; Elizama Cavalcante de Paiva[6]

[1](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)
[2](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)
[3](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)
[4](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)
[5](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)
[6](Department of Rural Economics, Federal University of Ceará (UFC), Brazil)

Abstract: *The research tested the hypothesis that price forecast errors not only influence Brazilian exporters' errors in forecasting their exports, but also do so in different ways in historical periods of fifty years each, between the years 1821 and 2020. To do so, we used historical series of these series, obtained from the Brazilian Institute of Geography and Statistics (IBGE) and the COMEX STAT (2022). ARIMA forecast models were fitted to the two series, from which the forecast errors of the two variables were generated. The series were divided into four quartiles, each of fifty years. It was for these quartiles that the geometric growth rates of these variables were estimated, as well as the elasticities that measured the response of the forecast errors of exports to the forecast errors of prices. The evidence confirmed the hypotheses that the growth rates of the variables were different in the quartiles, as well as the elasticities. And these differences may have been caused by the facts that happened, both in the world economy and, mainly, to the problems inherent in the cultivation of cocoa in Brazil.*

Key Word*: Commodity. Cocoa disease.; International competition. Economic Crises in the world*.

Date of Submission: 16-07-2023 Date of Acceptance: 26-07-2023

I. Introduction

In Brazil, cacao was one of the first American products to win the world after the discovery. According to Piasentin and Saito (2014)[1], the introduction of cocoa (Theobroma cacao L.) cultivation occurred in Bahia in 1746 expanding mainly in the southeastern region of the state.

Cocoa originated in the Amazon Region and has been cultivated as an agricultural product since the 17th century. In the middle of the 18th century, cocoa was brought to the southern region of Bahia, where it experienced the expansion of its production and commercialization from the 19th century on, in face of the crisis of the sugar activity in the end of the century and beginning of the 20th century. Around 1903, cocoa becomes the first export product of the State of Bahia, and Brazil, the first in world exports, with intense expansion until 1930 [2].

However, the world crisis of 1929 directly affected the marketing of cocoa, due to the stagnation of international demand, which led to the creation of the Instituto de Cacau da Bahia (ICB) in 1931, focusing on the infrastructure of production units, marketing and availability of credit for farming. In the 1950s, the cocoa activity in Brazil was affected by a new crisis due to the increase in the world supply driven by the production of African countries, impacting the international price of cocoa. From this moment on public interventions were implemented for the recovery of the activity, among which we highlight the creation of the Executive Commission of the Cocoa Farming Plan (Ceplac) in 1957, the Plan of Guidelines for the Expansion of the National Cocoa Farming (Procacau), introduction of the technological package from the Green Revolution. Thus the period of 1960 and 1970 was characterized as the golden period of cocoa activity due to high prices and increased production [2, 3,4].

Historically, the Northeast region, more specifically the South of Bahia, since the early years of the twentieth century, stands out in the national production of this commodity. However, between 1990 and 2004, there was a sharp drop in production in the Northeast due to the incidence of the disease known as "witches' broom", caused by the fungus Moniliophthora perniciosa in southern Bahia, implying a crisis of great proportion

for the Brazilian cocoa activity. On the other hand, production started to grow in the Northern Region, especially in the state of Pará. The area planted in Pará showed an increase of more than 100% between 1990 and 2016, while Bahia, the main cocoa producing state in the Northeast, had a drop of more than 10% in the same period. Despite the loss of leadership in the recent period, the Northeast region has its importance in occupied area, with 69.7% of the national area. In the Southeast, most of the production is located in Northern Espírito Santo and Northern Minas Gerais [5,6].

In 2020, according to FAO - Food and Agriculture Organization of the United Nations (2022)[7], reports that Brazil ranked seventh in the world production of cocoa beans, with 269.7 thousand tons and 38th in quantity exported of the product. In the world scenario, Ivory Coast, Ghana and Indonesia are the main producers. Together these countries accounted for 68.63% of world production in 2020 [5, 7].

In a scenario of two centuries of observations and commodity prices, in which events of different natures have occurred, it is likely that the performance of these two variables has not manifested itself in a homogeneous manner. Anchored in this premise, this research seeks to answer the following questions: How have exports and cocoa prices evolved between the years 1821 and 2020, divided into four periods of fifty years each? How did the forecast errors of cocoa prices made by Brazilian exporters influence the forecast errors of the product's exports in these four periods?

The hypotheses that support the research are that the evolution of exports and prices of cocoa occurred in different ways in each of the 50 years in which the research was unfolded, influenced by world historical factors, the significant entry of competing countries in the production of cocoa in the world and the problems associated with the cultivation of the crop, especially due to the occurrence of the fungus that caused the disease known as "witches' broom". The other hypothesis of the research is that there were responses in the forecast errors of exports as a result of the forecast errors of cocoa prices, and that these responses manifested themselves in different ways in the quartiles in which the research was carried out in the period from 1821 to 2020.

To answer these questions the study has the following objectives: a - to gauge the differences in the instabilities of cocoa exports and prices in the four quartiles; b - to estimate the growth rates of cocoa prices and exports in each of these quartiles; c - to estimate forecasting models of cocoa prices and exports between 1821 and 2021; d- to estimate the impacts of price forecast errors on the forecast errors of cocoa exports in the four periods that classify the trajectory of production/exports of the product: 1821 to 1870, 1871 to 1920, 1921 to 1970, and 1971 to 2020.

The present work is structured in four sections. Besides this introduction (Section 1), Section 2 presents the methodology used in the research; Section 3 refers to the results and discussion; and, in Section 4, the final considerations about the research results are exposed.

II. Material And Methods

The variables used in the research were: quantities exported and prices of cocoa in Brazil, between the years 1821 and 2020. The data were collected from the Brazilian Institute of Geography and Statistics (IBGE) and the COMEX STAT (2022)[8], the information for the years 1821 to 1987 were taken from IBGE (1990)[9], while the information for the years 1988 to 2020 were extracted from COMEX STAT (2022)[8]. In this period, according to the Central Bank of Brazil (BACEN, 2007)[10], due to the occurrence of inflationary periods that provoked the elaboration of monetary stabilization plans that, most of the time, had as one of the actions the change of currencies. For this reason, in these two centuries there have been nine (9) different types of currencies in Brazil.

The prices were updated to Brazilian reais of 2021 (the current currency of Brazil), using the general price index, internal availability (IGP-DI) of the Getúlio Vargas Foundation. Then the average exchange rate of the end of 2021 was taken, and the entire price series was converted into 2021 US dollars.

To carry out the research, two strategies were used. To estimate the models for forecasting export and price errors (third objective), the original series over 200 years of observations (1821 to 2020) were used. For the other objectives, the 200 years of observations were divided into four periods of fifty (50) years, called quartiles. It is assumed that these are long enough periods to capture changes in the trajectories of export quantities and cocoa prices. And, it is believed that the behaviors evaluated in this research, in each of the quartiles, manifested differently. The justifications for the study to develop between the given quartiles are broken down below.

The period from 1821 to 1870, which comprises the first quartile of the study, is marked by the growth of cocoa cultivation in Brazil and by factors that led to its economic exploitation. Until the 1820s cocoa was of little significance as a Brazilian export product. The cacao activity gained importance only after the establishment of the culture in southern Bahia during that decade. According to Rangel (1982)[4], an episode that occurred in 1822 contributed to this. In that year, 28 German families, gathering approximately 160 people,

arrived in Ilhéus, in the state of Bahia, with the perspective of working and settling in that state of the Northeast of Brazil.

However, due to poor housing and food conditions, the settlers sought government assistance, which resulted in the founding of the "Colônia de São Jorge dos Ilhéus" in the state of Bahia, where they started small cocoa plantations. Initially, Bahia's production was practiced almost at subsistence level. It was grown in parallel with other crops such as tobacco, coffee, and sugar cane, mainly. The economic exploitation of cocoa in Bahia became important only after 1860, due to the growing demand for the product abroad. The expansion of production was due to the wide availability of land and labor migrated from other regions of the Northeast in search of jobs and remuneration offered in cocoa plantations [2, 4].

The second quartile, which covers the years from 1871 to 1920, is marked by the expansion of cocoa production and export, especially in the State of Bahia. The intensification of the migratory current toward the cocoa zone in the south of the state occurred with the abolition of slavery in 1888, which caused the displacement of workers who had previously been slaves coming from the traditional areas of sugar exploitation. This labor force was completed with the engagement of backwoodsmen who aimed to build their own plantations. At the same time, there was a growth in cocoa exports, becoming one of the main products on the state's export list. In 1901, Brazil already ranked first in world production and, in 1920, Bahia gained national prominence as a major producer of cocoa [11, 4].

In the initial years of the third quartile, from 1921 to 1970, the cocoa activity was affected by successive crises, leading to the implementation of important public interventions for the recovery of the activity. From 1920 to 1930, the Brazilian cacao activity went through a period of great instability due to the economic and social effects produced by the 1929 crisis in the United States and aggravated by World War II (1939-1945).

The post 1929 period was marked by crop failures, a sharp drop in international cocoa prices and a reduction in exports, which resulted in the creation of the Cocoa Institute of Bahia with the purpose of supporting the cocoa farming in 1931. Between 1930 and 1940 successive records of Brazilian cocoa production were experienced but, at the end of the period, the cocoa activity was affected by another crisis, this time due to the Second World War that impacted the world consumption caused by the closing of markets [4].

With the end of the war, the cocoa economy was reestablished driven by high cocoa prices. In 1954, with the advent of the Korean War (1950 to 1953), there was an exceptional rise in international prices, probably due to the fear of international buyers about the lack of the product. But in 1956 cocoa producers were faced with plummeting prices and rising production costs. According to Rangel (1982)[4], the high cocoa prices in the past had stimulated the producers to make large disbursements and take on debts for improvements, expansion or installation of new plantations. This scenario turned into a deep crisis for the Brazilian cocoa economy, combined with the aging of the plantations, exploited on an extractive basis and with low productivity. The Federal Government, aiming to contain the serious crisis, instituted in 1957 the Plan for Economic-Rural Recovery of Cocoa Plantations and established the Executive Commission of the Cocoa Plantation Plan (Ceplac), in order to recover the payment capacity of producers [2, 4].

The resumption of the cocoa economy also included the creation of the Center for Cocoa Research (Cepec), the Ceplac Middle School for Regional Agribusiness (Emarc), and the Plan of Guidelines for the Expansion of National Cocoa Culture (Procacau). These plans aimed at strengthening the cacao activity. According to Andrade et al. (2015)[2], the years from 1960 to 1970 corresponded to the golden period of the cacao activity due to high prices and increased production [2, 4].

The fourth quartile of this research encompasses the years 1971 to 2020. For the Brazilian cocoa activity, this period is marked by crises that made this period very unstable for cocoa production in Brazil. At the end of the 1970s, specifically in 1977, there was a historic high in international cocoa prices reflecting the increase in cocoa production worldwide, especially in Brazil, Malaysia, and Ivory Coast. In subsequent years, the context of oversupply of the product was followed by falling international prices [12, 13, 2].

Until the mid-1980s the national production of cocoa experienced growth, however, the cultivation of cocoa in the State of Bahia, then the main producing state in Brazil at the end of the decade, was severely affected by the emergence of the disease vassoura-de-bruxa (caused by the fungus Moniliophthora perniciosa). With low international prices, especially in the 1990s, unfavorable weather conditions and the disease in Bahia, the Brazilian production went into decline. Given this context, from the 1990s on, a scenario of declining exports and increasing imports of the product is observed, with records of negative balances in the Brazilian trade balance of cocoa and derivatives in recent period [5, 14, 13].

According to the 2017 Agricultural Census (IBGE, 2019)[15], in that year there were a total of 274 municipalities producing cocoa in Brazil. Of this total, 108 municipalities were in the state of Bahia, in the Northeast of Brazil, 125 municipalities in the Northern region (58 in Pará, 45 in Rondônia, 22 in Amazonas), and 41 municipalities in the state of Espirito Santo, located in the Southeast of the country. The total production

was 234.98 tons on 589.611 hectares. The state with the highest production was Pará with 131.89 tons and with the highest productivity of 882.23 kg.ha-1 (IBGE, 2019)[15].

Methodology to achieve the first objective.

To achieve the first objective we estimate the averages of exports and cocoa prices among the four quartiles into which the export and price series were divided. The stabilities/instabilities of the selected variables were measured by the Coefficient of Variation (CV), which measures the percentage ratio between the standard deviation and the mean of a random variable. In practice, the CV measures the degree of homogeneity or heterogeneity of the distribution of values of a random variable around its mean. It can be assumed that the CV measures the instability/stability of the way the observations of a random variable are distributed around its expected value. The greater the magnitude of the CV, the more unstable, or more heterogeneous, will be the distribution of the observed values of the random variable around its mean. Thus, the CV can also be interpreted as a risk measure and has the additional advantage of comparing variables measured in different measurement units [16, 17].

Methodology to achieve the second objective: Estimations of the geometric growth rates (GGR) of exports and cocoa prices.

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

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

(1)

In equation [1], "e" is the base of natural logarithms; $d[\log(Y_t)]/dT = \rho 1$ multiplied by 100 is the instantaneous TGC 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 cocoa prices are studied. The random term (λt) also assumes the assumptions of being white noise [18].

Methodology to reach the third objective: models estimation for cocoa price and export forecast between 1821 and 202

To estimate the forecast of exported quantities and cocoa prices, the Box and Jenkins methodology was applied, which allows for the analysis of data characterized as temporal series, consisting of a set of observations ordered in time. Such methodology aims to adjust auto-regressive integrated moving average models, known as ARIMA (p,d,q) in which the choice of model structure is based on the data itself. In this case the forecast of cocoa prices and exports is derived from its own past, or lagged, values and the stochastic error terms [19, 20].

The necessary condition for making forecasts using the ARIMA model is that the series be stationary, that is, that it progresses in time randomly around a constant mean, with homoscedastic and non-autoregressive residuals [21, 20, 18].

To check whether the series Y_t is stationary, initially a visual inspection is made of the graph that describes the trajectory and the autocorrelation function is evaluated. If it stabilizes with the first lags around the null value, one can be sure that the series is stationary.

To definitively confirm whether the series is stationary, the unit root test is performed. To do so, 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 3 differentiations to turn a nonstationary series into stationary [21].

There are different ways to perform the unit root (RU) test. Some of them are Augmented Dickey-Fuller (ADF); Phillips-Perron (PP) and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. In most tests the null hypothesis is that the series has a unit root and is therefore not stationary.

Modeling an ARIMA (p, d, q) integrated autoregressive moving average time series consists of four steps: 1) identification of the appropriate values of p, d, and q, where p denotes the numbers of the autoregressive terms, d the number of times the series must be differentiated before it becomes stationary, and q the number of moving average terms; 2) estimation of the parameters of the autoregressive terms and the moving average terms included in the model; 3) verification of the diagnosis by analyzing the residuals; and 4) forecasting [20].

The time series model can take a variety of forms: autoregressive (AR), moving average (MA), autoregressive and moving average (ARMA) and autoregressive integrated and moving average (ARIMA). In this case, the identification step aims to find the appropriate values of p, d, and q.

According to Morettin and Toloi (2006), an autoregressive model of order p, AR(p) can be defined by:

$\tilde{Z}_t = \emptyset_1 \tilde{Z}_{t-1} + \emptyset_2 \tilde{Z}_{t-2} + \cdots + \emptyset_p \tilde{Z}_{t-p} + a_t$
(2)

Where a_t is white noise. In this case, the stationary autoregressive operator of order p can be defined by:
$\emptyset(B) = 1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_p B^p$
(3)
can be rewritten as,
$\emptyset(B)\tilde{Z}_t = a_t$
(4)
For a moving average model MA(q), this can be denoted by:
$Z_t = \mu + a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q}$
(5)
With $\tilde{Z}_t = Z_t - \mu$, we have the moving average operator of order q
$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q$
(6)
The autoregressive moving average model ARMA(p,q) in turn can be defined by:
$\tilde{Z}_t = \emptyset_1 \tilde{Z}_{t-1} + \ldots + \emptyset_p \tilde{Z}_{t-p} + a_t - \theta_1 a_{t-1} - \cdots - \theta_q a_{t-q}$
(7)
Considering the autoregressive, ∅(B), and moving average operators, θ(B), the ARMA(p,q) model can be rewritten as
$\emptyset(B)\tilde{Z}_t = \theta(B) a_t$
(8)

The models described above are adequate to describe stationary series, according to Morettin and Toloi (2006)[19]. In case a Z_t time series is nonstationary, the transformation procedure to make it stationary consists in taking one or more differences. Thus, the d differences needed until the series becomes stationary are called the integration order. If $W_t = \Delta^d Z_t$ is stationary, one can apply the ARMA (p,q) model as:
$\emptyset(B)W_t = \theta(B) a_t$
(9)
If W_t is a difference of Z_t, then the ARIMA model (p, d, q) is defined by
$\emptyset(B)\Delta^d Z_t = \theta(B) a_t$
(10)
where p and q are the orders of the autoregressive operators, ∅(B), and moving averages, θ(B), respectively, as emphasized by Morettin and Toloi (2006).

For the estimation of the forecast of Brazilian cocoa exports and its international prices between the years 1821 and 2020 by the Box and Jenkins method, it is first verified if the two series of the study are non-stationary, then the adjustment of the ARIMA models (p, d, q) had as a fundamental point to find the value of the integration order d, besides the autoregressive terms p and the moving average terms q.

Procedures to verify the accuracy of the proposed forecast models is through statistical error analysis.

In the choice of statistically appropriate formulations, six criteria were adopted to anchor the decision of choosing the best adjustment: 1 - look for the most parsimonious model, in the perspective that the smaller the number of parameters, the better the model adjustment; 2 - estimate the determination coefficient (R^2). The higher this coefficient the better the adjustment. 3 - estimate the percentage of the mean absolute error (MAPE), in which the lower its value, the better the adjustment obtained. 4 - assess the Bayesian Schwartz Criterion (BIC). The smaller its magnitude, in absolute value, the better the fitted model will be. 5 - Ljung-Box test to check the hypothesis that the residuals generated in the model are white noise. 6 - correlation coefficient between the observed values in the series and their predicted values. The closer to one this coefficient is, the better the adjustment All estimates in the paper were performed using the Statistical Package for the Social Sciences (SPSS) software version 26.0 [22, 23, 24, 25, 26, 27, 28, 18].

After estimating the forecast of Brazilian cocoa exports and their prices, the price forecast errors were used to estimate the impacts on the forecast errors of cocoa exports in four periods: from 1821 to 1870, from 1871 to 1920, from 1921 to 1970, and from 1971 to 2020. The details are described in the next sub-item.

Methodology to reach the fourth objective: estimation of the impacts of price forecast errors on the forecast errors of cocoa exports

In forecasting Brazilian exports and/or international cocoa prices (Y_p), forecast errors were generated, as already discussed in this text. We denoted ϵ_t as the absolute errors generated in the export forecast model and

ε_t the absolute errors generated from the cocoa price forecast model. To estimate the impact of the price forecast errors (ε_t) on the cocoa export forecast errors (ϵ_t) the log-linear model presented below will be used:

$$|\epsilon_t| = \beta_0 . |\varepsilon_t|^{\beta_1} e^{\theta_t} \quad (11)$$

In equation [11] the coefficient β_0 is the log-linear parameter; the constant "e" is the base of natural logarithms; θ_t is the random term associated with equation [11]; the coefficient β_1 is defined as follows:

$$\beta_1 = (\alpha_0 + \alpha_1 . D_1 + \alpha_2 . D_2 + \alpha_3 . D_3) \quad (12)$$

In equation [12], D1 takes on a value equal to 1 (D1 = 1) in the years 1821 to 1870, and D1 = 0 in the other periods. The binary variable D2 = 1 for the years 1871 to 1920, and D2 = 0 in all other years; D3 = 1 in the years 1921 to 1970; D3 = 0 in all other years. When D1 = D2 = D3 = 0 corresponds to the observed cocoa exports and prices between 1971 and 2020.

Thus, equation [12] can be rewritten as follows, already applying the natural logarithm operator:

$$\ln(|\epsilon_t|) = ln\ ln\ (\beta_0) + [(\alpha_0 + \alpha_1 . D_1 + \alpha_2 . D_2 + \alpha_3 . D_3)] . ln\ ln\ (|\varepsilon_t|) + \theta_t \quad (12a)$$

III. Result and Discussion

We begin the presentation and discussion of the research results by showing the averages and the variation coefficients of exports and cocoa prices observed in each of the quartiles studied, as well as showing the geometric growth rates of these variables estimated for each of the quartiles.

Averages, coefficients of variation and GGR of exports and cocoa prices by quartile.

Over the four periods (quartiles) of 50 years of the series of exports and prices of cocoa studied in this research, it is observed that in the first quartile (1821 to 1870) Brazilian exports were quite reduced with an average of 2,530.32 tons, which shows the small relevance that the country enjoyed in the market of this commodity in those years. In that period, as discussed, the cultivation of cocoa in Brazil was practically beginning. It is also observed that in those years happened the lowest average price of cocoa. In that period prices presented the highest instability with CV = 65.42%, and exports presented the third highest instability among the four quartiles with CV = 45.21% (Table 1).

Table 1 - Averages and coevicient of variation (CV) of Brazilian exportations and price of cocoa from 1821 to 2020

		Exportations (Ton)		Prices (USD2020/Ton)	
Quartilis	**OBS**	**Average**	**CV (%)**	**Average**	**CV (%)**
Q1: 1821 - 1870	50	2,530.32	45,21	142,37	65.42
Q2: 1871 -1920	50	18,283.84	85.63	537,28	40.26
Q3: 1921 - 1970	50	95,384.86	27.11	2824.97	64.73
Q4: 1971 - 2020	50	60,987.88	103.72	3970.79	52.17

Source of original data: IBGE, 1990; MIC, 2022.*Significant to less than 1%; NS = not significant to at least 7% error.

However, in that first quartile, cocoa production and exports started to expand markedly, so much so that Brazilian cocoa exports presented the second highest geometric growth rate (GGR = 2.9% p.a.), which would make the second quartile (1871 - 1920) present an average value of exports (18,283.84 ton) that was 7.2 times higher than the average observed in the first quartile (2,530.32 ton) (Table 1).

In the second quartile exports showed the second highest instability as measured by CV=85.63%, which was only exceeded by the estimated CV for the fourth quartile (CV=103.72%). However, it was in the second quartile that the lowest instability of cocoa prices was observed, even though it was quite high (CV=40.26%). Exports expanded at the highest rate among the quartiles (5.5% per year) and prices also had an expressive average of annual growth of 2.1% per year (Tables 1 and 2).

As a result of the great growth of cocoa exports observed in the second quartile, the third quartile obtained the highest average of Brazilian cocoa exports (95,384.86 ton). We observe that the growth of exports in this quartile had a very reduced rate (0.8% per year), although the prices of cocoa experienced, in this period, the highest average annual growth (4.3% per year) (Tables 1 and 2).

In the initial years of this quartile, as discussed earlier, the production and, as a result, the export of cocoa experienced difficulties associated with the problems arising from the occurrence of the great depression in the USA in 1929, the Second World War and other external factors. Cocoa exports would experience a positive inflection between the years 1960 to 1970. As a result of actions through policies adopted by the Federal Government starting in 1957 that, among others, created the Plan for Economic-Rural Recovery of Cocoa Crops and the creation of Ceplac, among other actions (Andrade et al.2015; Rangel, 1982).

These actions, together with a good international price scenario, which expanded at an average annual rate of 4.3%, provided a record average export of 95.38 thousand tons for this quartile. In this period we also

observed the lowest instability in exports (CV = 27.11), although prices presented the second highest instability (CV = 64.73%) (Tables 1).

In the fourth quartile a sharp decline in cocoa exports was observed, strongly caused by the more effective participation of several competing countries and also due to the incidence of the plague known as " witch's vassoua" (Crinipellis perniciosa) mainly in the cocoa fields of Bahia. In this quartile the cocoa exports had an annual deceleration of about 15% and the prices in annual decline of 1.1%. The average exports were 60,987.88 tons, which represented only 64% of those observed in the third quartile. It was in this quartile that the greatest instability in cocoa exports was observed (CV = 103.7%) (Tables 1 and 2).

Table 2 - Geometric growth rates (GGR) of exports and cocoa prices in the studied periods

	Results for the GGR of cocoa exports			**Results for the GGR of cocoa prices**		
Períods	Adj. R^2	Const.	Regr. Coef.	Adj. R^2	Const.	Regr. Coef.
Q1 (1821-1870)	0.599	6.985 (0.000)	0.029 (0.000)	0.728	3.757 (0.000)	0.040 (0.000)
Q2 (1871-1820)	0.928	8.132 (0.000)	0.055 (0.000)	0.510	5.701 (0.000)	0.021 (0.000)
Q3 (1921-1970)	0.146	11.223 (0.000)	0.008 (0.004)	0.749	6.676 (0.000)	0.043 (0.000)
Q4 (1971-2020)	0.818	13.062 (0.000)	-0.152 (0.000)	0.090	8.452 (0.000)	-0.011 (0.024)

Source of original data: IBGE, 1990; Comex Stat, 2022.
Note: The values in brackets are the significance levels associated with the estimated parameters.

Results Found in the Estimation of ARIMA Models for Forecasting (third objective)

The results found in the estimates of the parameters of the forecast models of exports and cocoa prices are presented in Table 3. The evidence presented suggests that the series of exported quantities as well as their prices were not stationary, but it was possible to make them stationary through a difference.

The best fitted models were parsimonious and presented robust statistics. The best fit for forecasting the series of cocoa exported quantities, ARIMA (0,1,2) is in natural logarithm. To forecast cocoa prices the best model found was an ARIMA (1,1,1). In both models the statistics such as adjusted R2, MAPE, and BIC and Ljung Box proved adequate to make the forecasts with technical rigor. It is also observed that the estimates of the moving average coefficients in both models are statistically different from zero with high significance levels or fairly low error levels (<1,0%).

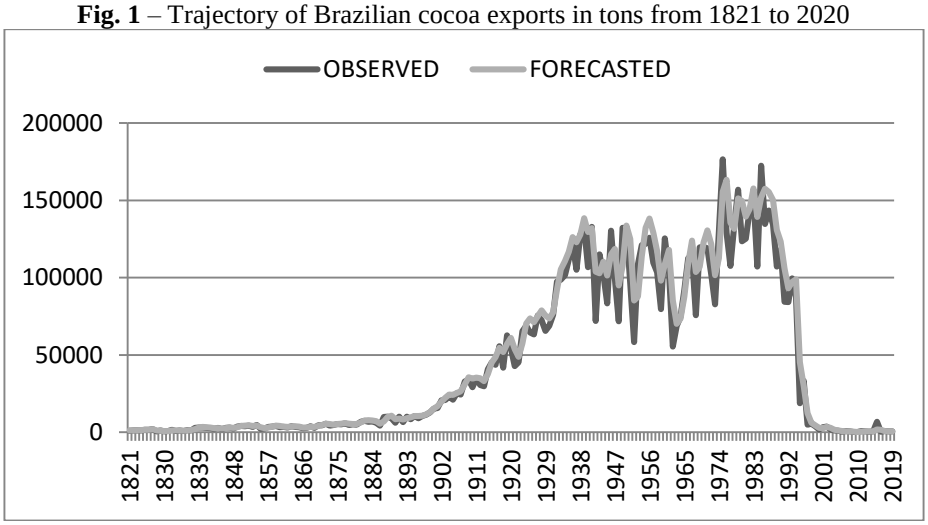
Table 3 - Models fitted to the forecasts of Brazilian exportation and price of cocoa from 1821 to 2021

Estimated models	**Ln (Exportations) (t) ARIMA (0,1,2)**	**Ln (Cocoa Price) (USD 2021) ARIMA (1,1,1)**
AR lag 1	0,000	-0,856*
MA lag 1	0,508*	-0,910*
MA lag 2	-0,191**	0,000
R^2	0,877	0,830
Ljung Box	22,912 ^{NS}	20,702 ^{NS}
MAPE	33,030	19,238
BIC	19,632	13,589
R Pearson	0,985	0.995

Source of original data: IBGE, 1990; Comex Stat, 2022. .*Significant to less than 1%; NS = not significant to at least 7% error.

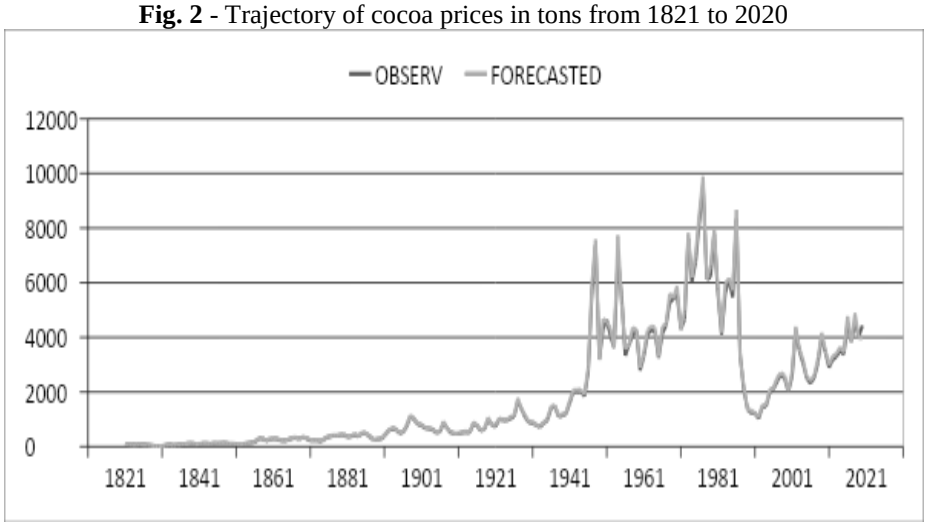
This information is complemented by the Pearson correlation coefficients estimated to assess the adherence between the observed values and the expected values of the quantities (0.985) and prices (0.995) series. Figures 1 and 2 corroborate, with the visual analysis, the good adjustments between the observed and expected series of exports and prices of cocoa in Brazil between the years 1821 and 2020 (Table 3; Figure 1; Figure 2).

Fig. 1 – Trajectory of Brazilian cocoa exports in tons from 1821 to 2020



Sources: Estimated values from IBGE, 1990; Comex Stat, 2022.

Fig. 2 - Trajectory of cocoa prices in tons from 1821 to 2020



Sources: Estimated values from IBGE, 1990; Comex Stat, 2022.

Elasticities of export forecast errors as a result of forecast errors in cocoa prices in the periods studied.

Table 4 presents the elasticities that measure the impact of price forecast errors on the forecast errors of cocoa exports in each of the four quartiles studied. It is observed that the elasticities were statistically different in the periods, as it was assumed in the construction of the research.

Table 4 - Elasticities of forecast errors exports in response to price forecast erros of cocoa.

Variables/período	**Coeficient**	**Sign.**	**Elasticity**
Constant	6,157	0,000	-
$\ln(\|\varepsilon_t\|)$.D1 (1821-1870)	-0,570	0,000	-0,280
$\ln(\|\varepsilon_t\|)$.D2 (1871-1920)	-0,135	0,005	0,155
$\ln(\|\varepsilon_t\|)$.D3 (1921 – 1970)	0,316	0,000	0,606
$\ln(\|\varepsilon_t\|)$/(1971-2020)	0,290	0,000	0,290
Adjusted R^2	0,298		
Source of original data: IBGE, 1990; Comex Stat, 2022.			

From the evidence shown in Table 4, it appears that it was precisely in the third quartile, the one that presented the best results for cocoa exports by Brazilian exporters, that the elasticity that measures the forecast errors of exports due to the forecast errors of prices, presented its highest magnitude (0.606). It is observed that in this period the prices presented their greatest instability as measured by CV = 64.73% (Table 1) and also experienced the highest growth rate (4.3% per year). Probably the facts that caused the greater instabilities in prices in this period, associated with the higher GGR, increased the forecast errors of these prices that ended up inducing a greater sensitivity in the forecast errors of exports. It is worth noting that cocoa exports only began to manifest themselves in a cxpressive manner from the 1960s on, as shown earlier in this study (Tables 1, 2, 4).

On the other hand, in the period of greater instability of exports (CV = 103.72%) in the fourth quartile, the elasticity presented the second largest magnitude in absolute terms (0.290). One can see that in this period prices declined at a rate of 1.1% per year, but these prices also presented high instability, as measured by CV= 52.17%. As already discussed in this paper, it was in this quartile that the entry of competing countries in cocoa exports intensified and it was also in this period that the occurrence of the "witches' broom" plague intensified, causing the average production of this quartile to represent only 64% of that observed in the third quartile. These factors combined, probably have great responsibility in this sensitivity of forecast errors of exports due to forecast errors of prices (Tables 1. 2. 4).

IV. Conclusion

From the results found in the research it was possible to confirm the hypothesis that there were differences in the growth rates of exports and prices of cocoa in the four quartiles in which the research was divided: from 1821 to 1870, from 1871 to 1920, from 1921 to 1970, and from 1971 to 2020.

The research shows that in the four periods studied, with the exception of the period from 1971 to 2020, prices and exports showed positive geometric growth rates.

According to the evidence found, it was in the second quartile (1821-1970) that the greatest expansion of cocoa production and exports by Brazil occurred. It is noteworthy that in 1901, Brazil ranked first in world production, which made the country a major player in influencing the international price formation of the commodity.

However, it was in the third quartile that the highest average of Brazilian cocoa exports was observed. That quartile (1920-1970) experienced difficulties in its early years due to the crisis in the United States (major importer of the commodity at that time) and the Second World War, but in the late 1950s the Federal Government created programs that managed to recover the production and export of cocoa, making the years 1960/1970 to have been called the epoch of another of the production and export of cocoa by Brazil.

The results also showed that the instabilities in exports and cocoa prices were quite different among the quartiles, however, exports were much more unstable in the last quartile, when there was a greater participation of competitor countries and the occurrence of the disease "vassoura de bruxa" which had a very big impact on cocoa crops in Bahia in that period. The crisis became worse after the 1990s when the country started to import cocoa.

The results obtained with the model adjustments that proved to be robust, from a statistical point of view, allowed us to confirm the hypothesis that the forecast errors of prices impacted the forecast errors of exports. And these impacts may have been influenced by the historical factors that happened in each of the quartiles evaluated.

Thus, the hypotheses raised at the beginning of the work were confirmed, since the exports and cocoa prices were quite unstable, the geometric growth rates of exports and cocoa prices maintained different behaviors in the four periods studied. And these elasticities may have been strongly influenced precisely by the instabilities that marked the trajectories of exports and prices of cocoa captured by the research.

Thus, it can be concluded that throughout the period analyzed, 1821 to 2020, the cultivation of cocoa had great relevance for the economic formation of Brazil, highlighting the generation of foreign exchange and jobs for rural workers, despite the difficulties encountered by producers/exporters of the commodity over these 200 years.

References

[1]. Piasentin, Flora Bonazzi; Saito, Carlos Hiroo. (2014). Os Diferentes Métodos De Cultivo De Cacau No Sudeste Da Bahia, Brasil: Aspectos Históricos E Percepções. Boletim Do Museu Paraense Emílio Goeldi. Ciências Humanas, V. 9, P. 61-78.

[2]. Andrade, J. Et Al. (2015). A Economia Do Cacau No Sul Da Bahia. In: Gomes, A; Pires, M. (Orgs) Cacauicultura: Estrutura Produtiva, Mercados E Perspectivas, Ilhéus: Editus. P. 79-93. Available At: Http://Www.Uesc.Br/Editora/Livrosdigitais 2018/Cacauicultura.Pdf

[3]. Lemos, J.J.S (1983). Spectral Analysis Of Agricultural Trade Cycles In Brazil. Viçosa-MG, UFV, University Press. 186p. Phd Thesis.

[4]. Rangel, J. F. (1982). Ceplac/Cacau Ano 25. Brasília: Instituto Interamericano De Cooperação Para A Agricultura, Escritório No Brasil, Unidade De Informação E Documentação.

[5]. Brainer, M.S.C.P. (2021). Produção De Cacau. Caderno Setorial ETENE. Banco Do Nordeste. Ano 6. Nº 149, Jan 2021. Available At: Https://Www.Bnb.Gov.Br /S482dspace/Bitstream/123456789/650/3/2021_CDS_149.Pdf.

[6]. Landau, E. C.; Silva, G. A.; Moura, L. Evolução Da Produção De Cacau (Theobroma Cacao, Malvaceae). In: Landau, E. C.; Silva, G. A.; Moura, L.; Hirsch, A.; Guimaraes, D. P. (2020). Dinâmica Da Produção Agropecuária E Da Paisagem Natural No Brasil Nas Últimas Décadas: Produtos De Origem Vegetal. Brasília, DF: Embrapa. V. 2, Cap. 17, P. 529-555.

[7]. Food And Agriculture Organization (FAO). (2022). Commodities By Country. Available At: Https://Www.Fao.Org/Faostat/En/#Rankings /Commodities_By_Country.

[8]. Estatísticas De Comércio Exterior (Comex Stat). Portal Para Acesso Gratuito Às Estatísticas De Comércio Exterior Do Brasil. Available At: Http://Comexstat.Mdic. Gov.Br/Pt/Home.

[9]. Instituto Brasileiro De Geografia E Estatística (IBGE). (1990). Estatísticas Históricas Do Brasil: Séries Econômicas, Demográficas E Sociais De 1550 A 1988. 2. Ed. Rev. E Atual. Do V. 3 De Séries Estatísticas Retrospectivas. Rio De Janeiro: IBGE.

[10]. Banco Central Do Brasil (BACEN). (2007). Relatório De Inflação. Available At: Https://Www.Bcb.Gov.Br/Publicacoes/Ri
[11]. Noia, A. C.; Midlej, M. M. B. C.; Romano, J. O. (2015). A Cacauicultura Na Regiao Sul Da Bahia: Trajetoria, Crises E Perspectivas In: GOMES, A; PIRES, M. (Orgs) Cacauicultura: Estrutura Produtiva, Mercados E Perspectivas, Ilhéus: Editus. P. 79-93. Available At: Http://Www.Uesc.Br/Editora/Livrosdigitais2018/Ca Cauicultura.Pdf
[12]. Dand, R. (2011). The International Cocoa Trade. 3. Ed. Woodhead Publishing.
[13]. Zugaib, A. C. C.; Andrade, F. C. (2015). Uma Análise Dos Mercados Nacional E Internacional De Cacau E Chocolate. In: Gomes, A; Pires, M. (Orgs) Cacauicultura: Estrutura Produtiva, Mercados E Perspectivas, Ilhéus: Editus. P. 207-227. Available At: Http://Www.Uesc.Br/Editora/Livrosdigitais2018/Cacauicultur A.Pdf
[14]. Mendes, F. A. T. (2018). Agronegócio Cacau No Estado Do Pará: Origem E Desenvolvimento. Belém, PA.
[15]. 15 Instituto Brasileiro De Geografia E Estatística (IBGE). (2019). Censo Agropecuário 2017 -Resultados Definitivos. Rio De Janeiro. Available At: Https://Sidra.Ibge.Gov.Br /Pesquisa/Censo-Agropecuario/Censo-Agropecuario-2017.
[16]. Markowitz, H.M.(1952). Portfolio Selection. Journal Of Finance 7, 77–91.
[17]. Santos, C., & Dias, C. (2021). Note On The Coefficient Of Variation Properties. Brazilian Electronic Journal Of Mathematics, 2(4), 101-11.
[18]. Wooldridge, J. M. (2013). Introductory Econometrics: A Modern Approach. Cengage Learning.
[19]. Morettin, P. A.; Toloi, C. M. C. (2006). Análise De Séries Temporais. 2. Ed. São Paulo: Egar Blucher.
[20]. Gujarati, D. N., & Porter, D. C. (2011). Econometria Básica-5. Amgh Editora.
[21]. Enders, W. (2009). Applied Econometric Time Series. 3. Ed. New York.
[22]. Box, G. E. P.; Jenkins, G. M. (1976). Time Series Analysis, Forecasting And Control. San Francisco: Holden-Day.
[23]. Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). Time Series Analysis: Forecasting And Control. John Wiley & Sons.
[24]. Camelo, Henrique Do Nascimento Et Al. Proposta Para Previsão De Velocidade Do Vento Através De Modelagem Híbrida Elaborada A Partir Dos Modelos ARIMAX E RNA. Revista Brasileira De Meteorologia, V. 33, P. 115-129, 2018.
[25]. Clement, E. P. (2014). Using Normalized Bayesian Information Criterion (BIC) To Improve Box-Jenkins Model Building. American Journal Of Mathematics And Statistics, 4(5), 214-221.
[26]. Greene, W. (2012). Econometric Analysis. 7th Ed. Pearson Education, New Jersey.
[27]. Lemos, J. J. S. Et Al. (2022). Rainfed Crops Forecasting In The Semi-Arid Region Under Scenarios Of Rainfall Instability In Ceará, Brazil. Journal Of Agricultural Science And Technology. Volume 12, Number 2, Mar.-Apr.
[28]. Makridakis, S., Wheelwright, S. & Hyndman, R. J. (1998). Forecasting Method Sand Applications. 3. Ed. New York: John Wiley& Sons.