







Predicting Exports Using Time Series and Regression Trend Lines: Brazil and Germany Competition in Green and Roasted Coffee Industry

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Abstract. Trade is essential for countries development. In Brazil, coffee has been one of the most important export items and by large is commercialized as a green or roasted bean. The aim of this article is to establish a prediction mode for coffee exports using time series and trend lines. To do so, we collected the exportation volume from the two main export countries in each segment: Brazil and Germany. A five-year forecasting was produced using regression curves provided by Microsoft Excel. Our results indicated that polynomial fits best and this function is consistent with agricultural production that is conditioned to edaphoclimatic factors.

Keywords: Coffee · International trade · Time series forecasting

1 Introduction

Trade is an essential part in daily basis of humanity and entails knowledge, negotiation and regulation [1,2]. In 2019, 18.9 USD billion were exported worldwide being agricultural products responsible for 1.8 USD billion [3].

Agribusiness guarantee food security and is an important income source for developing countries [4]. Among many kind of products, coffee has been one of the most consumed items globally. The bean usually is commercialized as green beans or dehydrated form, but also can be sold benefited or roasted [5,6].

The two major world players in the sector are Brazil and Germany. In 2019, Brazil green coffee accounted for 4.5 million USD and 0.9 million USD in Germany. Regarding benefited form, the scenario is reversed. While Germany receive 1.4 million USD, Brazil obtained 9.765 thousand USD [7].

Previous literature have been studying different aspects from coffee supply chains. Lee and Bateman [8] analyzed the demand for fair trade and organic

coffee, its price range, and its demand by category. Naegele [9] studied the role of fair trade in the marketing of coffee beans in industrialised countries. Vogt [10] dealt with the definitions of the quality of the coffee bean and how these can be evaluated in different ways according to the type of market. Conceição [11] investigated the added value to the agro-industrial chain of Brazilian coffee [11]. However, we could find articles that investigate specifically prediction models in coffee industry.

To fill this gap, the article aims to estimate a prediction model for coffee exports. In this regard, we use time series applied to Brazil and Germany exports and forecast the volume for five years based on historical series. Our hypothesis is that the production of green and roasted coffee bean can be predicted using time series and regression trend line. These analysis are essencial to better understand the coffee supply chain.

The article is divided into sections. First, the introduction brings a scenario of the coffee bean trade and how two important players stand out in this area. Next, Sect. 2 presents materials and methods where the regression method is described to track trends and make predictions, and the steps followed in the construction of the work are presented. Then, the third section shows the results and discussions. Finally in Sect. 4 we remark the final considerations and perspectives.

2 Materials and Methods

2.1 Materials and Data

As previously mentioned the focus of the paper is to estimate a time series prediction for the export trade of green and roasted coffee beans considering Brazil and Germany historical series. To this regard, the study was conducted according to the following steps:

1. First, the export values of green and roasted bean coffee of Brazil and Germany were collected. Data were obtained from the FAOSTAT system of the United Nations Food and Agriculture Organization of the United States [7], considering the period between 1979 and 2019;
2. Second, the data were processed using Microsoft Excel©. Regressions models were performed to track trends and make predictions for five years. All trend lines were estimated. The prediction was made using the value closest to 1 of the coefficient of determination - a number that demonstrates the relationship between the variables analyzed [12];
3. Third, regression analysis was used to determine the relationship of each year analyzed (41 years) and the corresponding USD volume;
4. Finally, the predictions were analysed and discussed in the results section.

2.2 Method

Time series investigates the behavior over the years of historical series using different methods such as linear function, exponential, logarithmic, polynomial

and power. It checks trends, seasonality, and randomness in a dataset [12,13]. The most appropriate model for a specific set of data is one which presents the coefficient of determination (R) (Eq. 1) that aims to explain the relationship between variables, being considered appropriate the closer to one. Any measure above 0.7 is satisfactory and calculated based on the ratio between the explained and the total variance; the mean absolute error (MAE) (Eq. 2); and the mean squared error (MSE) (Eq. 3) are calculated according to the equations [13–15].

$$R = \frac{\sum(\hat{y} - y)^2}{\sum(y - \bar{y})^2} \tag{1}$$

$$MAE = \sum |y - \hat{y}| / n \tag{2}$$

$$MSE = \sum (y - \hat{y})^2 / n \tag{3}$$

3 Results and Discussion

3.1 Brazil and Germany Exports

An overview of coffee exports - green coffee beans and roasted coffee - of Brazil and Germany in USD value between 1979 and 2019 is presented in Fig. 1.

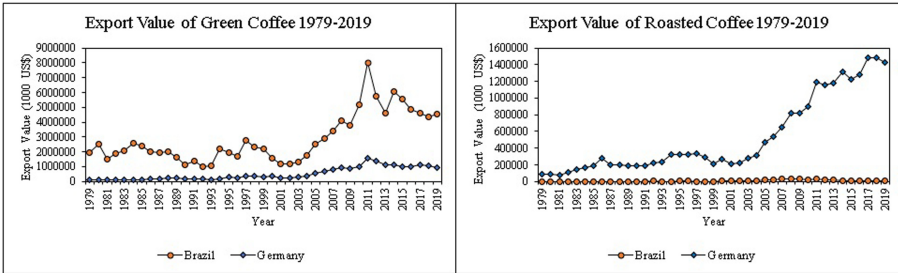


Fig. 1. Green and roasted coffee exported between 1979–2019 in USD by Brazil and Germany

Brazil leads the green coffee market while Germany is the main player in roasted coffee market. Note that the peak in roast coffee segment is almost the double of the peak in green coffee segment. In other terms it means that Germany domains premium market while Brazilian sell is based on volume in commodity market [16,17].

Germany is renowned for supplying quality coffee beans, mainly to Europe. Its privileged location and the existing trade agreements reinforce its sovereignty, making the country a reference in coffee industry. Brazil, on the other hand, appears timidly roasted coffee sales. The country is recognised for exports of commodities and to advance for a most relevant sector of the markets [18], although timid, is a breakthrough for the country.

Despite these figures, Germany buys 20% of the volume of Brazilian green coffee. Considering that the country is not a producer of coffee beans due to climate, there is a clear indication that Brazil is one of the main sources of raw material to Germany coffee industry [19].

Another important aspect is that Brazil coffee industry has not yet achieved commercial advantages for the export of products with higher added value. It is evident that the world’s largest producer of green coffee beans has difficulties in adding value to the product and chooses to export commodity which reflects the need of investments in the productive sector [11].

3.2 Time Series Regression Model

As mentioned previously, our article investigates a prediction model for green and roasted coffee based on the figures of Brazil and Germany. Table 1 presents the results of Brazil and Table 2 of Germany, as well. Functions excluded means that model is not fit to the research.

Table 1. Trend lines for Brazil’s green coffee and roasted coffee

Function	Equation	R^2	MAE	MSE
Green coffee				
Linear	$y = 98588x + 791196$	0.507	885083	1.32217E+12
Exponential	$y = 1E+06e0.0309x$	0.461	2861506	1.08711E+13
Logarithmic	$y = 973966\ln(x) + 152625$	0.264	1601363	4.54925E+12
Polynomial	$y = 5006.3x^2 - 111678x + 2E+06$	0.653	723891	1.01876E+12
Power	$y = 1E+06x^{0.2917}$	0.220	1098970	2.26624E+12
Roasted coffee				
Linear	$y = 584.51x - 3976.8$	0.517	4963	44715747
Logarithmic	$y = 6976.3\ln(x) - 11105$	0.393	10976	188292819
Polynomial	$y = -5.4821x^2 + 814.76x - 5626.9$	0.522	8316	116393863

To find the appropriate trend line, the value which best approximates to 1 of the coefficient of determination (R^2) was considered. For the scenario of green coffee beans in Brazil the trend line is polynomial with a coefficient of determination of 65.34%. For Germany, the appropriate trend line would be the exponential with a coefficient of determination of 89.33%. However, analyzing the numbers, it was found that the situation is not appropriate and we chose to fit the country with the polynomial trend line with a coefficient of determination 81.10%, which is more similar to the situation of the country’s export market.

Note that in the scenario of roasted coffee beans Brazil has a polynomial trend line with a coefficient of determination of 52.19% and Germany also has a polynomial trend line with a 93.93% coefficient of determination. In the case

Table 2. Trend lines for Germany’s green coffee and roasted coffee

Function	Equation	R^2	MAE	MSE
Green coffee				
Linear	$y = 31011x - 145219$	0.763	156232	4.1783E+10
Exponential	$y = 78519e0.071x$	0.893	7.86154E+12	9
Polynomial	$y = 734.22x^2 + 173.47x + 75780$	0.811	120837	3.3346E+10
Power	$y = 29935x0.8826$	0.737	182038	6.9956E+10
Roasted coffee				
Linear	$y = 34265x - 193105$	0.787	179287	4.4629E+10
Exponential	$y = 83859e0.0696x$	0.892	5.01286E+12	3
Logarithmic	$y = 368502\ln(x) - 498471$	0.486	579805	4.7617E+11
Polynomial	$y = 1428.6x^2 - 25738x + 236915$	0.939	93241	1.2684E+10
Power	$y = 33035x0.8605$	0.728	208763	8.758E+10

of Germany, the relationship between the studied variables is much higher than in the other scenarios.

Polynomial trend lines are more complex and have specific characteristics [12]. They are connected with coffee beans supply chains in which the market is subject to edaphoclimatic changes [20–22]. As remarked in 2011, Fig. 1, for green coffee beans, we realize that arose an increase in the production of Brazilian coffee beans reflected in the market as a whole.

3.3 Five-Year Prediction

The forecasts of trend lines based exports for the five-years were made for green and roasted coffee bean for both Germany and Brazil. Table 3 shows the USD values and Fig. 2 compares both countries in both scenarios.

Table 3. Five-year coffee prediction in USD

Coffee type	Country	USD/year					Growth
		2020	2021	2022	2023	2024	
Green	Brazil	6,140,637	6,454,495	6,778,365	7,112,248	7,456,143	18%
	Germany	1,378,230	1,440,812	1,504,863	1,570,382	1,637,369	16%
Roasted	Brazil	38,263	39,544	40,836	42,138	43,452	12%
	Germany	1,675,969	1,771,662	1,870,213	1,971,620	2,075,885	19%

The five-years predictions allows us to exemplify our model application based on polynomial trend line. Note that according of model Brazil (18%) and Germany (19%) should maintain the lead in their correspondent markets. However,

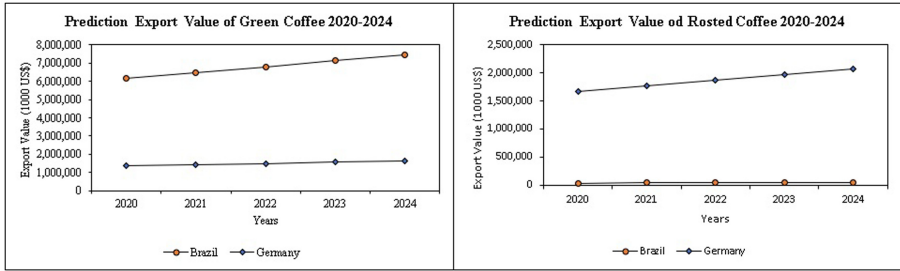


Fig. 2. Green and roasted coffee five-year prediction in USD for Brazil and Germany

the growth of Germany (16%) in green coffee market is higher than Brazil in roasted coffee segment. A logical conclusion is an increase of participation of Germany in both analyzed segments.

Finally, the results suggest that Brazilian producers and country government must focus on premium market to obtain a real profitability or will remain a raw material supplier subject in the fluctuations of commodity market. There is a growth forecast as coffee beverage consumption is increasing worldwide. Several studies have been pointing an increase in the consumption of specialty, gourmet and organic coffees [8–11, 23] confirming the necessity of a change for players willing to meet these new demands.

4 Final Remarks and Outlook

This article aimed to estimate the time series for the export trade of green and roasted coffee beans considering Brazil and Germany scenario making a prediction for five years using an historical series of 41 years.

The results indicated that for both scenarios: green bean exports and roasted bean exports, the trend lines are polynomials which is consistent with agricultural production. The agricultural production of green coffee bean is conditioned by climate and relief factors which directly influence the quantity and quality of the production. Note that may be influenced by market demand that by opting for different types of coffee beans leverages production to meet demand.

In relation to the forecasts made for exports of green and roasted coffee beans for five years, it can be seen that the values are coherent with the growth in coffee drink consumption and its specificities that have been increasing over time. As a study limitation, the analysis of only 2 countries may not show the true world scenario, therefore the addition of other countries would bring better overview.

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