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Whether Factors Affecting the Price of US Coffee C Futures Are Influenced by the COVID-19 Social Environment

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Abstract: During COVID-19, the social environment influenced factors, including monetary policy, precipitation, temperature, exports, imports, tariffs, inflation, and household incomes, resulting in the fluctuation of coffee pricing. This paper selects US Coffee C futures as the benchmark of global coffee pricing, with the US as the representative of the exporting country and Brazil as the representative of the importing country. Based on the data collected from Brazil and US from 2015 to 2022, the research found the following: (1) Before the COVID-19 pandemic, the relationship between the US & EU tariffs and coffee pricing showed a positive trend due to the increase of substitutions' price. Monetary policy, delegated by the exchange rate of BRL against USD, indicates a negative direction toward coffee pricing. This is because it changes the value of coffee beans. Also, the import of coffee beans from Brazil to the US is slightly positively related to coffee pricing since the demand for coffee beans in the US exceeds Brazil's supply. (2) Combined with what is mentioned in (1), the following three factors most affect the COVID-19 social environment. The EU tariffs are becoming insignificant due to general and preferential rates converging. Because the monetary policy has lost much of its ability to influence local markets, it becomes unimportant to global coffee pricing. Meanwhile, international import from the US and export from Brazil becomes relevant to coffee pricing because of the transportation and Brazilian production problems.

Keywords: COVID-19, influence, coffee pricing, United States, Brazil

1. Introduction

Since the price of US Coffee C futures is the standard of Arabica coffee (generally referred to as coffee beans) worldwide, the cost of coffee beans/coffee and the US Coffee C futures used in this paper have the same meaning.

During the COVID-19 pandemic, coffee bean prices have been escalating. Based on the data, the uptrend fluctuated between January 2020 and December 2022 (pandemic period). By comparison, the US Coffee C price before the pandemic was stable compared with that after the pandemic, and the increase in Coffee price was particularly significant.

Prior research estimated a threshold autoregressive (TAR) model of Brazilian coffee prices. It assessed its ability to explain the time-series behavior of the price series compared to a standard AR model [1]. However, the time series suffers from a prediction error because it does not consider the influence of external factors and tends to be more biased when encountering significant exterior

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changes, such as COVID-19. Moreover, the production of coffee beans has been affected by the socioeconomic disruption caused by COVID-19, as mentioned by researchers [2].

This research summarized several significant factors leading to the fluctuation of C prices during the pandemic by constructing a multiple linear regression model on the data collected.

1.1. Factors Selection

Many factors contribute to this price surge, which can be categorized into demand and supply factors.

1.1.1. Supply Factors

Agricultural Production

For the supply factors, agricultural production in Brazil is becoming increasingly important worldwide because coffee beans are produced mainly for export, so this topic has been widely discussed. As a developing country, Brazil's small agricultural producers are heavily dependent on the income generated by the coffee trade. Therefore, the amount of coffee beans produced profoundly influences global coffee pricing. US Coffee C futures, as a worldwide authority, are also affected [3].

Because agriculture production is a vast concept, what it represents is broad. To make a more detailed analysis of the factors affecting the future pricing of coffee C, agriculture production is subdivided into four variates.

The underlying institutional environment significantly impacts agricultural production in Brazil [4]. In 2023, after seven years of reform, many primary institutions have been changed, and opportunities for research on the impact of monetary policy on agriculture (including Arabica coffee beans) have been created.

Studies have shown that climate change is also contributing to the COVID-19 outbreak. In other words, extreme weather problems coexist with COVID-19. From a biological perspective, coffee bean production is also closely linked to climate change [5]. Some say under the impact of the extreme weather, Brazil could not produce as many coffee beans as before, causing a sudden increase in price in 2021. To quantify this variation, the two most influential factors in the category of climate change are selected, which are precipitation and temperature [5].

Exports of Coffee Beans

Moreover, export is the most significant feature of Brazilian coffee production [6]. Therefore, the total export of Brazil's coffee beans to the world, combined with the above three factors, constitutes the supply variates that will directly lead to fluctuations in coffee bean production and thus indirectly lead to changes in the future pricing of US coffee C during COVID-19.

1.1.2. Demand Factors

Imports of Coffee Beans

For the demand factors, the US, where US coffee C is priced, will be the focus of this research. Because of its particularity with Brazil, coffee beans imported by the US from Brazil, which also means the ones exported from Brazil to the US, will be analyzed individually.

As can be seen from the statistics of 2020, the United States is the largest importer of coffee beans, almost twice as much as the second place, Germany. This confirms the choice of the United States as the representative country of demand. At the same time, it also means that the total amount of coffee beans imported by the United States worldwide is one of the critical variables affecting the pricing of American coffee C futures.

1.1.3 Tariffs

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Existing research illustrates the impact of tariffs on the coffee sector (International Coffee Council) [7]. The report pointed out that import tariffs in coffee-exporting countries are generally very high, severely hampering increased trade flows between producing countries.

As two significant consumers of coffee beans in the world, the study on tariffs will be divided into EU and US tariffs. In addition, because of various kinds of taxes, this paper will focus on analyzing the tariffs on agricultural products.

Inflation

In addition, once produced, coffee beans cannot be stored for long periods without a decline in quality or high storage costs [5]. In the case of unexpected inflation, wholesalers and retailers react quickly by passing on a percentage of the price increase to consumers. It is also mentioned in the previous research that the majority of these consumers' decisions are based on price rather than other attributes [6].

Household Income

As a non-essential drink, the demand for coffee also changes with people's consumption ability. The decision to purchase coffee for household consumption is positively correlated with the price of coffee. Still, the impact of changes in household income on household coffee consumption is not explored in detail, and only a rough judgment is made by the 0.2 elasticity coefficient for coffee [8].

1.2. Hypothesis

Because the study is based on the analysis of multiple linear regression models, independent and dependent variables must be defined.

The price of US coffee C future is set as a dependent variable. The independent variables include a monetary policy on agriculture in Brazil, precipitation in Brazil, the temperature in Brazil, the total export of Brazil's coffee beans to the world, coffee beans imported by the US from Brazil, the total amount of coffee beans imported by the United States from worldwide, US tariffs, EU tariffs, inflation in the US, and household income in the US.

Due to previous research support, this paper reasonably hypothesized that all the independent variables listed above had significant changes relative to the dependent variable before and after the pandemic period. That is, all of the above factors (monetary policy on agriculture in Brazil, precipitation in Brazil, the temperature in Brazil, the total export of Brazil's coffee beans to the world, coffee beans imported by the US from Brazil, the total amount of coffee beans imported by the United States from worldwide, US tariffs, EU tariffs, inflation in US, and household income in US) were affected by the COVID-19 social environment and led to the fluctuation of US Coffee C future price.

It can be seen that many factors are involved in this paper. Given the adjustable nature of multiple linear regression models, the core explanatory variable will be captured in this study.

1.3. Description

This work collected data for all factors monthly from January 2015 to December 2022.

1.3.1. Dependent Variable

Table 1: The US coffee C futures' price and description(continue).

Dependent Variable Name	Description
US Coffee C Futures' Price	Official historical data from the market is used as a global benchmark for pricing coffee beans. The data is presented in USD.

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1.3.2. Independent Variable

Table 2: The factors affecting the US coffee C futures' price and description(continue).

Independent Variable Name	Description
Monetary Policy on Agriculture in Brazil	To quantify the measurement of Brazil's monetary policy, the Real exchange rate with the US dollar is the representation. The data is shown in the unit of how much BRL is worth 1 USD.
Precipitation in Brazil	One of the indicators that quantify climate change. The data is presented in average monthly rainfall in millimeters.
Temperature in Brazil	One of the indicators that quantify climate change. The data is presented in average temperature in degrees Celsius.
Total Export of Brazil's Coffee Beans to the World	The coffee bean export serves as an indicator of the general supply of coffee beans. This data is shown in value (thousands of USD).
Coffee Beans Imported by the US from Brazil / Coffee Beans Exported from Brazil to the US	The coffee bean import serves as an indicator of the demand of the US for coffee beans from Brazil, which is also the supply of Brazil for coffee beans to the US. The data is shown in value (thousands of USD).
Total Amount of Coffee Beans Imported by the United States from Worldwide	The coffee bean import serves as an indicator of the general demand for coffee beans. The data is shown in value (thousands of USD).
US Tariffs	The collected data sets contain the monthly tariff data of agricultural products calculated by simple average method from 2015 to 2022 of the US, one of the largest consumers of coffee. The data is presented by the percentage compounded to the imported products.
EU Tariffs	The collected data sets contain the monthly tariff data of agricultural products calculated by simple average method from 2015 to 2022 of the EU, one of the largest consumers of coffee. The data is presented by the percentage compounded to the exported products to the US.
Inflation in the US	CPI is an indicator measuring inflation. The CPIs of the US are calculated monthly with their base year set in 2015 (Index 2015 = 100).
Household Income in the US	For the US citizens' incomes, the data presents the median household income (yearly, in current USD) is collected.

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2. Data Analysis Method and Analysis

2.1. Model Design

2.1.1. Period

The timing of the outbreak is controversial due to geographical and information asymmetry factors. This report will analyze the hypothetical year 2020 as the outbreak time benchmark.

2.1.2. Multiple Regression Model

According to the literature review, our report supposes that these variables are mentioned to have a relationship with the coffee price. Besides these dependent variables, the models analyze the environmental factor by building different models with different periods.

2.2. Methodology Based on the Training Data (2015-2022, 2015-2020, 2020-2022)

2.2.1. Models With All Variables

The regression model was built on the data to generate a general relationship between coffee bean prices and independent variables. To begin the data analysis, all ten independent variables are applied for the regression, including EU tariff, US tariff, US CPI, US income, BRL/USD, Brazil Temperature, US coffee imports from Brazil, Brazil coffee exports from the world, US coffee imports from the world and Brazil precipitation. The regression results are summarized in Table 1. As shown in Table 1, the original model from 2015 to 2022 with an adjusted R square of 0.787 may still need improvement, although the model seems to perform well in the current step. To analyze the effect of COVID-10, the overall period is divided into two parts, which are 2015-2020 and 2020-2022, respectively. Table 1 shows that the adjusted R square of original models in 2015-2020 and 2020-2022 are 0.626 and 0.800, respectively, which seem more reliable models. By comparing the significance of the variables, it is evident that too many insignificant variables result in overfitting, which could make a bad performance in predicting unseen data.

Additionally, Multicollinearity exists among variables, adversely affecting the regression model and setting VIF smaller than ten as the baseline to select variables. VIFs for most variables are too high in these three different time interval models, including US CPI and US income.

2.2.2. Adjusted Models with Reduced Variables

Considering the general regression model, it is not necessarily that all of the independent variables are useful to dependent variables. Our report introduces a backward elimination method to reduce the number of independent variables so that the final model is more fit and easy to make appropriate interpretations. After these models are experienced, several adjustments, as table 1 shows that US CPI and US income with the higher VIFs are removed in the final adjusted models.

Period: 2015-2022

The final regression model

Coffee bean price = -685.8967+144.5496 US tariff+22.9800 EU tariff+0.0019 US income-0.0003 US coffee imports from Brazil+0.0001 Brazil coffee exports from the world+0.0001 US coffee imports from the world

The adjusted R squared of this model is 0.791, which means that the model could explain 79.1% of the total variation of the training data. Although the value of the adjusted R square is not high, removing insignificant variables could increase the model's accuracy in predicting future data. Most of the variables, including US & EU tariffs, US income, US coffee imports from Brazil, Brazil coffee

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exports from the world, and US coffee imports from the world, are significant at a significant level of 5%.

Period: 2015-2019 & 2020-2022

The final regression model:

2015-2019: Coffee bean price = -96.9679 +40.4281 US tariff +22.9050 EU tariff -24.0749 BRL/USD + 0.0002 US coffee imports from Brazil

2020-2022: Coffee bean price = -538.7192+193.6473 US tariff - 0.0006 US coffee imports from Brazil+0.0001 Brazil coffee exports from the world+0.0002 US coffee imports from the world

The adjusted R squared of the second and third models is 0.662 and 0.780, respectively, which seems more reliable than the original ones. By comparing the independent variables, US & EU tariffs, ERL/USD, and US coffee imports from Brazil are significant at a significant level of 5% before COVID-19. In contrast, US tariff, US coffee imports from Brazil, Brazil coffee exports from the world, and US coffee imports from the world, and EU tariff are significant at a significant level of 5% after COVID-19.

Table 3: Original (1) and adjusted (2) regressions with three time intervals(continue).

	2015-2022(1)	2015-2022(2)	2015-2019(1)	2015-2019(2)	2020-2022(1)	2020-2022(2)
Predictors	Estimates	Estimates	Estimates	Estimates	Estimates	Estimates
(intercept)	-652.1195 ***	-685.8967 ***	-0.4746	-96.9679	2249.5623	-538.7192 **
US tariff	127.7360 ***	144.5496 ***	31.8695	40.4281 **	346.9735	193.6473 **
EU tariff	22.0000	22.9800 *	21.4605 *	22.9050 **	-513.3955	
US CPI	0.6079		-0.3056		3.1194	
US income	0.0009	0.0019 *	-0.0001			
BRL/USD	0.4673		-24.5611 ***	-24.0749 ***	6.7195	
Brazil Temperature	0.7106		-0.2572		1.4011	
US coffee imports from Brazil	-0.0004 **	-0.0003 **	0.0002	0.0002 *	-0.0008 **	-0.0006 **
Brazil's coffee exports from the world	0.0001 **	0.0001 ***	0.0000		0.0001	0.0001 *
US coffee imports from the world	0.0002 ***	0.0001 ***	-0.0000		0.0003 **	0.0002 **
Brazil precipitation	0.0340		-0.0050		0.0913 *	
Observations	96	96	60	60	36	36
R2 / R2 adjusted	0.810 / 0.787	0.804 / 0.791	0.689 / 0.626	0.685 / 0.662	0.851 / 0.800	0.805 / 0.780
* p<0.05 ** p<0.01 *** p<0.001						

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2.3. Result

An in-depth analysis of each independent variable and the arabica coffee bean price will be conducted in this section to explain the empirical results from the regression table. In the first part, the results from the training dataset will be elaborated to understand how coffee prices were affected by different factors in the pre-COVID period (2015-2020). In the second part, by comparing with the comprehensive training set period (2015-2022), determine whether COVID-19 environmental factors influence these factors.

2.4. Significant Variables in Pre-COVID Era

2.4.1. US Tariff & EU Tariff

The US tariff & EU tariff are significant in influencing the coffee bean price in the pre-covid era. In the adjusted model, every percent increase in US tariff & EU tariff on agricultural products will lead to a 40.4281 and 22.9050 increase in the coffee bean price. The p-value in the final model is less than 0.01, which reaches very close to 0, showing vital significance in influencing the coffee bean price. This result meets our previous research that higher tariffs will cause a higher coffee bean price with a positive correlation. According to the demand and supply curve from microeconomics, tariffs on agricultural products will increase the cost of coffee substitution, such as tea, which will shift people's demand from the substitutions to coffee; higher demand then increases the coffee bean price.

2.4.2. BRL/USD

The BRL/USD exchange rate is significantly and negatively correlated with the price of coffee beans in the pre-covid era. This means that for every increase of 1 real per USD, which is USD worth one real more, the price of the coffee would decrease by 24.0749 dollars. The previous research shows Brazil's coffee production is closely related to monetary policy. If USD is the standard, then the decrease in BRL value means that the US can buy more coffee beans for less money. Instead, Brazil needs to produce more coffee beans to earn a certain amount of dollars. In both ways, the dollar price of coffee beans has fallen. Therefore, the Coffee C future price has also been decreased.

2.4.3. US Coffee Import from Brazil

The US coffee import from Brazil is the same as Brazilian coffee export to the US. Table 1 shows that this variable is slightly significant and has a positive relationship with the coffee bean price, and its p-value is smaller than 0.05. In the previous literature review section, our report found Brazil is a significant source of U.S. coffee bean imports. One possible reason is that, in the US, the demand for coffee consistently exceeds the supply. So, the quantity of coffee bean imports increased slightly and could not satisfy the order in the market.

2.5. Analyzing Variables Influenced by COVID-19

This section analyzes variables with different significance before and after the COVID-19 pandemic.

2.5.1. EU Tariff

Unlike the pre-covid model, the EU tariff shows insignificance in the adjusted regression model during COVID-19, with a more considerable significance (p-value >0.05). To explain this phenomenon, the International Coffee Council (ICC) report illustrates that the import tariffs have

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been reduced in importing countries through various regional and multilateral trade agreements. So, many exporting countries are benefiting from this relatively free trade. However, these particular tariff preferences granted to some exporting countries are becoming less critical as the difference between general and preferential rates is narrowing.

2.5.2. US Coffee Import From the World & Brazil Coffee Export From the World

Compared with the pre-COVID era, these two variables significantly affect coffee beans' prices, with the lowest p-value of almost 0. There are two main reasons for this phenomenon: transportation and Brazilian production problems. Due to the rapid spread of the epidemic, most countries have banned trade imports and exports at various times, and there are also companies at risk of bankruptcy, which leads to the scarcity of supply. Furthermore, Brazil is facing natural disasters such as droughts that have affected coffee bean production, which can lead to a decrease in Brazilian exports. Although the model shows that Brazilian weather and rainfall had no direct impact on the price of coffee beans, subsequent reports will further examine the impact of these two factors on Brazilian production and the indirect impact on coffee bean prices.

2.5.3. BRL/USD

Compared with the significance before the epidemic, the exchange rate of BRL and USD had no valid impact on the pricing of coffee beans during the COVID-19 pandemic. Studies show that after the outbreak of COVID-19. However, the exchange rate is less affected, and the impact of monetary policy on the financial market, including the foreign trade market, is significantly reduced [9]. In this case, the influence of economic policies, especially the exchange rate, has been considerably weakened in Brazil's financial market of coffee beans. In previous studies mentioned above, monetary policy has influenced local markets and coffee beans production and indirectly influenced coffee pricing in the US. While monetary policy is less linked to local coffee beans production, the impact of Brazilian economic policy on coffee prices in the US is also lessened.

3. Conclusion

3.1. Summary

For the pre-pandemic era, the results suggest that US tariff & EU tariff, monetary policy in Brazil, and the US coffee beans imported from Brazil are the main factors that affect the US Coffee C futures pricing. Higher US & EU tariffs, lower BRL's exchange rate against USD (the representation of monetary policy), and higher exports from Brazil to the US can cause the coffee pricing to increase.

For the post-pandemic era, the results indicate that EU tariffs, US coffee imports from the world & Brazil coffee export from the world, and monetary policy in Brazil's influence on coffee bean pricing have changed drastically. The analysis supports that EU tariffs and monetary policy in Brazil have become unimportant factors. In contrast, US coffee import from the world & Brazil's coffee export from the world has become critical.

3.2. Interpretations

In line with the hypothesis, monetary policy on agriculture in Brazil, the total export of Brazil's coffee beans to the world, the total amount of coffee beans imported by the United States from worldwide, and EU tariffs were affected by the COVID-19 social environment and led to the fluctuation of US Coffee C future price. However, contrary to the hypothesized association, coffee beans imported by the US from Brazil and US tariffs are not influenced by the social environment of COVID-19 and remain significant reasons for the change of coffee pricing. In addition, the results contradict the

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previous assumptions that precipitation in Brazil, the temperature in Brazil,EU tariffs, inflation in US, and household income in US are the factors that can affect the US Coffee C futures pricing for all periods.

3.3. Implications

These results build on existing evidence of factors affecting the coffee beans chain (production, export, import, sale) from Brazil to the US, covering a wide range of possible elements and using the adjust feature of the multiple linear regression model to identify the most critical factors for pricing coffee beans. Combining this, this paper provides a new insight into the influence of the COVID-19 social environment by dividing collected data into two periods and analyzing separately to compare and contrast the significant changes. Thus, concluding.

These results should be considered when considering how to use the factors affected by COVID-19 to predict the future pricing of US Coffee C futures or other similar import and export-based products.

3.4. Limitations

The ambiguity limits the generalizability of the results about the exact period before and after the outbreak. The two time periods differ for every country, including Brazil and the US. However, to control the analysis based on the data of two countries in the same period, this work can only use the division of periods in units of years.

The lack of post-pandemic data impacts the reliability of these results. It took only two years for many countries to overcome the epidemic. Monthly data were used in this paper, indicating that only 24 data were collected after the outbreak. It is a relatively small amount of data for stable analysis.

3.5. Recommendations

To solve the problems mentioned in the limitations, further research is needed to establish a more accurate chronology of the pre and post-pandemic periods by selecting import and export countries with similar COVID-19 timelines for analysis. The timeline is ideally exact to months. Moreover, future studies should accumulate more post-epidemic data for analysis to ensure the accuracy of the results.

Besides, future research should consider household income in the US. In this work, the multiple linear regression model shows an overall significance of income in the US towards coffee pricing. Nonetheless, for both before and after the COVID-19 pandemic models, the payment in the US shows insignificance. This is worth deeper research for this reason.

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