Analysis on CAF Economic Export

STA 137 Final Project

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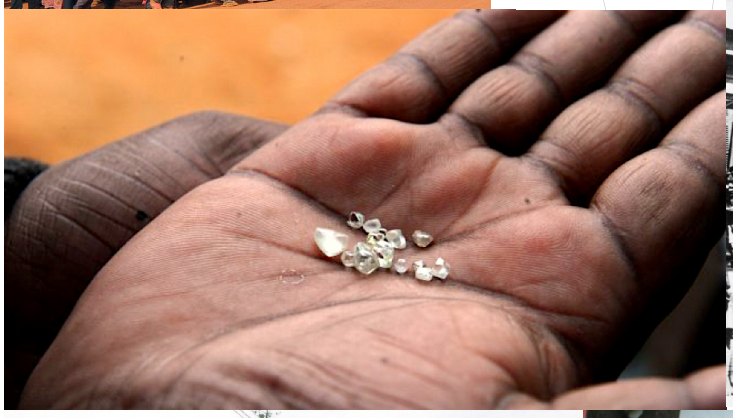



Background

The country we are researching this time, the Central African Republic (CAR), is bordered by Chad to the north, Sudan and South Sudan to the east, the Democratic Republic of the Congo and the Republic of the Congo to the south, and Cameroon to the west. It was formerly a French colony and declared its independence on August 13, 1960.

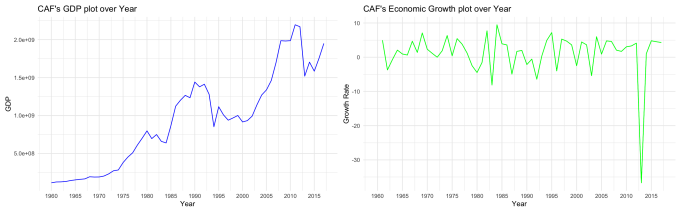
As a landlocked country in Central Africa, the Central African Republic mainly consists of tropical savannas and rainforests, so its economy primarily relies on relatively primitive agriculture and mining. Agricultural crops include cassava, maize, peanuts, and cotton. Mineral resources include diamonds, gold, and uranium. There is also significant timber export. However, due to its weak economic foundation, underdeveloped industrial base, and limited domestic consumption capacity, the Central African Republic heavily relies on exports. The most important exports are timber, diamonds, cotton, and coffee. Belgium is the country's main trading partner, purchasing most of the diamond exports. France is also a key partner, buying most of the produced coffee and tobacco. China, Germany, and Saudi Arabia are other important trading partners. Nevertheless, due to prolonged political instability and ongoing civil conflicts, economic development has been severely affected.

The focus of this project is to try to discover the relationship between the export economy of the Central African Republic from 1960 to 2017 and some historical periods and events. It also aims to identify patterns through time series (ARIMA) and attempt to predict future export economic developments.

Description of Dataset

The database includes information on the economic development of the Central African Republic from 1960 (the year of independence) to 2017. This includes the Gross Domestic Product (GDP) for each year and its growth rate, the Consumer Price Index (CPI), import and export values, as well as the population size.

Although my aim is to analyze the export economic data, we can still briefly analyze and derive insights regarding the overall development history and situation of the Central African Republic.



Based on the line charts depicting the Gross Domestic Product (GDP) and its growth rate over time in the Central African Republic, we observe that although the country's economy has been on a growth trend since 1960, it has experienced significant fluctuations throughout the period. Severe negative growth occurred during certain periods (1990-1995, 2010-2015). We attempt to correlate this with the export economy and speculate that the Central African Republic's economy is highly dependent on the export of commodities such as diamonds, gold, timber, and agricultural products, making it vulnerable to global market fluctuations and internal unrest. Moreover, multiple instances of political instability, coups, and civil conflicts have had a significant impact on the stability and growth of its export economy. In the following analysis, we will attempt to verify this through a detailed examination of the export economy.

Methodology

$$X_t - \alpha_1 X_{t-1} - \ldots - \alpha_{p'} X_{t-p'} = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$$

Our goal is to attempt to fit an ARIMA model and make forecasts, with the specific steps outlined as follows:

Plot the data and identify any unusual observations.

If necessary, transform the data (using a Box-Cox transformation) to stabilize the variance.

If the data are non-stationary, take first differences of the data until the data are stationary.

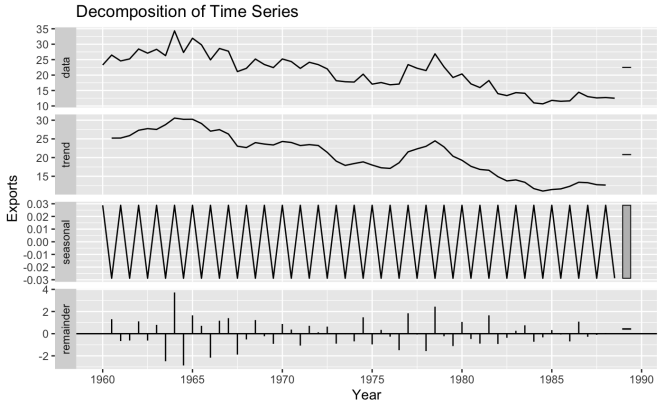
Examine the ACF/PACF: Determine if it is an MA or AR process for the differenced data.

Try your chosen model(s) and use the AIC/BIC criteria to search for a better model.

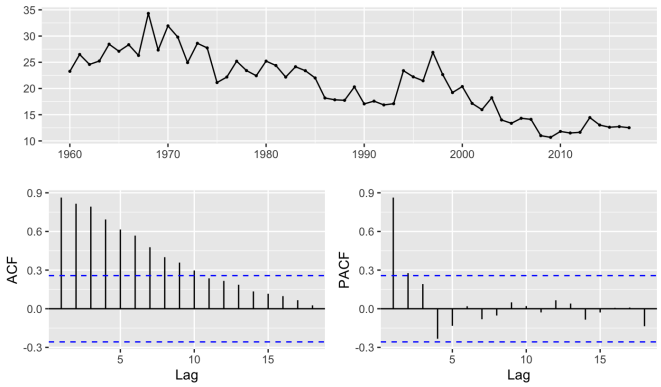
Check the residuals from your chosen model by plotting the ACF of the residuals and performing a portmanteau test on the residuals. If they do not resemble white noise, try a modified model.

Once the residuals look like white noise, calculate forecasts.

Examination and Prediction



Although the original data is counted in units of one year, we can still attempt to capture the trend, seasonal, and random components of the time series by changing the frequency. Similar to the trend observed in GDP, the export trade of the Central African Republic shows an overall declining trend with a periodicity of approximately five years, and it currently appears to be stabilizing.



Based on the time series plot of the export data from the Central African Republic from 1960 to 2017, we observed that the volatility of export data varies significantly over different time periods, especially the sharp decline in the 2000s and the low levels in the 2010s. This indicates the possibility of heteroscedasticity (variance instability). The time series plot further confirms this, as the ACF plot shows significant autocorrelations at multiple lags, with a slow decay, usually indicating a non-stationary time series. The PACF plot shows significant autocorrelation at lag 1, followed by a rapid decay, suggesting that the time series may have an autoregressive component.

Moreover, we performed ADF and KPSS tests on the original time series. For the ADF test, since the p-value is greater than 0.05, we cannot reject the null hypothesis (the time series has a unit root, i.e., non-stationary). This indicates that the time series may be non-stationary. For the KPSS test, since the p-value is less than 0.01, it also indicates that the time series is non-stationary.

```
        Augmented Dickey-Fuller Test

data:  tts_fp
Dickey-Fuller = -3.1744, Lag order = 3, p-value = 0.1006
alternative hypothesis: stationary

Warning in kpss.test(tts_fp) : p-value smaller than printed p-value

        KPSS Test for Level Stationarity

data:  tts_fp
KPSS Level = 1.2824, Truncation lag parameter = 3, p-value = 0.01
```

Therefore, we attempted to perform Box-Cox and log transformations. However, after both transformations, the p-values were 0.2281 and 0.1821, respectively, which did not improve the situation. Consequently, we decided to take the first-order difference of the original data, and if necessary, perform the second-order difference.

After performing the first-order differencing and conducting the ADF & KPSS tests, we found that the ADF p-value was still greater than 0.05, so we cannot reject the null hypothesis (the time series has a unit root, i.e., non-stationary). This suggests that the time series may still be non-stationary.

However, after performing the second-order differencing, we were fortunate to obtain an ADF p-

value of 0.01, allowing us to reject the null hypothesis, indicating that the second-order differenced series is stationary. For the KPSS test, the p-value was 0.1, greater than 0.05, so we cannot reject the null hypothesis, suggesting that the second-order differenced series is likely stationary.

Now that we have obtained a stationary series after the second-order differencing, indicated by both the ADF and KPSS tests, we can consider fitting an ARIMA model to the second-order differenced series.

```
        Augmented Dickey-Fuller Test

data:  diff2_tts_fp
Dickey-Fuller = -5.883, Lag order = 3, p-value = 0.01
alternative hypothesis: stationary

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  p-value greater than printed p-value

        KPSS Test for Level Stationarity

data:  diff2_tts_fp
KPSS Level = 0.04633, Truncation lag parameter = 3, p-value = 0.1
```
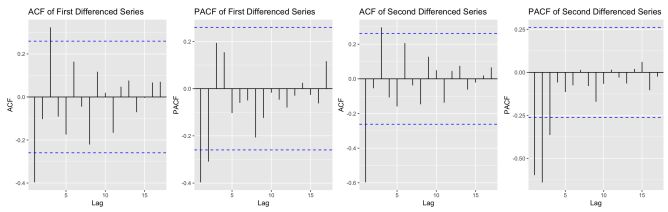

After plotting the ACF and PACF for the second-order differenced series, we found that at lags 1 and 2, the ACF values are significantly negative and then gradually decrease. This suggests the presence of a moving average (MA) component. Similarly, at lags 1 and 2, the PACF values are significantly negative and then rapidly decrease, usually indicating an autoregressive (AR) component.



Based on the above analysis, I attempted to fit the following ARIMA models and use the AIC/BIC criteria to select the best model: ARIMA(2, 2, 0), ARIMA(0, 2, 2), ARIMA(2, 2, 2). To ensure a comprehensive analysis, I also considered the first-order differencing plots and attempted to fit the following models, as overly strict p-value criteria might exclude potentially suitable models: ARIMA(2, 1, 0), ARIMA(0, 1, 3), ARIMA(1, 1, 1)

By fitting and calculating the models mentioned above, including auto ARIMA and stepwise ARIMA, we compiled the following table that presents various statistical information for each model. We selected the top four models based on their AICc values and conducted root tests to ensure all red points fall within the unit circle. Our findings confirmed that all red points were indeed within the unit circle. Therefore, the models are both stable and invertible. Based on these results, we can confidently choose the model with the smallest AICc value, which is ARIMA(2,1,0), for forecasting.

$$\Delta y_t = -0.5050\Delta y_{t-1} - 0.2897\Delta y_{t-2} + \epsilon_t$$

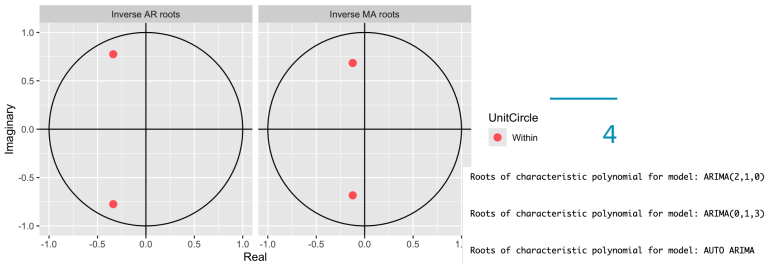
This selection ensures that our forecasts are based on a model that not only fits the historical data well but also adheres to the necessary statistical properties of stability and invertibility. This robust model selection process enhances the reliability and accuracy of our future predictions, providing

results_final

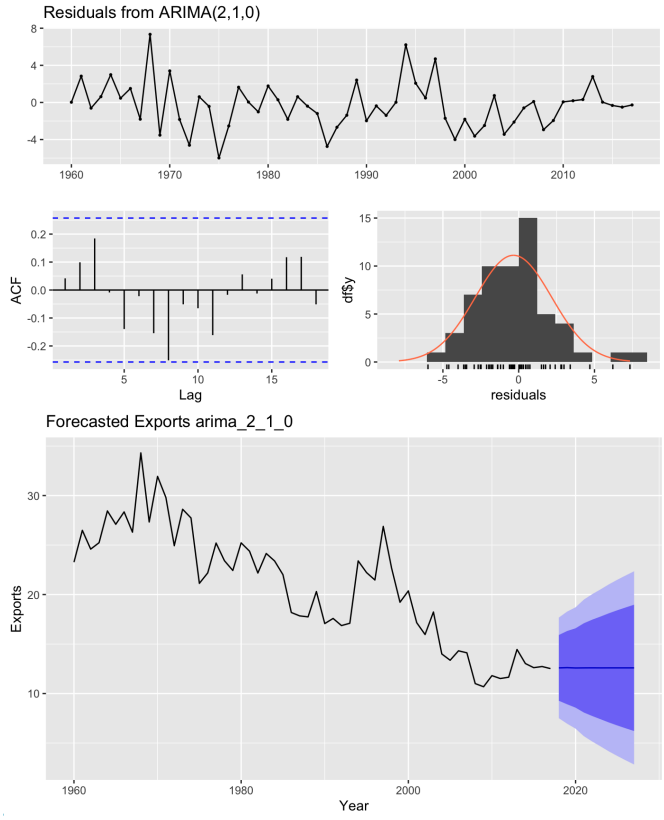
Model	AICc
ARIMA(2,2,0)	287.124776953821
ARIMA(0,2,2)	278.676557799789
ARIMA(2,2,2)	278.907589772749
ARIMA(2,1,0)	274.989673037223
ARIMA(0,1,3)	275.016905882921
ARIMA(1,1,1)	277.88000383611
AUTO ARIMA	275.373248894175
STEPWISE AUTO ARIMA	275.373248894175

valuable insights for further analysis and decision-making.

Based on the Auto ARIMA model, which corresponds to ARIMA(2,1,0), and ACF plot in graph of the residuals from the model shows that most autocorrelations are within the threshold limits, which indicates that the residuals are like white noise. We forecasted the Central African Republic's export economy for the next ten years. The



forecasted export values are approximately 12 units per year. The confidence intervals are detailed below. According to our projections, the export economy is expected to stabilize in the coming years.



Conclusion

Based on the analysis of the export data, we can conclude that the export data of the Central African Republic shows a significant long-term downward trend. Although there were export peaks during certain periods (such as after Bokassa's coup in 1966), the overall trend is declining. By decomposing the data, we found that there is a certain seasonal fluctuation, generally in cycles of five years. These export fluctuations may be related to changes in international market demand or domestic political events. Using the ARIMA model to forecast the export situation for the next ten years, the results indicate that the export economy tends to stabilize, but at a low level. However, unforeseeable events may affect this conclusion.

When we look back at the export economic development of the Central African Republic and try to establish connections with historical events, we find that changes in the export economy are not isolated. After 1966, CAR's export business increased significantly, reaching the highest recorded values. At the same time, Central African military officer Bokassa staged a coup and took power. Given CAR's many important mineral resources (including uranium and diamonds), countries like France, Switzerland, and the United States supported Bokassa and traded with him, leading to a logical increase in export figures.

After 1993, the export economy experienced considerable fluctuations. This period coincided with CAR's first multiparty democratic elections, resulting in Ange-Félix Patassé's presidency. Although the change in governance improved the export economy to some extent, economic challenges persisted, and export activities remained volatile.

To this day, CAR has been embroiled in civil wars among various armed groups. The ongoing insecurity has devastated the economy, leading to a significant decline in export activities. Major export commodities like diamonds and timber have been illegally smuggled out of the country, resulting in revenue losses. Furthermore, global changes in individual export products have also been crucial. The issue of blood diamonds in the late 1990s led to a decrease in international demand for CAR's diamonds, especially after the Kimberley Process Certification Scheme was implemented in 2003, making it difficult for non-certified diamonds to enter legal markets. During this period, export trade continued to decline.