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Research Article

Forecasting of Rice Import Data: An Application of ARIMA Model

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ABSTRACT

Forecasting the import and export of any agricultural product is crucial to making the best decisions for the policymakers and stakeholders of a country. Bangladesh is not beyond it. Many agricultural products like rice, lentils, and onions have great demand in Bangladesh. As a result, policymakers made decisions to import those agrarian products when necessary. This study has analyzed the milled rice import data of Bangladesh to select the best-fitted ARIMA model and to forecast for the upcoming ten years. This study has determined ARIMA (2, 1, 1) as the best-fitted model from a set of Autoregressive Integrated Moving Average (ARIMA) models based on rice import data of Bangladesh from 1960 to 2022 and forecasted for the next ten years following the Box-Jenkins methodology.

Key Words: Rice Import, ARIMA Model, Box-Jenkins Methodology, Rice Import Forecasting, Rice Import Statistics

Introduction

Forecasting international trade is very important for that; it performs a very momentous role for the economic growth of a country (Rahman et al., 2016). Academics and policymakers have a great interest in import, export, and economic growth known as international trade. The first reason for this observable fact is to raise GDP, whereas the other reason is to develop the quality of life of the inhabitants of a country (Turan and Karamanaj, 2014).

Bangladesh, a developing nation with an agricultural economy, is actively pursuing economic growth. The agriculture sector, which accounts for around 22% of Bangladesh's GDP, is the backbone of the country's economy. 9.5 percent of the agricultural GDP is produced by rice alone, or twelve percent of gross operating profit (GOP), which comes from crops (BBS, 2008).

One of the most significant crops and a key agro-product of the economy of Bangladesh is rice. Bangladesh has the highest average rice yield by international standards in South Asia. Regarding global rice production, Bangladesh will overcome Indonesia to occupy third place with an increase in output of 38.54 million tons (MT) over the production years 2019–20. Including 1.2 million ROHINGYA refugees, a surplus of 4.0 MT will be sufficient to cover the demands of 167.0 million people. Bangladesh has been a leader in the fight against hunger on an international scale and has had great success in turning the country from one with ongoing food shortages to one with surplus food (Momen, 2020). However, Bangladesh frequently needs to import rice from other countries every year, which creates anxiety for the stakeholders of Bangladesh.

As a result, it is important to assess the rice import data of Bangladesh based on previous trends significantly. But, for Bangladesh, the number of studies of the individual crops in terms of the import and export is very limited, where most of the studies focus on the total import, export, and production of agriculture. Once more, this study is being conducted for a sustainable Bangladesh, that the "Covid-19," the "Ukraine-Russia war," and "climate changes" of the world have had a great impact on Bangladesh. As food security is obvious for a country, this study concentrates on historical rice import data of Bangladesh from 1960 to 2022.

METHODOLOGY

Agriculture plays a vital role in the economy of Bangladesh. Analysis and forecasting of rice import data can contribute to the strategy of importing and exporting rice. As a result, the objectives of this study have been carefully defined so that it can create value for policymakers and the stockholders of Bangladesh.
The objectives are given below:

1. To determine the best-fitted ARIMA model
2. To forecast the rice, import of Bangladesh for the upcoming ten years

LITERATURE REVIEW

The title of this work is "Forecasting of Rice Import Data: An Application of the ARIMA Model.". Analysis of import data is crucial for a country because it shows the consumption and production behavior of consumers and producers along with the barriers and opportunities of a country in terms of the demand and production of a crop. However, there are not many studies that are concerned about import statistics of individual crops. Though most of the studies include the total import, export, and production, this study has found a chance to investigate rice import data and forecasting for the next ten years.

Is there any noteworthy correlation among the factors of international trade similar to export, import, and GDP? In the paper "An Empirical Study on Import, Export, and Economic Growth in Albania," Turan & Karamanaj have shown that the growth of the economy of a country is significantly influenced by its imports and exports. By using several empirical studies, microeconomic models, and the annual data from the years 1984 to 2012, it has been revealed that "GDP has an equilibrium connection with imports and exports over the long run in the economy of Albania. The interesting outcome of the study is that a 1% annual increase in imports will reduce GDP by 0.23% (Turan and Karamanaj, 2014).

In the year 2021, a study was attempted to analyze the trend and predict the agricultural export of India in the paper titled "Forecasting of Indian agricultural export using ARIMA model.". This study uses univariate historical data to analyze its trend and forecast future cycles. It came to light that, as a percentage departure from the estimated and observed figures, the estimated values of agricultural exports from 2016–17 to 2018–19 were quite similar to the actual values. It was in the range of -2 to -4, and the projected values for the three years ahead of 2019 to 2022, based on the ARIMA model, are within confidence limits (Goyal *et al.,* 2021).

The goal of the study titled "Rice production in Bangladesh employing the ARIMA model" was to determine the enlargement pattern and evaluate the most effective model for accurately projecting the Aman, Aus, and Boro rice in the land of Bangladesh. The time series information for "Aus" and "Aman" emerged as first-order identical stationary, whereas the Boro was second-order stationary. According to the study, the most effective models for the production of Aus, Aman, and Boro rice were ARIMA (4, 1, 4), ARIMA (2, 1, 1), and ARIMA (2, 2, 3). ARIMA models were more effective in short-term forecasting than the other deterministic models based on the study (Awal & Siddique, 1970).

To make the best decisions for the government and the agricultural sector in India, forecasting any agricultural product is crucial. Through the use of an appropriate model and time series data from 1950–1951 to 2016–2017, Sunali Mahajan, Manish Sharma, and Amit Gupta have constructed a suitable model for rice production by using autoregressive integrated moving average (ARIMA) mostly by following the Box-Jenkins methodology. Analytical tests showed that the ARIMA (0, 2, 2) model is the best fit for forecasting based on parameters, Akaike Information Criteria (AIC), model magnitude, and Schwartz Bayesian Information Criteria (SBIC). The predicted outcomes indicated there are plans to enhance rice production in India (Mahajan *et al*., 2020).

The government of Saudi Arabia has established several strategies, including Saudi Vision 2030 for the potential projection of the country. The paper titled "Forecasting exports and imports through an artificial neural network and autoregressive integrated moving average" has modeled the artificial neural networks (ANN) and autoregressive integrated moving averages (ARIMA) to forecast the total yearly exports and imports of Saudi Arabia. This study revealed that "the total yearly import and export of the Kingdom of Saudi Arabia can be predicted properly by using ARIMA (1, 1, 2), and ARIMA (0, 1, 1) and ANN models (Alam, 2019).

The scientific community has newly shown a lot of interest in the behavior of econometric and machine learning model forecasting. The study "Forecasting Rice Production of Bangladesh Using ARIMA and Artificial Neural Network Models" has compared the forecasting behavior of Autoregressive Integrated Moving Average (ARIMA) and Artificial Neural Network (ANN) using univariate time series data of yearly rice production of Bangladesh (1972 to 2013). Based on RMSE, MAE, and MAPE values, the results have demonstrated that the estimated error of the ANN (Artificial Neural Network) model is significantly greater than the estimated error of the ARIMA model. As a result, the ARIMA model can provide better forecasting over the ANN for the rice production of Bangladesh (Sultana and Khanam, 2020).

The economic status of Bangladesh mostly depends on agriculture, and the principal crop of Bangladesh is rice. The majority of Bangladeshi citizens rely on rice to meet their nutritional needs. The nation has achieved self-sufficiency in rice production, despite the strain from overpopulation. To anticipate rice output in the districts of Jessore, Dinajpur, and Kushtia, a study has been done and named "Forecasting rice production in Jessore, Dinajpur, and Kushtia districts of Bangladesh by time series model" that has tried to verify the optimal ARIMA model. In this study, the ARIMA (1, 2, 1) has represented the Jessore and Dinajpur districts, where the ARIMA (1, 2, 2) models were used for Kashia, respectively (Rahman and Hossain, 2019).

The nationwide rice output decreased in 2019, particularly in the province of North Sumatra. The titled study "The Effectiveness of the ARIMA Method in Rice Production Forecasting of North Sumatera Province" discovered the predicted amount of rice production using the Box-Jenkins method. The ARIMA (2, 0, 6) model exhibited an up-down trend. The MAPE (Mean Absolute Percentage Error) deviation value was obtained by 12.84%, indicating that the forecasted model is quite effective (Siregar & Nababan, 2022).

Considering all the above literature results, this study has found the opportunity to determine the appropriate ARIMA model for rice import data of Bangladesh and to perform forecasting for the next ten years with the best-fitted ARIMA model, which helps policymakers and stakeholders to make decisions.

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The Box-Jenkins methodology has been followed to determine the best fit ARIMA model and to forecast the upcoming ten years with the appropriate diagnostic checking.

RESEARCH METHODOLOGY

Time series analysis has many important applications in a vast subject area of study, including business, econometrics, finance, planning, production control, resource allocation, pattern recognition, and signal processing, even in astrophysics and astronomy. Time series data is one of the significant types of data that is used in empirical analysis. This study has collected rice import data from Bangladesh from 1960 to 2022 and analyzed the data through the ARIMA model for the forecasting of the next ten years, following the Box-Jenkins methodology. As a result, this study precisely describes the description of data & tools and the Box-Jenkins methodology.

DESCRIPTION OF THE DATA & TOOLS:

The main source of rice import data for Bangladesh is the "United States Department of Agriculture," which has been published on the website named "indexmundi.com.". From the source, this study has processed the data set as univariate data. The data set has sixty-three rows and two columns that are "time" and "import" sequentially. There were no missing values in the data set. To perform data analysis and forecasting, this study has taken "RStudio," which is an integrated development environment (IDE) of "R," a statistical and graphical programming language software. Augmented Dickey-Fuller test (ADF), Phillip-Perron (PP), & Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests were performed to check the stationarity of data and followed the Box-Jenkins methodology. All-important values of the imported data set are provided below:

Table 1: Important values of Rice Imports data set of Bangladesh

Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
10.0	167.5	367.0	559.1	728.5	3200

The Box-Jenkins Methodology:

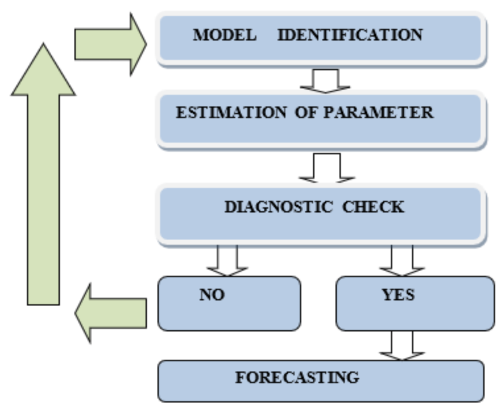

Figure1: Representation of the Box-Jenkins Methodology for Time Series Modeling

As the purpose of forecasting and estimating univariate time series is to predict future events, Box and Jenkins' (1976) method was liked by many researchers to perform the structural process. To apply the Box-Jenkins Methodology, one needs either a time series that is stationary or one that could become stationary after the first or second differencing. The justification for the requirement of stationary data is that every model contingent on them can be understood as stable, providing a strong foundation for forecasting. The four steps that make up the Box-Jenkins approach are identification, estimation, diagnostic check, and forecasting (Zakai, M., 2014). This study has followed the Box-Jenkins methodology that is depicted below:

The first purpose of this study is to determine the best-fitted ARIMA model. To determine the best-fitted model, this study has imported the data into "R Studio" software and found that this is a univariate time series data set that has 63 rows and 2 columns. The headings of the two columns are time and import value of the particular year sequentially. So, the data set has been converted as time series data into "R Studio" and plotted for visualization.

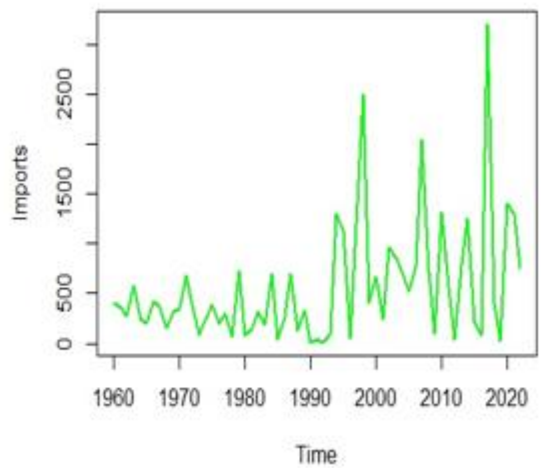

Fig 1: Data Plot

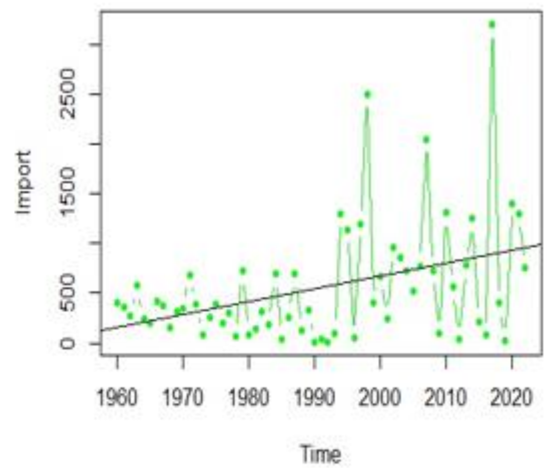

Fig 2: Dot plot with Trend

In the above diagrams, figure 1 shows the plotting of the rice import data as time series data where the x-axis represents the time and the y-axis represents the amount of rice imported in thousands of metric tons (1000 MT). Figure two shows the dot plot for the same data set and clearly shows that there is a positive trend in the data set.

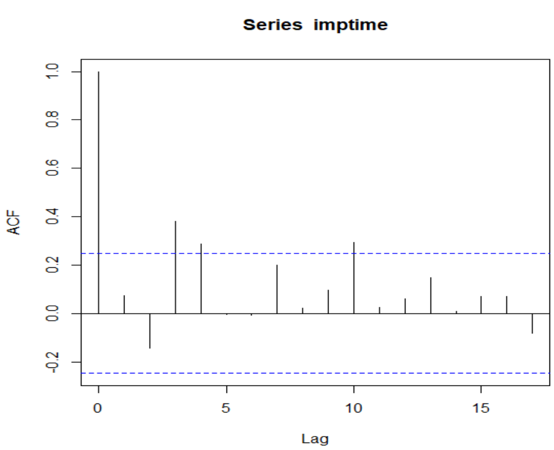

Fig 3: ACF Plot

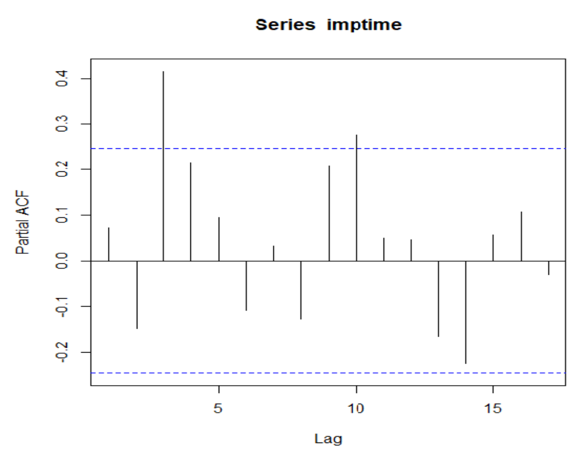

Fig 4: PACF Plot

It is obvious that, to perform time series forecasting based on the Box-Jenkins method, time series data must be stationary. The above figures, 'ACF' & 'PACF,' tell us that there can be a correlation between the leg value and the time series that may not be stationary. To perform the stationary check, this study has performed the Augmented Dickey-Fuller, Phillips-Perron (PP) & Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test and placed the results in Table 2. Among the tests, the ADF & KPSS test has determined the time series is not stationary, and the PP test has determined the time series is stationary. As a result, this study has determined that the time series is not stationary.

Table 2: The ADF, PP & KPSS test

Test	Ho	p-value	Result	Comment
Augmented Dickey-Fuller (ADF)	The series is not stationary	0.08	The printed p-value is greater than the p-value at 5% CI (0.05)	Fail to reject the null hypothesis
Phillips- Perron (PP)	The series is not stationary	0.01	The printed p-value is smaller than the printed p-value at 5% CI (0.05)	Reject the null
Kwiatkowski–Phillips–Schmidt–Shin (KPSS)	The series is stationary	0.01	Printed p-value smaller than printed p-value at 5% CI (0.05)	Reject the null

To make this time series stationary, this study has performed the first difference transformation and found the series as a stationary one by re-testing the ADF, PP, & KPSS test. After the first difference, the result of the ADF, PP & KPSS tests is given below in Table three with the plot diagram (Fig. 5).

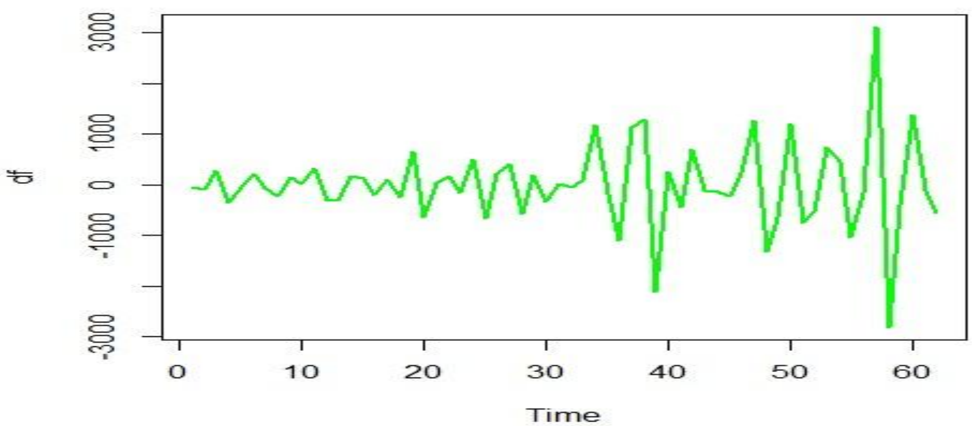

Figure 5: Data plot after differencing

Figure five shows the data plot after the first differencing, and Table three describes the ADF, PP & KPSS test results. The data plot after the first differencing shows us that there is a constant mean at the zero level.

Table 3: ADF, PP & KPSS Test after first differencing

Test	**Ho**	**p-value**	**Result**	**Comment**
Augmented Dickey-Fuller (ADF)	The series is not stationary	0.01	Printed p-value is greater than p-value at 5% CI	Reject The null Hypothesis
Phillips-Perron	The series is not stationary	0.01	The printed p-value is smaller than the printed p-value at 5% CI	Reject the null Hypothesis
Kwiatkowski–Phillips–Schmidt–Shin (KPSS)	The series is stationary	0.1	Printed p-value smaller than printed p-value at 5% CI	Accept the null Hypothesis

In the above table, the three tests, "ADF," "PP," and KPSS, have shown the time series is stationary, that the printed p-value is less than 0.05 for the "ADFandPP" tests, and the printed p-value is greater than 0.05 for the "KPSS" test. So, each test has defined the time series as stationary. Figure six and Figure seven given below show the auto-correlation function (ACF) & partial auto-correlation function (PACF) that have been plotted after the first differencing of the time series.

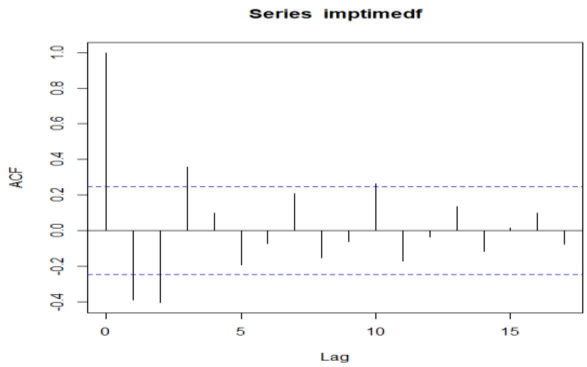

Fig 6: ACF after differencing

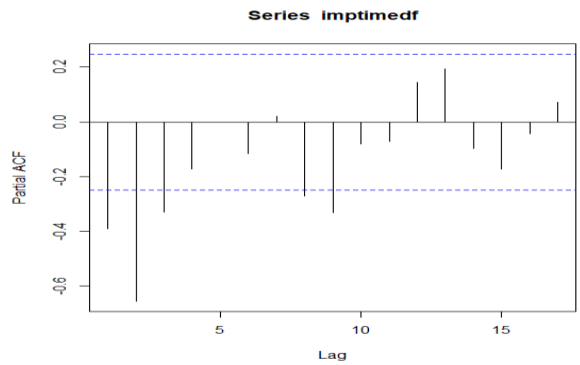

Fig 7: PACF after differencing

As the time series data has become stationary, this study has determined that the value of "d" in the ARIMA model is one (d=1). Now we can select the best fit ARIMA model based on the values of the Akaike information criterion (AIC). The models with different parameters have been chosen based on the prominent legs that cross the boundary lines in the ACF & PACF plots. The model that provides the lowest AIC value will be treated as the best-fitted model. In the concern of the same value, we also consider Bayesian Information Criteria (BIC) and the error values, mostly the Root Mean Square Error (RMSE). To find out the best-fitted model, the "auto arima" function can help us to determine the best-fitted model too. This study has performed the model selection task manually and found the same result through the auto ARIMA function.

Table 4: The Best Fit ATIMA Model.

ARIMA (p d q)	**AIC**	**BIC**
ARIMA (1,1,1)	972.98	979.36
ARIMA (1,1,2)	970.46	978.96
ARIMA (1,1,3)	967.73	978.36
ARIMA (2,1,1)	962.39	970.89
ARIMA (2,1,2)	964.00	974.63
ARIMA (2,1,3)	964.73	977.48
ARIMA (3,1,1)	963.38	974.01
ARIMA (3,1,2)	964.72	977.48
ARIMA (3,1,3)	964.21	979.09

From table four, this study has found that the lowest AIC value is 962.39 and the lowest BIC value is 970.89, which determines the ARIMA (2, 1, 1) is the best-fitted model. This study also notes from the results of table five that the lowest RMSE value is 492.54, whereas the RMSE of the ARIMA (2, 1, 1) model is 520.53. Though the AIC value of ARIMA (3,1,3) is 964.21, this study has determined ARIMA (2,1,1) as the best-fitted one.

Table 5: Error values of different models

ARIMA(p,d,q)	ME	RMSE	MAE	MPE	MAPE	MASE
ARIMA (1,1,1)	77.80	567.84	352.75	-274.60	306.92	0.65
ARIMA (1,1,2)	73.19	547.42	370.97	-245.86	286.17	0.58
ARIMA (1,1,3)	63.25	554.21	331.15	-219.96	251.54	0.61
ARIMA (2,1,1)	46.27	520.53	312.90	-202.40	247.54	0.57
ARIMA (2,1,2)	57.18	518.34	317.09	-199.85	255.47	0.58
ARIMA (2,1,3)	63.37	512.59	312.56	-191.80	235.65	0.57
ARIMA (3,1,1)	65.73	515.43	318.80	-197.44	251.05	0.58
ARIMA (3,1,2)	66.73	512.70	314.18	-195.20	245.42	0.58
ARIMA (3,1,3)	67.27	492.54	317.04	-164.61	198.28	0.58

Now it has become worthy to forecast the rice import data of Bangladesh with the ARIMA (2, 1, 1) model for the next ten years, but before that, we need to do a diagnostic check. Diagnostic checking helps us to detect misspecifications. To make a proper diagnostic check, it has to be sure that the time series data has no autocorrelation. It has a zero mean, and the time series data is normally distributed.

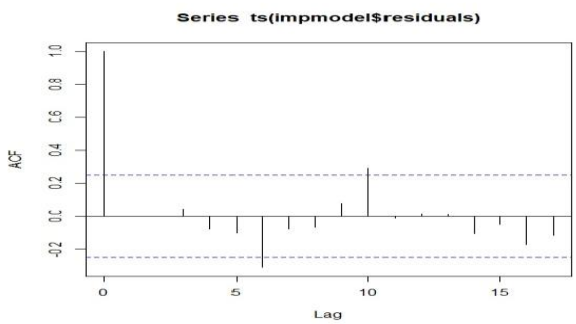

Fig- 8: Residuals ACF plot

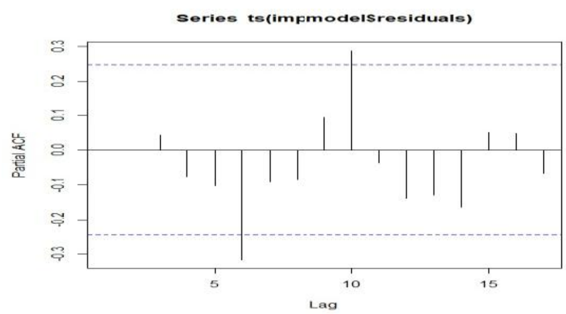

Fig-9: Residuals PACF Plot

By the 'ACF' and 'PACF' residuals diagram, figure eight and figure nine have shown that there is no auto-correlation in our time series residuals because only two lags have crossed the control line, which is acceptable. Figures ten, eleven, and twelve show that the time series data that we have taken has a zero mean. After fitting the ARIMA (2, 1, 1) as the best-fit model, it has been found that the time series data is normally distributed by distribution and QQ plot. So, this study is now able to forecast the time series data that is the concern of this study.

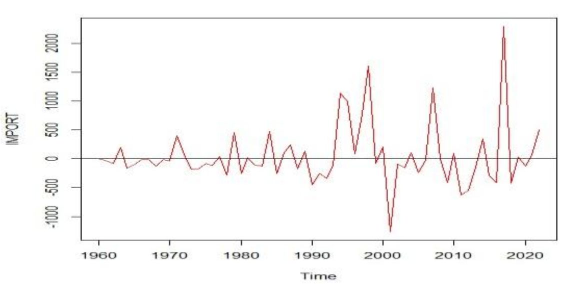

Fig-10: Zero Mean

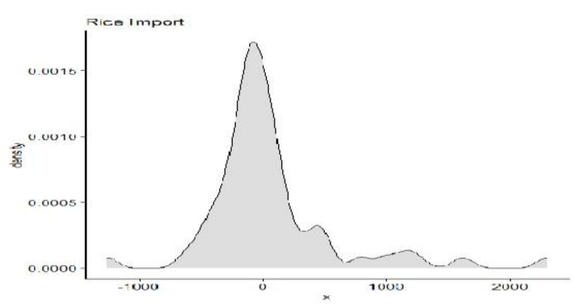

Fig-11: Distribution

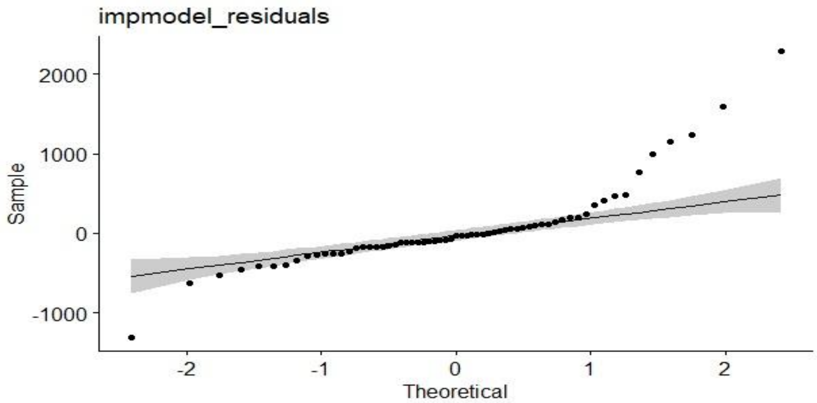

Fig 12: QQ Plot

Results and Discussions

Though the selected model has satisfied all the diagnostic requirements, this study forecasted the amount of rice that can be imported into Bangladesh during the next 10 years with an eighty percent (80%) confidence interval along with lower-class and upper-class limits. As the selected model has satisfied all the diagnostic requirements, Table 6 is given below, which shows the details of forecasted values.

Table-6: Forecasted Values of upcoming ten years, based on the ARIMA (2, 1, 1)

Point/ Year	**Forecast Values (1000 Metric Ton)**	**Lo-80(LCL)**	**Hi-80(UCL)**
2023	879.7137	190.3772	1569.050
2024	1122.5058	432.3938	1812.618
2025	974.3352	275.9310	1672.739
2026	897.3876	144.7170	1650.058
2027	1000.0043	214.5929	1785.416
2028	1005.8831	219.3796	1792.387
2029	950.5812	153.1607	1748.002
2030	965.9148	144.5996	1787.230
2031	989.5655	158.3087	1820.822
2032	973.7294	134.2690	1813.190

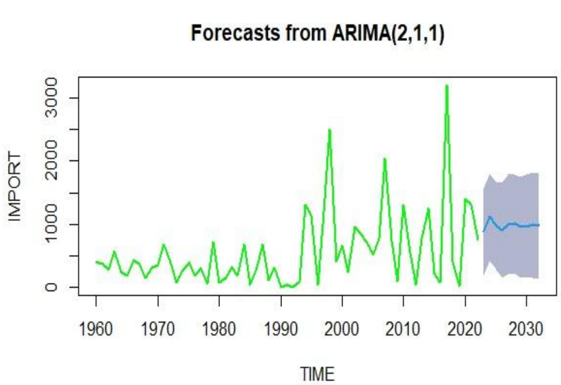

Fig-13: Visual Pattern of forecasting (1960-2032)

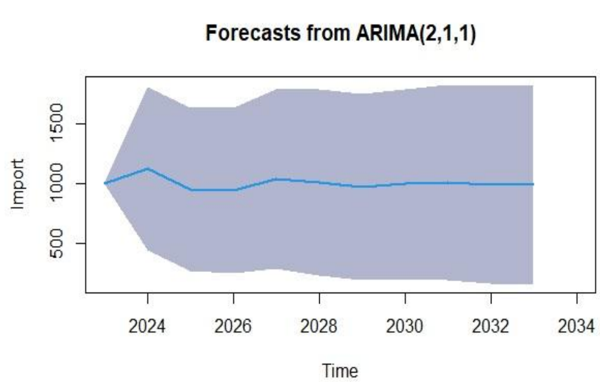

Fig-14: Visual Pattern of forecasting (2024-2032)

Throughout the result, this study has found that ARIMA (2, 1, 1) is the best-fitted model for forecasting the rice import data of Bangladesh from 1960 to 2022. Again, this study has made the forecasted values and the graph for 2023 to 2032 and found that Bangladesh will import nearly 880 thousand metric tons of rice (± 190.37, ± 1569.05 for an 80% confidence interval) in the year 2023 and nearly 974 thousand metric tons of rice (± 134.264, ± 1813.19 for an 80% confidence interval, respectively) in the year 2032. The amount of imported rice can be increased by 243 thousand metric tons compared to that of 2023 in the year 2024.

Even if the time series has become stationary, correlations can occasionally be found in the time series model. To get around this issue, this study used the BOX-Ljung Test by raising the lag value. However, instead of the p-value increasing as indicated in Table 7, the p-value does not appear below 0.05. It demonstrates the mathematical validity of the forecasting.

Table-7: BOX-Ljung Test

BOX- Ljung Test	
LEG /DF	p-value
5	0.9381
10	0.103
15	0.3157
20	0.1513
25	0.1902
20	0.3389

Limitation and Future Research

Even though the ARIMA model has demonstrated the best results in terms of "AIC" and "RMSE," a number of researchers discovered that the model's ability to reliably anticipate short time periods, such as two to four years, is a shortcoming. Neural networks or deep learning models can be effective for long-term forecasting. Additionally, the rice import data set showed inconsistent frequency, with a mean of 559.1 thousand metric tons and a maximum of 3200 thousand MT. As a result, this study has been forecasted with an 80% confidence interval.

Conclusion and Recommendations

This study has found that the ARIMA (2, 1, 1) is the best-fitted model to forecast and analyze the milled rice import data of Bangladesh from 1960 to 2022. This study determines that the amount of imported rice will be increased in the upcoming years compared to that of 2023. As previously mentioned, Bangladesh will import approximately 880 thousand metric tons of rice in 2023 (± 190.37, ± 1569.05 for 80% confidence interval) and 974 thousand metric tons of rice (± 134.264, ± 1813.19 for 80% confidence interval) in 2032. This study wants to conclude that Bangladesh should try to become self-dependent in the aspect of producing an agricultural product like rice. While both imports and exports contribute to a nation's economic success, effective strategic planning and execution of the production, import, and export policies, as well as local market control, are essential to gain competitive advantages through the importation of foodstuffs like rice and others, so that it can ensure the happy life of the inhabitants of Bangladesh.

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