Time Series Model to Forecast Fresh Coconut Exports from Sri Lanka

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Abstract - *Coconut accounts for approximately 12% of all agricultural produce in Sri Lanka with the total land area under cultivation covering 409, 244 hectares ranking second to rice production. The primary regions for coconut cultivation are the Puttalam and Kurunegala districts in North-Western Province and Gampaha district in the Western Province, forming what is known as the Coconut Triangle. This region accounts for 232,270 hectares (50.94%) of the overall coconut cultivation area. The remaining coconut cultivation areas are found in the Southern Province, specifically in the districts of Galle (13,833 hectares), Matara (14,946 hectares), and Hambantota (25,837 hectares), and in non-traditional regions of the Eastern and Northern provinces. The annual coconut production varies between 2,800 to 3,000 million nuts. Having advanced knowledge of exporting coconuts offers numerous advantages to Sri Lanka, particularly in terms of establishing forward contracts with other countries. Based on secondary data of annual fresh coconut exports from 1981 to 2020 obtained from the Coconut Development Authority (CDA) of Sri Lanka, the paper developed ARIMA (2,1,0) model to forecast export. The model was selected out of three parsimonious models which were identified from the Sample Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) of the stationary series and a comparison of significant parameters and lowest values of Akaike Information Criterion (AIC), Schwarz Bayesian Information Criterion (SBIC) and Hannan-Quinn Information Criterion (HQIC). The errors of the fitted model were found to be random and constant variance. The model was validated using 2021 and 2022 data. The percentage errors for 2021 and 2022 are 20.23% and -29.57% respectively. The predictions for 2023 and 2024 are 14696 and 15052 respectively. The model can be used effectively by the Coconut Development Authority for decision-making. However, it is suggested to develop the model further to reduce the percentage error.*

Keywords: ARIMA model, Forecast**,** Fresh Coconut Exports and Validate.

I. INTRODUCTION

A. Status of coconut in Sri Lanka

Sri Lanka has long prioritized the production of coconuts because it is an island centered on agriculture with abundant natural resources. Coconut production captures the third most significant commercial crop in Sri Lanka. Fresh coconuts have been a crucial ingredient in Sri Lankan cuisine, a driver of local employment, particularly in rural areas, and ultimately a significant source of inflows of foreign currency. Sri Lanka witnesses a concentrated growth of fresh nuts in the Puttlam, Kurunagala, and Gampaha districts, together known as the 'Coconut Triangle' (Sri Lanka Export Development Board, 2023b). The island ranks fourth in the world for the export of fresh coconut and goods made from it, followed by tea and rubber production and its byproducts. Sri Lanka exports goods made from coconut and its derivatives under three main products: Coconut Fiber products,

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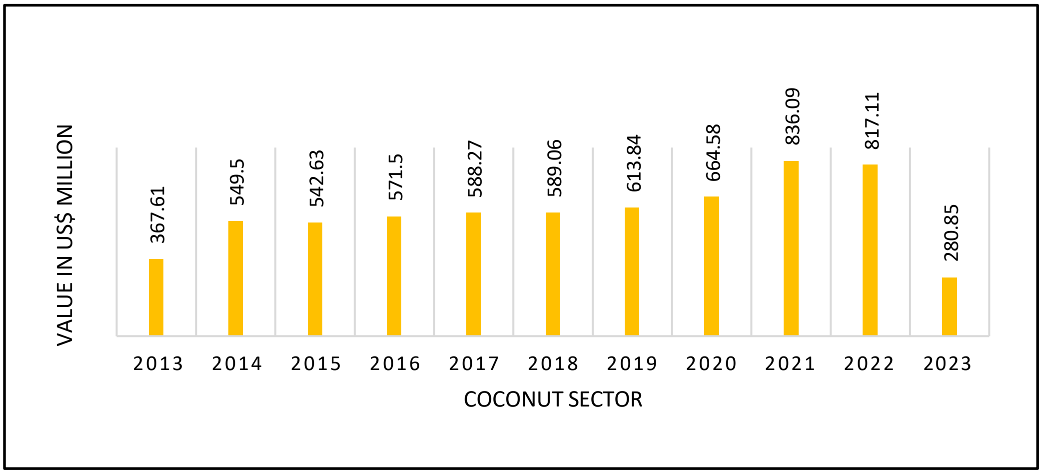
Coconut Kernel products, and Coconut Shell products. These include goods like Desiccated Coconut, Virgin Coconut Oil, Coconut Milk, Coconut Chips, Coconut Flour, Coconut Butter, Coconut Cream, and a wide range of other goods (Sri Lanka Export Development Board, 2023a). By supplying the said coconut and its based products to countries the United States, Netherlands, China, Germany, United Kingdom, Australia, Spain, Canada, Croatia, Slovenia, and United Arab Emirates, Sri Lanka secure a significant place in their market (Trend Economy, 2023).

With the growth in international demand for Coconut, the country estimates a production of 6 billion for both local and international markets, whereas, in the current context, the country produces 4.2 to 4.5 billion fresh nuts only, of which 2/3 are consumed domestically (Sri Lanka Export Development Board, 2023b).

Figure 1. Coconut Export Performance



Source: Sri Lanka Export Development Board.

This massive production of about 2800 Mn to 3000 Mn fresh nuts spans over 444,000 hectares of the island. This vast output is expected to bring in over 600 million USD in money for the nation, which is close to covering 6% of the entire export earnings of the nation, and about 0.9% of the country's total income (Central Bank Sri Lanka, 2022). Coconut production promises a livelihood for about 700,000 citizens (Sri Lanka Export Development Board, 2023b). Sri Lanka, which serves about 5% of the total global demand for coconut and its based products, holds a strong position in the international markets due to its eco-friendly cultivation, persistent novelty, promising quality, and in-depth industry knowledge (Sri Lanka Export Development Board, 2023b). The global market is driven to import Sri Lankan products due to the rising demand for fresh nuts as a result of the following factors: the rising population and their insatiable appetites for food products made from coconuts; the growth of the beauty industry towards organic products; the medical industry claiming coconut water as an energy drink and exploring the nutritional value and goodness of consuming coconut and its based edible products for one's health; to produce a wide range of products like mattresses, broomsticks, ropes, door mats, and many more (Allied Market Research, 2019).

As mentioned above, Sri Lanka is known for its abundant coconut plantations and has been a significant exporter of coconut products for many years. The island's tropical climate and fertile-rich soil create an ideal environment for producing nuts.

Coconut exports play a crucial role in Sri Lanka's economy, contributing to foreign exchange earnings and employment generation. Sri Lanka, known for its deep cultural connection to the coconut tree and favorable climate allowing year-round harvesting, holds the fourth-largest position in exporting coconut and its byproducts. Among the popular exports from Sri Lanka to global markets, Desiccated Coconut, Virgin Coconut Oil, and Coconut Water holds a significant place. Additionally, the country's bristle fiber products, produced using the traditional 'Drum' extraction method, and activated carbon derived from coconut shells are highly sought after (Sri Lanka Export Development Board, 2023b).

Coconut cultivation plays a significant role in Sri Lanka's agricultural sector, accounting for approximately 12% of the country's total agricultural produce. The cultivated land area spans 409,244 hectares as of 2017, with an annual coconut yield of around 2,500 to 3,000 million nuts during that time. To further boost coconut production, new measures have been implemented with the aim of reaching an annual crop of 3,600 million nuts (Sri Lanka Export Development Board, 2023b).

B. Exports of Coconut and its Products

Coconut exports from Sri Lanka include a wide range of products, as described below:

1) Desiccated Coconut (DC): Sri Lanka is renowned for its high-quality desiccated coconut. DC is produced by drying coconut meat and is widely used in the confectionery, bakery, and food processing industries. The reputation of Sri Lankan desiccated coconut in the global market is founded on its unparalleled quality, rich taste, and texture. International manufacturers of biscuits, chocolates, and other sweets highly value their superior quality. Sri Lanka is recognized as the birthplace of desiccated coconuts, with the dried and shredded particles obtained directly from the peeled kernel of the coconut fruit (Sri Lanka Export Development Board, 2023b).

2) Coconut Oil*:* Sri Lanka is globally recognized as a leading exporter of coconut oil. The country produces both refined and virgin coconut oil, which has applications in various industries including food, cosmetics, and pharmaceuticals. Sri Lankan coconut oil is highly esteemed as a superfood and is widely utilized in the food and beverage, culinary, and beauty care sectors. Sri Lankan coconut oil is highly regarded for its quality, versatility, and unique nutritional profile, making it a highly sought-after product in the global market (Sri Lanka Export Development Board, 2023b).

3) Coconut Milk and Cream: Sri Lanka is a major exporter of coconut milk and cream, which are essential components in diverse cuisines, particularly Asian and Caribbean dishes. These products are widely used in the food processing industry and are favored by health-conscious consumers. Sri Lankan coconut milk is highly regarded for its versatility in culinary applications and enjoys significant demand in the global market. Coconut milk is available in both concentrated and diluted forms, and can be found in liquid, skimmed, and spray-dried powder formats. While coconut milk has traditionally been used in cooking, it has gained popularity as a dairy milk substitute due to global dietary trends such as vegan, gluten-free, and soy-free diets. Consequently, Sri Lanka now manufactures and exports a wide range of flavored and unflavored drinking coconut milk to cater to these preferences. The distinctive white color, along with the unique aroma and flavor, has made Sri Lankan coconut milk highly sought after in the international market. Its superior quality has further contributed to its reputation as a premium product in the industry. Coconut milk serves as a popular dairy-free alternative in the preparation of various food and beverage items. Like coconut milk, coconut cream offers similar nutritional benefits, provides rich flavor, and imparts a creamy texture to dishes (Sri Lanka Export Development Board, 2023b).

4) Coconut Fiber and Coir Products: Sri Lanka is a major exporter of coconut fiber and coir products. Coir is the fibrous material obtained from coconut husks and is used to make products like coir mattresses, carpets, rugs, ropes, and erosion control mats (Sri Lanka Export Development Board, 2023b).

5) Coconut Water: Sri Lanka exports packaged coconut water, which is the clear liquid found inside young coconuts. Coconut water is gaining popularity worldwide due to its refreshing and hydrating properties (Sri Lanka Export Development Board, 2023b).

6) Coconut Shell-based Products: Sri Lanka also exports various products made from coconut shells, such as activated carbon, charcoal, and handicrafts. Activated carbon is widely used in water purification, air filtration, and industrial applications (Sri Lanka Export Development Board, 2023b).

C. Quality of Coconut Products

Sri Lanka has gained considerable recognition in the global market for its DC and Brown fiber. The country's DC stands out with its distinctive white color and unique flavor, positioning Sri Lanka as the fourth-largest supplier of kernel goods to the global market. Additionally, Sri Lanka holds the leading position in global brown fiber exports. The traditional drum system employed for fiber extraction yields long and pure fibers that are particularly well-suited for the brush industry (Sri Lanka Export Development Board, 2023b).

The production, quality enhancement, supply development, and research activities related to coconuts in Sri Lanka are primarily overseen by three major government institutions: the Coconut Research Institute, the Coconut Development Authority, and the Coconut Cultivation Board. These organizations play a crucial role in ensuring the overall well-being and advancement of the coconut industry in the country (Sri Lanka Export Development Board, 2023b).

To maintain the quality of DC exports, every shipment must be accompanied by a certificate issued by the Coconut Development Authority. Furthermore, coconut manufacturers and suppliers in Sri Lanka strictly adhere to regulations to guarantee the excellence of their products. These stringent measures help uphold the reputation of Sri Lankan coconut and its derived products in the international market (Sri Lanka Export Development Board, 2023b).

D. Coconut Export Counties

The demand for Sri Lankan coconut products remains robust in both domestic and international markets. However, it's important to note that specific export volumes and market dynamics may vary over time. It is advisable to consult up-to-date trade data or reach out to relevant trade authorities for the most accurate and current information regarding coconut exports from Sri Lanka. Sri Lanka exports coconuts and coconut products to various countries around the world. Some of the major export destinations for Sri Lankan coconuts include:

1) United States (US): The US is one of the major consumers of Sri Lankan coconut products, including coconut oil, desiccated coconut, and coconut water. United Kingdom: The UK is another significant market for Sri Lankan coconut exports. Sri Lankan coconut oil, desiccated coconut, and coconut milk are popular among consumers in the UK.

2) Germany: Germany is a major importer of coconut oil and coconut-based products from Sri Lanka. The country's strong demand for organic and sustainable products makes Sri Lankan coconut products attractive to German consumers.

3) Netherlands: The Netherlands serves as a major distribution hub for coconut products in Europe. Sri Lanka exports a significant amount of coconut oil, desiccated coconut, and coconut milk to the Netherlands.

4) Australia: Sri Lankan coconuts and coconut products have a good market presence in Australia. Coconut oil, desiccated coconut, and coconut-based snacks are among the products imported by Australia.

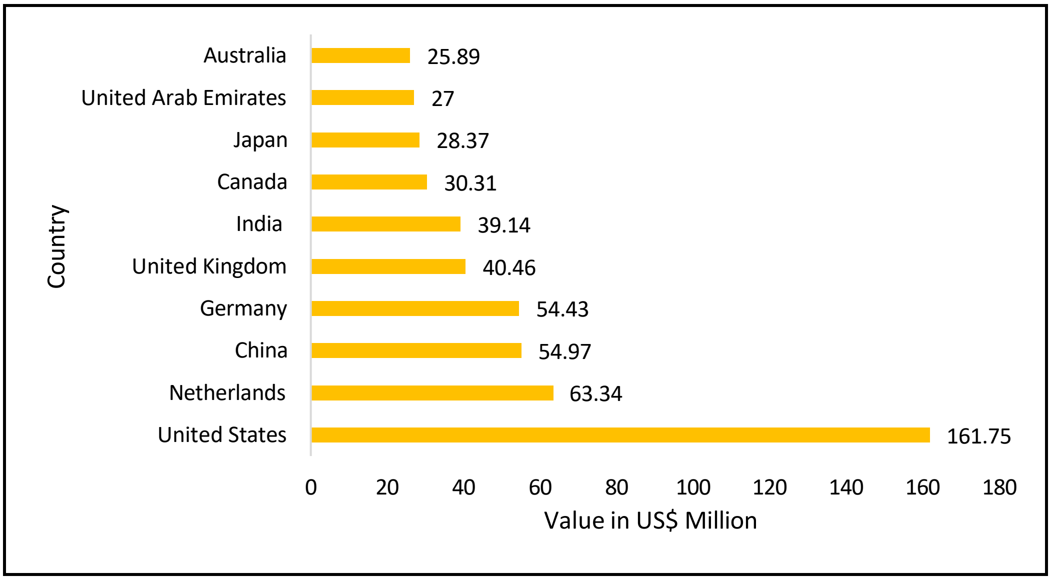
5) Middle Eastern Countries: Countries in the Middle East, such as Saudi Arabia, United Arab Emirates (UAE), Qatar, and Kuwait, are prominent importers of Sri Lankan coconut products. Coconut oil, desiccated coconut, and coconut milk are commonly consumed in these countries.

6) India: While India is a large coconut producer itself, Sri Lanka exports coconut products to India as well. Sri Lankan coconut oil and desiccated coconut are sought after in the Indian market.

7) Japan: Japan has a growing market for healthy and natural food products, including coconut-based products. Sri Lankan coconut oil, coconut water, and desiccated coconut are imported by Japan.

In addition to the above countries, Sri Lankan coconut exports also reach other destinations globally, including other European countries, Canada, New Zealand, and various Asian markets. The specific export destinations and volumes may vary depending on market demand and trade dynamics.

Figure 2. Major Markets of the Coconut Sector 2022



Source: Sri Lanka Export Development Board.

It becomes increasingly difficult to sustain export levels and meet worldwide demand for fresh nuts to support the country's economy at its robust level as the importance of the coconut sector to Sri Lanka's economy and the global coconut market grows. The study also identifies and explores problematic situations when there is an abnormal departure from the norm, such as the deviations that occurred in the years 2010 and 2018 in accordance with the dataset that was utilized in this study. In situations like the spread of diseases that affect coconut trees, unfavorable climate conditions, and the emergence of a pandemic, the exports of fresh nuts are being severely hampered, which negatively impacts the nation's coconut industry and the workers who are employed in the related sector and ultimately has an adverse influence on the Sri Lankan economy.

E. Factors Influencing Coconut Production and its Challenges

Several factors can affect coconut production in Sri Lanka. Here are some of the key factors:

1) Climate and Weather*:* Sri Lanka's coconut production is heavily dependent on favorable climatic conditions. Coconuts thrive in tropical climates with abundant rainfall and high humidity. Extreme weather events such as droughts, cyclones, or excessive rainfall can negatively impact coconut production.

2) Pests and Diseases: Pests and diseases pose a significant challenge to coconut cultivation. Common pests include coconut mites, rhinoceros beetles, and coconut leaf caterpillars. Diseases like coconut leaf wilt, root wilt, and bud rot can also cause damage to coconut palms and reduce productivity.

3) Land Availability and Soil Quality*:* The availability of suitable land for coconut cultivation is crucial. Coconuts require well-drained soil with good fertility. Land degradation, soil erosion, or inappropriate land management practices can affect coconut plantations and productivity.

4) Agricultural Practices and Management: Proper agricultural practices and management techniques play a vital role in coconut production. This includes regular pruning, fertilization, weed control, and pest management. Inadequate or improper agricultural practices can result in reduced yields and lower-quality coconuts.

5) Varietal Selection: The choice of coconut varieties planted can impact production. Different varieties have varying levels of resistance to pests and diseases, as well as different growth characteristics and yields. Optimal varietal selection based on local conditions and market demand is essential.

6) Labor Availability and Skill Levels*:* The availability of skilled labor for coconut farming activities, such as harvesting, pruning, and maintenance, can affect production. Labor shortages or a lack of trained workers can lead to decreased productivity or increased costs.

7) Market Demand and Prices: Primely market demand and coconuts and their byproducts' prices can influence production decisions. If market prices are favorable, farmers may be motivated to increase coconut cultivation. Conversely, fluctuations in demand or prices may impact planting decisions and overall production levels.

8) Government Policies and Support*:* Government policies, regulations, and support programs can significantly impact coconut production. Policies related to land use, subsidies, research and development, and infrastructure development can influence the growth and productivity of the coconut industry.

These factors, individually or in combination, can have both positive and negative effects on coconut production in Sri Lanka. Farmers, policymakers, and industry stakeholders work together to address these challenges and promote sustainable coconut cultivation and productivity.

Coconut cultivation holds a significant position in Sri Lanka, covering approximately 20% of the country's arable land. Most coconut plantations (82%) are operated on a small-scale basis by individual farmers.

In terms of coconut production, around 63% of the total output is consumed domestically within Sri Lanka. This proportion is closely tied to the country's increasing population. As the population grows, there is a higher demand for coconut and its various products within the local market.

These statistics reflect the importance of coconut as a staple crop and a significant part of Sri Lanka's agricultural landscape. The domestic consumption of coconuts highlights their vital role in the country's food and beverage industry, as well as their contribution to the dietary needs of the population. This specific percentage of fresh coconuts consumed locally in Sri Lanka out of the total annual production can vary from year to year and is influenced by factors such as market demand, population size, and the availability of alternative coconut products.

However, it's worth noting that Sri Lanka has a strong domestic demand for fresh coconuts due to their extensive use in various aspects of Sri Lankan cuisine and daily life, as mentioned earlier. Fresh coconut water is a popular and widely consumed beverage. Historically, Sri Lanka has had a balance between domestic consumption and export of coconuts and coconut products. The country's abundant coconut production has allowed for both local consumption and export markets. Nevertheless, the exact percentage of fresh coconuts consumed locally can be influenced by factors such as export demand, processing industries, and the availability of alternative coconut products.

F. Importance of Forecasting of Fresh Nuts Exports

Forecasting the consumption and production of coconuts in Sri Lanka is important for various reasons:

1) Supply Planning: Accurate forecasting helps in planning the supply of coconuts and coconut products. It enables farmers, processors, and distributors to anticipate demand and adjust production and distribution accordingly. This helps avoid shortages or surpluses in the market.

2) Market Analysis: Forecasting provides valuable insights into market trends and consumer preferences. It helps identify patterns, changes in demand, and emerging market opportunities. This information can guide strategic decisions and product development to meet evolving consumer needs.

3) Price Stability: By forecasting coconut supply and demand, price fluctuations can be anticipated and managed. This allows stakeholders to make informed decisions regarding pricing strategies, inventory management, and market timing, contributing to price stability in the coconut market.

4) Resource Allocation: Forecasting helps in efficient allocation of resources, such as land, labor, and capital, for coconut cultivation and processing. Farmers can make informed decisions about planting decisions, crop management practices, and investments based on projected demand and market conditions.

5) Policy Formulation: Accurate forecasting provides policymakers and government agencies with data-driven insights into the coconut industry. It assists in formulating policies related to agriculture, trade, and rural development, ensuring the sustainable growth of the coconut sector, and supporting the livelihoods of farmers.

6) International Trade: Forecasting coconut production and consumption helps in planning export and import strategies. It assists exporters in meeting international demand and complying with quality standards. Importers can assess domestic supply gaps and plan imports, accordingly, ensuring a stable supply of coconut products.

Overall, forecasting plays a crucial role in supporting decision-making, market analysis, resource management, and policy formulation in the coconut industry. It helps stakeholders navigate market dynamics and contributes to the sustainable growth of the sector.

G. Objective of the Study
The prime objective of this research is to develop a statistical model for Sri Lanka's exports of fresh coconuts and validate the model using secondary data.

H. Significance of the Study
The finding of this study supports a stable domestic economy and satisfy the international demand for fresh nuts, by formulating foreign earnings and supply of national fresh coconut exports.

The article equips principal government entities like the Coconut Development Authority (CDA), Coconut Cultivation Board (CCB), and Coconut Research Institute (CRI) which are responsible for Coconut production and quality improvement, supply development, and research, respectively in Sri Lanka. The results would be beneficial to the stake holders of various coconuts products such as desiccated coconut, copra, coconut oil, shell charcoal, value added fiber goods, activated carbon producers, fiber millers, and exporters who are the major stakeholders in the coconut business, to respond effectively and efficiently and support the local and global demand for fresh coconuts under normal or exceptional circumstances that would take place in an active economy (Padmasiri, 2021).

II. METHODOLOGY
The analysis considered secondary data from the Coconut Development Authority (CDA) bulletins on Fresh Coconut Exports from Sri Lanka from 1981 to 2020. The behavioral patterns in the data were discovered using time series plots and fundamental descriptive analysis. The data were examined for stationary after the basic information was taken from the time series plot. The initial effort to turn a non-stationary data series into a stationary data series was to employ the first-order differencing approach.

The time series approach, which is suited for representing this type of stochastic process, was used to develop a forecasting model to anticipate the export of fresh coconuts. To do this, the forecasting model was created using the ARIMA modeling approach Box-Jenkins first suggested in 1976. The most comprehensive category of models used for time series forecasting is known as Auto-Regressive Integrated Moving Average (ARIMA).

The ARIMA model assumes that the observed data in a time series model is independent which means the value of it at one point does not influence at any other time. This model also assumes that the observed data is stationary. If it is not stationary, we can use differencing to make it stationary. This model assumes that there is a linear relationship between the past observations and future observations; if this relationship is not linear, ARIMA can provide insignificant results. Assuming Constant parameters is another assumption in ARIMA modelling.

The Auto-Regressive component refers to various series that are involved in the forecasting equations. The Moving Average approach is employed when there are delays in the forecast error within the model. In ARIMA (p, d, q) model, 'p' represents the order of the Auto-Regressive process, 'd' signifies the order of the data stationary process, and 'q' indicates the order of the Moving Average process (Arachchi & Peiris, 2022).

Auto-Regressive (AR) process of order p,

$$AR(p): y_t = \delta + \emptyset_1 y_{t-1} + \ldots\ldots + \emptyset_p y_{t-p} + \varepsilon t \quad (1)$$

Moving Average (MA) process of order q,

$$MA(q): y_t = \mu + \varepsilon t - \theta_1 \varepsilon_{(t-1)} - \ldots\ldots - \theta_q \varepsilon_{(t-q)} \quad (2)$$

A combination of Autoregressive/ Moving Average process containing p AR terms and q MA terms is expressed as an ARMA process with an order of (p, q), which is given by,

$$yt = \delta + \emptyset_1 y_{t-1} + \ldots. + \emptyset_p y_{t-p} + \varepsilon_t - \theta_1 \varepsilon_{(t-1)} - \ldots - \theta_q \varepsilon_{(t-q)} \quad (3)$$

Where,

δ – constant term

μ - Mean

$\theta_1, \theta_2 \ldots\ldots\ldots \theta_q$ - Co-efficients of Moving Average terms.

$\emptyset_1, \emptyset_2 \ldots\ldots \emptyset_p$ – Co-efficient of Autoregressive terms

ε_t – Random error term at time t, assumed to be normally distributed with mean 0 and constant variance.

$\varepsilon_{(t-1)}, \varepsilon_{(t-2)}, \ldots \ldots \ldots \varepsilon_{(t-p)}, \varepsilon_{(t-q)}$ – Past error terms of both Autoregressive and Moving Average terms (Arachchi & Peiris, 2022).

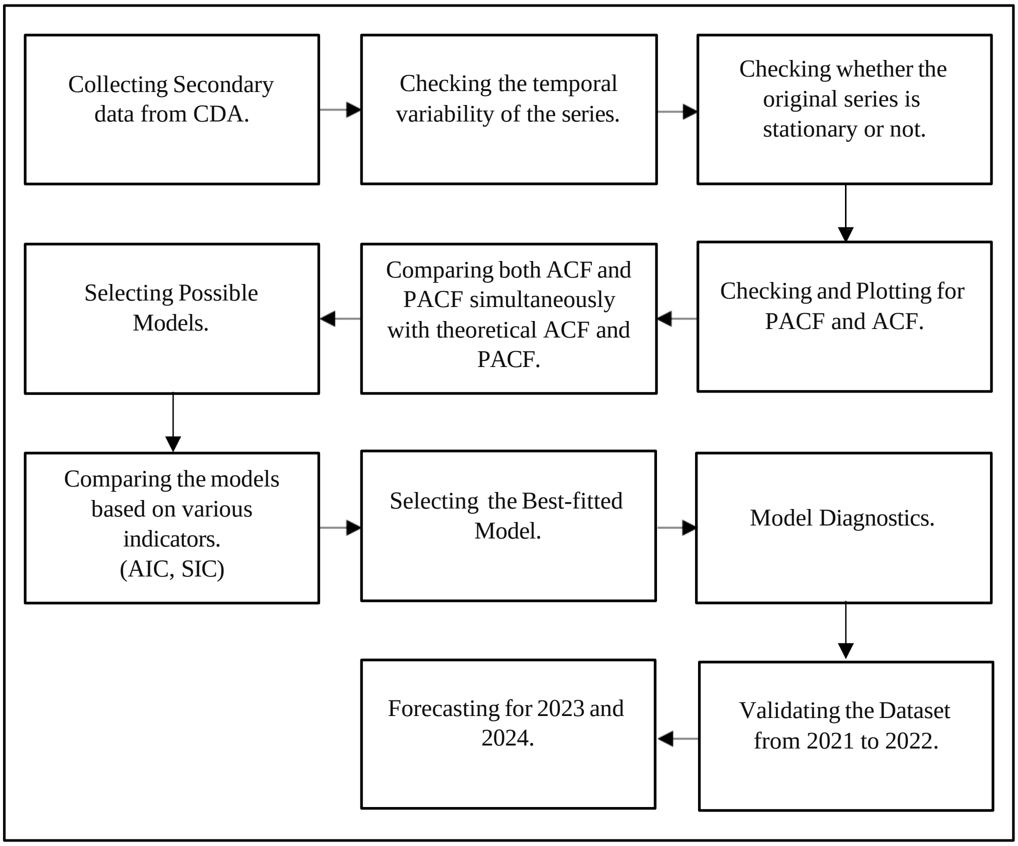
A mix of Auto-Regressive and Moving Average components, and non-seasonal differences makes ARIMA model. The parameters of the model are denoted by p, d, and q, which represents number of AR terms, the number of non-seasonal differences needed for stationarity, and the number of MA terms, respectively.

The AR terms refer to the lagged values of the response variable, while the MA terms capture the forecast errors. By specifying the values of p, d, and q, the ARIMA model can effectively capture the patterns and dynamics of a given time series.

The main challenge with the ARIMA modeling approach is determining the best values for p, d, and q. By examining the series' autocorrelation function (ACF) and partial autocorrelation function (PACF), this issue can be partially overcome (Pindyck, 1991). Based on where the ACF was close to zero, the degree of homogeneity, (d), or the number of time series that needed to be differentiated to produce a stationary series, was calculated.

Step 1: Identifying the Model - To identify the appropriate Auto-Regressive Integrated Moving Average (ARIMA) model, the time series data was plotted against time and evaluated for stationarity, trends, and seasonality. The stationarity of the data was assessed using a correlogram along with the Augmented Dickey-Fuller (ADF) test.

Figure 3. Summarization of the Methodology



Source: Authors' compilation.

Stationarity is characterized by mean reversion and a constant, time-invariant variance, which is reflected in a correlogram showing diminishing values as the lag increases. If the original data series is non-stationary, difference can be applied to achieve stationarity for further analysis. The selection of the ARIMA model order (p, d, q) is based on the significant lags observed in the correlogram (Arachchi & Peiris, 2022).

The correlogram of the first differenced series was examined to determine the values of p, q, and d. The Auto-Correlation Function (ACF) is employed to find the number of MA terms (q), the Partial Auto-Correlation Function (PACF) is used to determine the number of Auto-Regressive (AR) terms (p), and the need for differencing (d) is established through the differencing process. The decision criteria for selecting the model parameters are typically based on statistical measures and significance levels.

The PACF captures the correlation among Y_t and Y_{t-k} while accounting for the influence of intermediate Y values, thereby capturing the marginal impact (Arachchi & Peiris, 2022). In the context of selecting an appropriate ARIMA model, the goal is to achieve a parsimonious model, meaning a model with the fewest variables necessary. This is because introducing additional variables tends to improve the model's fit (R2) but at the expense of reducing degrees of freedom. Hence, the aim is to strike a balance between model complexity and goodness of fit.

Step 2: Model Estimation - During the model estimation phase, it was anticipated that the parameters of the model would demonstrate significance. The correlogram of the model's error series was expected to exhibit both significant and insignificant values for the ACF and PACF. This indicates the presence of appropriate lagged relationships in the model.

To select the best possible model, the Akaike Information Criteria (AIC), Schwarz Bayesian Information Criterion (SBIC) and Hannan–Quinn *Information Criterion (HQIC)* were employed. A well-performing model would be characterized by minimized values of both AIC and SBIC. These criteria serve as measures of the model's quality, with lower AIC and SBIC values indicating a better fitted model. The AIC and BIC (SIC) may be utilized to locate a forecasting ARIMA model that is appropriate for coconut exports (lower the better) (Arachchi & Peiris, 2022).

$$AIC = log\ (\frac{rss}{n}) + (log(n) * \frac{k}{n}) \quad (4)$$

$$BIC = log\ (\frac{rss}{n}) + (2 * \frac{k}{n}) \quad (5)$$

$$HQIC = 2log\ [\ log(n)\ (k - 2l)\ ] \quad (6)$$

Where,
k = number of coefficients estimated,
rss = residual sums of squares,
n = number of observations

Step 3: Model Diagnostic and Forecasting - After selecting a suitable model, several diagnostic tests were performed to assess its quality and suitability for forecasting. A good model was expected to exhibit white noise characteristics in its residuals. This was evaluated by examining the correlogram of the residuals, with an expectation of observing a flat correlogram and insignificant Ljung-Box Q statistic. The Ljung-Box test assesses the null hypothesis that the residuals follow a white noise process (Arachchi & Peiris, 2022).

Additionally, the stationarity (covariance) and invertibility of the underlying Autoregressive Moving Average (ARMA) process were examined. This was done by inspecting the roots of the AR and MA components on a unit circle. The presence of roots outside the unit circle would indicate non-stationarity or non-invertibility, which could suggest the need for further model refinement.

Finally, the forecasting accuracy of the selected model was assessed by comparing its predictions with the actual number of exports. This evaluation aimed to determine how well the model captured and predicted the real-world data, providing insights into the model's performance in forecasting future exports in fresh coconuts.

Understanding white noise is crucial for analyzing and forecasting time series data. Simply put, white noise helps determine whether further model optimization is necessary. White noise refers to a sequence of random numbers that lacks predictability. When constructing a model, if the residuals (the differences between predicted and actual values) exhibit the characteristics of white noise, it suggests that the model has been optimized to its fullest potential. Conversely, if there are discernible patterns in the residuals, it indicates the existence of a better model for the dataset.

To classify a time series as white noise, it must meet the following conditions:

1. The mean value is zero.
2. The standard deviation remains constant over time.
3. There is no significant correlation between the time series and its lagged versions.

The last condition may seem challenging without exploring autocorrelation, but the underlying concept is straightforward. It involves determining whether a meaningful correlation exists between the current time series and the same series shifted by N periods. There are three straightforward methods to test whether a time series resembles white noise:

Method 1: Plotting the time series - This is the simplest approach. The objective is to visually examine the entire series and confirm that the average value is zero, the standard deviation remains constant over time, and no distinct patterns are observable. After conducting a visual inspection, we can conclude that the mean and standard deviation remain relatively stable over time. Although there are occasional spikes, they are not significant. Additionally, there are no observable patterns in the series.

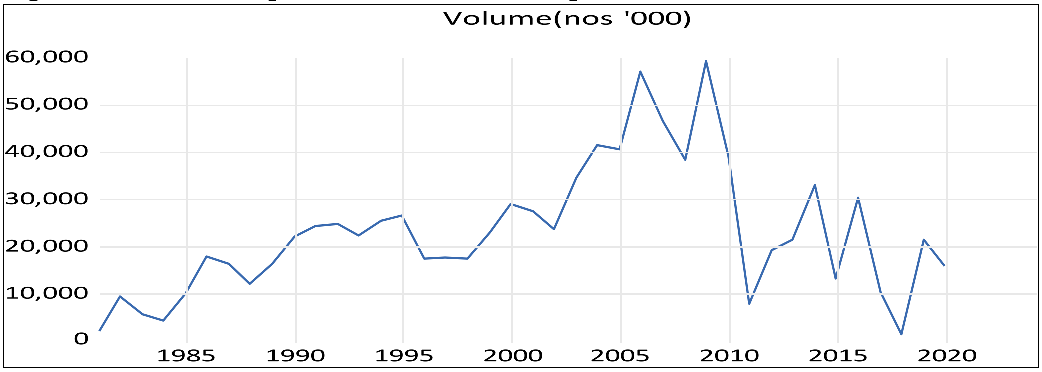
Method 2: Comparing mean and standard deviation over time - If the mean and standard deviation remain constant over time, we can split the white noise series into several subsets, such as 20 subsets with 50 data points each. By calculating the mean and standard deviation for each subset, we can compare them to assess their similarity. Visualizing the results can aid in interpretation.

Method 3: Examining autocorrelation plots - Autocorrelation and autocorrelation plots will be covered in detail later in the series. For now, it is important to know that autocorrelation plots illustrate the correlation between a time series and its lagged versions. Confidence intervals are typically included in these plots, representing the range of correlations that are statistically significant. An autocorrelation value of 1 at lag 0 indicates perfect correlation, as it compares the time series with itself.

III. RESULTS

A. Temporal Variability of the Original Series

Figure 4. Time series plot of fresh coconuts export [1981-2020]



Source: Authors' compilation.

Figure 4 shows that fresh coconut exports have a fluctuating trend over time. The observed series exhibits an increasing trend between 1981 and 2009. In 2009, coconut exports recorded the highest number, comparing it to the period from 1981 to 2020. Between 2009 and 2011, there was a significant drop in exports, and from 2011 to 2020, coconut exports fluctuated over time. The lowest coconut export was recorded in 2018.

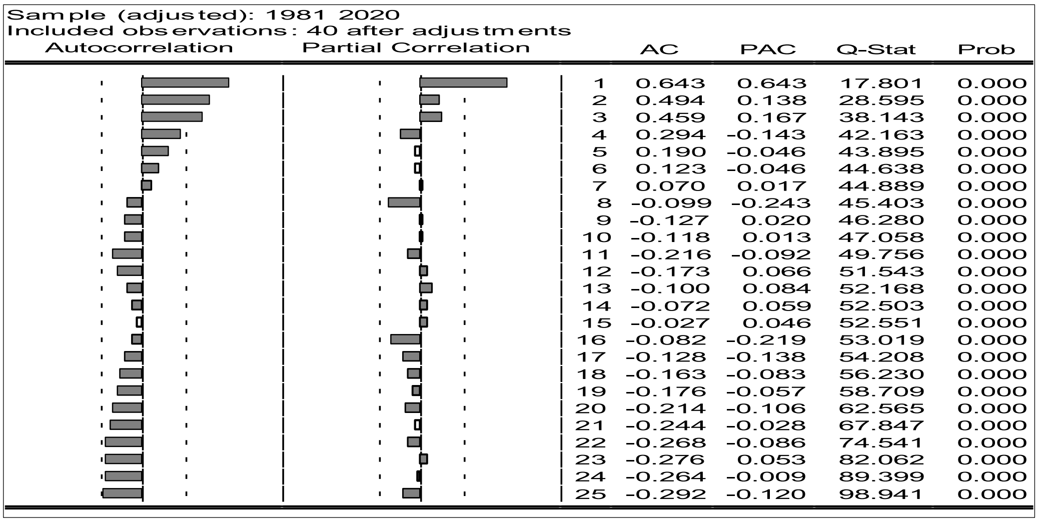
Table 1. Descriptive Analysis for Fresh coconut Exports in (000')

Description	Statistics
Mean	23163.65
Median	21824.50
Maximum	59199.00
Minimum	1433.000
Std. Dev	13690.83
Skewness	0.751692
Kurtosis	3.350713
Jarque- Bera	3.971939
Probability	0.137248

Source: Authors' compilation.

The temporal variability of fresh coconut exports from 1981 to 2020 is shown in Figure 4, and the basic statistics are shown in Table 2. During the period from 1981 to 2020, fresh coconut exports varied from a minimum of 1,433 in 2018 to a maximum of 59,199 in 2009, with a mean of 23,163.65 exports, a standard deviation of 13,690.83, and a median of 21,824.50. The p-value of 0.137248 indicates that the coconut exports data has not significantly deviated from normality, according to the Jarque-Bera test. Figure 1 shows the fluctuating trend in fresh coconut exports over time, confirming that the observed series is not stationary. This was confirmed by using the ACF plot (Figure 5) and the Augmented Dickey-Fuller (ADF) test.

Figure 5. Correlogram of the original series of data



Source: Authors' compilation.

The ACF plot of the original series indicates that the autocorrelation at lag 1, lag 2, and lag 3 is significantly different from zero, suggesting that the series is not stationary. This was further confirmed by conducting the ADF test (Table 2).

A. ADF Test for The Original Series

The results of the ADF test indicated that the original series is not significant (ADF Test statistic = -2.833502, p = 0.1946), confirming that the original series is not stationary. Thus, to make the series stationary, the first differenced series was considered.

Table 2. Results of the ADF test for the original series

Null Hypothesis: VOLUME_NOS__000_ has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.833502	0.1946
Test critical values:	1% level	-4.211868	
	5% level	-3.529758	
	10% level	-3.196411	

*MacKinnon (1996) one-sided p-values.

Source: Authors' compilation.

B. ADF test for the 1st difference series

Table 3. Results of the ADF test for the 1st difference series

Null Hypothesis: D(VOLUME_NOS__000_) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.800972	0.0000
Test critical values:	1% level	-4.226815	
	5% level	-3.536601	
	10% level	-3.200320	

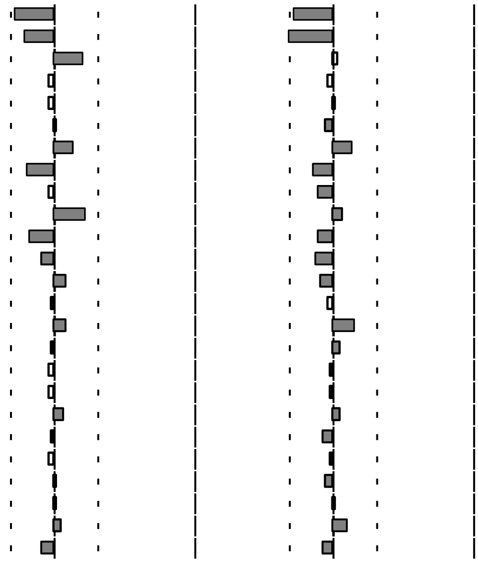
*MacKinnon (1996) one-sided p-values.

Source: Authors' compilation.

The results of the ADF test indicated that the 1st difference series is significant (ADF Test statistic = -6.800972, p = 0.000). Thus, it can be concluded with 95% confidence that the first difference series is stationary.

Figure 6. Correlogram of the stationary series

Sample (adjusted): 1982 2020
Included observations: 39 after adjustments



	AC	PAC	Q-Stat	Prob
1	-0.282	-0.282	3.3502	0.067
2	-0.223	-0.329	5.4979	0.064
3	0.208	0.038	7.4182	0.060
4	-0.040	-0.029	7.4913	0.112
5	-0.048	0.003	7.6011	0.180
6	-0.000	-0.052	7.6012	0.269
7	0.143	0.147	8.6288	0.280
8	-0.204	-0.148	10.772	0.215
9	-0.048	-0.105	10.897	0.283
10	0.223	0.070	13.636	0.190
11	-0.188	-0.101	15.662	0.154
12	-0.090	-0.128	16.144	0.185
13	0.093	-0.088	16.679	0.214
14	-0.008	-0.042	16.684	0.273
15	0.088	0.167	17.195	0.307
16	-0.014	0.065	17.209	0.372
17	-0.030	-0.019	17.273	0.436
18	-0.027	-0.016	17.328	0.501
19	0.071	0.058	17.732	0.540
20	-0.017	-0.071	17.757	0.603
21	-0.038	-0.016	17.882	0.656
22	0.017	-0.056	17.909	0.711
23	0.002	0.011	17.910	0.762
24	0.058	0.100	18.266	0.790
25	-0.086	-0.082	19.112	0.792

Source: Authors' compilation.

Figure 6 illustrates the ACF and PACF plots of the stationary series. Autocorrelation at lags 1 is significant, and partial autocorrelation at lags 1 and 2 is also significant. Based on these significant lags, possible ARIMA models were recommended and fitted. Table 5 presents the possible models.

C. Identification of the best-fitted model

Table 4. Comparison of the selected ARIMA models

Indicators	Model		
	ARIMA (2,1,0)	**ARIMA (1,1,0)**	**ARIMA (2,1,1)**
Parameter– AR (1)	Significant	Significant	Not Significant
Parameter– AR (2)	Significant	-	Significant
Parameter– MA (1)	-	-	Not Significant
Constant	Not Significant	Not Significant	Not Significant
AIC	21.45720	21.52066	21.50549
SBIC	21.62782	21.64862	21.71877
HQIC	21.51842	21.56657	21.58201

Source: Authors' compilation.

Based on the analysis, it seems that the ARIMA (2,1,0) model has lower values for AIC, SBIC, HQIC than the other two models. Additionally, both the two parameters of the

model are significant. Therefore, we can conclude that the ARIMA (2,1,0) model provides the best fit among the three models tested.
Thus, the model equation can be formed as:

$$Y_t = 259.63 + Y_{t-1} - 0.37\,(Y_{t-1} - Y_{t-2}) - 0.34\,(Y_{t-2} - Y_{t-3}) \qquad (7)$$

D. Diagnostics for Best-Fitted Model.

1) Randomness: In Figure 7, the residuals correlogram for the ARIMA (2,1,0) model is presented. The results indicate that the ACF and PACF were plotted against 25 lags. The correlogram reveals that each lag falls within a 95% confidence interval and is statistically insignificant. Therefore, it can be concluded that the residuals of the fitted model are randomly distributed.

Figure 7. Correlogram of the residuals of the ARIMA model (2,1,0)

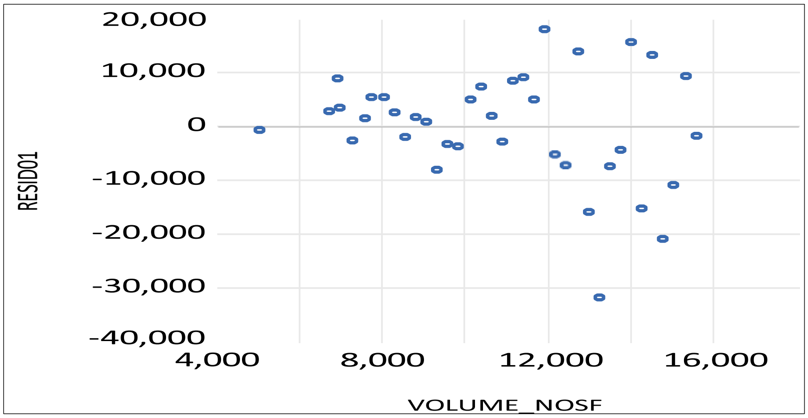
Sample (adjusted): 1982 2020
Q-statistic probabilities adjusted for 2 ARMA terms

Lag	AC	PAC	Q-Stat	Prob
1	0.010	0.010	0.0045	
2	-0.003	-0.003	0.0048	
3	0.039	0.039	0.0719	0.789
4	-0.040	-0.041	0.1459	0.930
5	0.020	0.021	0.1648	0.983
6	-0.019	-0.021	0.1820	0.996
7	0.029	0.033	0.2244	0.999
8	-0.152	-0.157	1.4136	0.965
9	-0.076	-0.070	1.7242	0.974
10	0.110	0.109	2.3968	0.966
11	-0.187	-0.183	4.4004	0.883
12	-0.131	-0.143	5.4179	0.862
13	0.059	0.066	5.6344	0.897
14	0.059	0.083	5.8564	0.923
15	0.126	0.123	6.9070	0.907
16	0.003	-0.029	6.9076	0.938
17	-0.014	-0.048	6.9222	0.960
18	-0.036	0.001	7.0195	0.973
19	0.062	0.050	7.3296	0.979
20	-0.015	-0.118	7.3488	0.987
21	-0.038	-0.009	7.4803	0.991
22	0.016	0.044	7.5048	0.995
23	-0.001	-0.004	7.5048	0.997
24	0.013	0.007	7.5219	0.998
25	-0.099	-0.112	8.6469	0.997

Source: Authors' compilation.

2) Constant variance:

Figure 8. Scatter plot of residuals vs fits

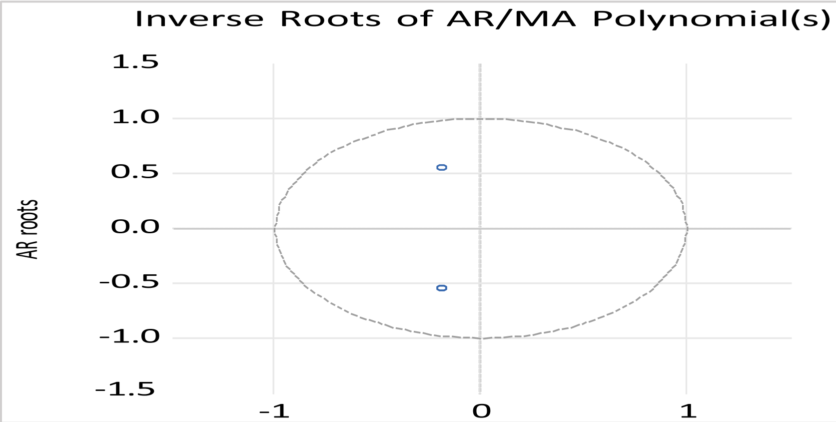


Source: Authors' compilation.

The figure 8 shows a random pattern between the two variables, with points scattered randomly around zero. Therefore, it can be confirmed that the variance of the errors is homogeneous.

3) Stability of the Model:

Figure 9. Inverse Root AR/MA Polynomial

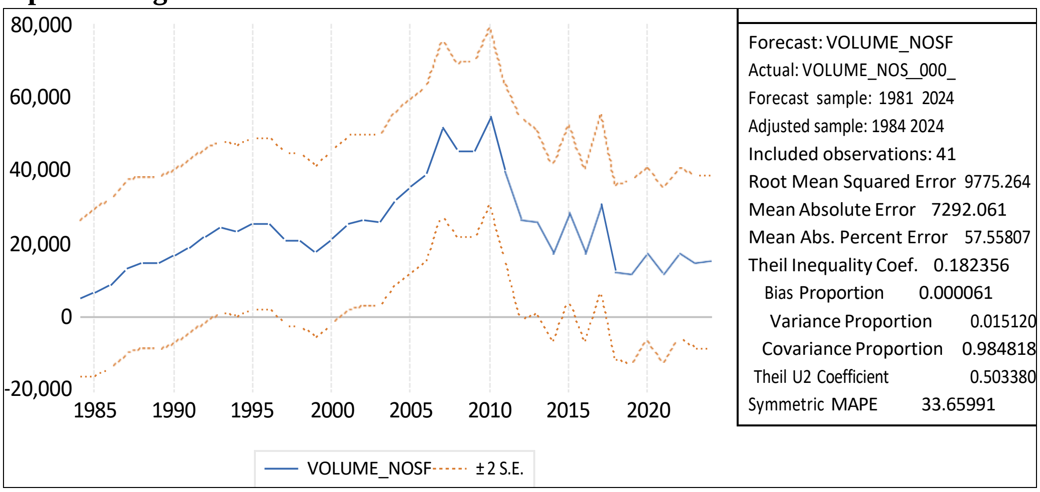


Source: Authors' compilation.

Analysis of the figure reveals that the AR roots are located inside the unit circle, indicating the stationarity of the ARIMA (2,1,0) process. Therefore, we can conclude that the ARIMA (2,1,0) process is both stationary and invertible. After confirming that the ARIMA process is stationary and invertible, we can forecast with ARIMA (2,1,0) model. The ARIMA (2,1,0) model is used to forecast fresh coconut exports from 1981 to 2024.

E. The comparison between the observed values and the predicted values.

Figure 10. The forecast and its confidence limits for the entire series of fresh coconut exports using the final model



Source: Authors' compilation.

The results reveal higher values for both MAE and RMSE, indicating significant deviation between the forecasted values and the actual data. The Theil Inequality Coefficient (U) was calculated to be 0.182356, and the bias proportion was found to be negligible at 0.000061. The value of U being closer to 0 suggests that the predictive power of the model was good.

Table 5. Percentage error of the training set

Year	Actual Volume (no's '000)	Forecast Volume (nos '000)	% Error
1984	4395	5048	-14.85
1985	10104	6586	34.82
1986	17794	8880	50.10
1987	16328	13482	17.43
1988	12112	14725	-21.57
1989	16262	14602	10.21
1990	22191	16593	25.23
1991	24434	19052	22.03
1992	24782	22056	11.00
1993	22329	24342	-9.01
1994	25444	23559	7.41
1995	26517	25563	3.60
1996	17450	25516	-46.23
1997	17717	20875	-17.82
1998	17535	21111	-20.39
1999	22999	17955	21.93
2000	29025	21488	25.97
2001	27515	25408	7.66
2002	23679	26488	-11.86
2003	34527	26044	24.57
2004	41356	32261	21.99
2005	40602	35633	12.24
2006	57078	39026	31.63
2007	46591	51700	-10.97
2008	38246	45359	-18.60
2009	59199	45292	23.49
2010	38915	54724	-40.62
2011	7916	39789	-402.64
2012	19150	26609	-38.95
2013	21458	25877	-20.59
2014	33076	17272	47.78
2015	13204	28459	-115.54
2016	30433	17065	43.92
2017	10232	31207	-205.00
2018	1433	12328	-760.26
2019	21426	11914	44.40
2020	15838	17457	-10.22

Source: Authors' compilation.

To assess the forecasting accuracy of each data point, percentage errors were calculated for all points. Table 1 displays the percentage errors for the training set, while Table 2 presents the percentage errors for the validation set. These tables provide insights into the forecasting performance of the model for each specific data point. The training set exhibited a wide range of percentage errors, ranging from -760.26% to 50.1%. However, significant percentage errors were only observed in a few specific years.

Table 6. Percentage error of the validation set.

Year	Actual Volume (no's '000)	Forecast Volume (no's '000)	%Error
2021	14563	11617	20.23
2022	13394	17355	-29.57

Source: Authors'compilation.

In 2010, coconut production experienced a significant decline of 536 million nuts compared to the previous year, resulting in a total production of 2,317 million nuts. This marked the lowest annual production in nearly 15 years and had a negative impact on the export of fresh coconuts. Low rainfall in major coconut-growing regions in 2009 had a lag effect that contributed significantly to the drop in coconut yield (Yogaratnam, 2013). Among the coconut triangle regions (Puttalam, Gampaha, and Kurunegala), the Puttalam district experienced the most significant decline in production, with a 34 percent drop, corresponding to the lowest rainfall recorded in 2009. Additionally, both Kurunegala and Gampaha districts saw a 24 percent decrease in total coconut production in 2010. Various factors, such as climate changes, inadequate fertilizer usage, and the conversion of coconut lands, were identified as reasons for the decrease in production. Because of this sudden decrease in coconut production, coconut exports rapidly declined from 2010 to 2011 (Central Bank of Sri Lanka, 2010).

Coconut production declined in 2017 due to prolonged drought conditions, resulting in lower yields and reduced production throughout the year. The last quarter of 2017 saw a particularly significant fall in production (Central Bank of Sri Lanka, 2017). In 2017, the significant decline in coconut production led to a severe shortage of nuts for both consumption and industrial usage. This shortage resulted in an unprecedented increase in coconut prices. To address the supply shortfall and price pressures, the government implemented measures such as temporarily halting the approval of fresh nut exports by the Coconut Development Authority (CDA) starting from June 2017 (Central Bank of Sri Lanka, 2017).

In addition, fresh coconut exports experienced a significant decline in 2018 due to the rise in domestic consumption without a corresponding increase in production (Sanderatne, 2019). Furthermore, the initial period of the COVID-19 pandemic also had an adverse effect on fresh coconut exports (Central Bank Sri Lanka, 2022). Consequently, because of these sudden changes in the market conditions, the fitted model couldn't accurately predict the export values in those years, resulting in significant percentage errors.

The percentage errors for the validation years 2021 and 2022 are 20.23% and -29.57% respectively. The fitted ARIMA model was able to capture the overall trend, but it falls short in forecasting values that deviate significantly from the norm. This is one of the disadvantages of ARIMA modeling.

Table 7. Forecasting export of coconuts from 2023 to 2024

Year	Number of fresh coconuts (nos '000)
2023	14696
2024	15052

Source: Authors' compilation.

IV. DISCUSSION

The paper reflects the subjective and objective analysis of Fresh Coconuts Exports from Sri Lanka from the year 1981 to 2022. This study on fresh nut exports from the island emphasizes the primary and imperative components of a time series analysis and basic statistics to make viable to make decisions and forecasts.

A prior study done on the exportation of fresh nuts encompasses basic statistics, AIC, and SBIC, producing a valid model, but when comparing the values forecasted in the previous work there is a drastic deviation from the actual values (Alibuhtto, 2013). This paper identifies that this radical change has taken place due to various reasons like climate change, the spreading of diseases among coconut trees, political decisions, and an outbreak of a global pandemic. As a result of these occurrences affecting the export of nuts from the country, and the limitations of the ARIMA (2,1,0) model, the percentage error becomes significant, making the model less accurate. Thus, to address the upheaval caused, this study has focused on the causes of the abnormal deviations in the data and suggests taking qualitative circumstances into account while making decisions and forecasting data. This study also uses actual data from the years 2021 and 2022 to validate the model derived.

Though the study identifies ARIMA (2,1,0) as the most suitable statistical method to predict the exportation of fresh coconuts from the country, the ARIMA model comes with certain limitations and drawbacks. The ARIMA model is not capturing the effect of external factors' interaction and interdependencies, on the fresh nut exports from the country. On a common basis ARIMA model assumes that the errors are normally distributed, whereas, in this instance, the residuals are not normally distributed, thus the assumption on normality affects the accuracy of forecasting and decision-making.

V. CONCLUSION AND RECOMMENDATIONS

This paper aims to model Fresh Coconuts Exports from Sri Lanka from the year 1981 to 2022 using ARIMA, a time series model, that could be used to make decisions and predict the future exports of fresh nuts. The original time series data is not stationary. Thus, applying the ADF test for the original data series makes the first-order differences series stationery. The various ARIMA models were assessed by using the Box-Jenkins approach. The comparative performance of these ARIMA models has been checked and verified by using the accuracy statistics (AIC and SIC). The ARIMA (2,1,0) was selected as the best-fitted model out of the three parsimonious models identified. This model was constructed and selected based on the Sample ACF and Sample PACF of the stationary series, along with a comparison of significant parameters and minimum values of AIC and SBIC. The residuals of the ARIMA (2,1,0) model were found to be random and constant variance. The model was validated using 2021 and 2022 data. The percentage errors for 2021 and 2022 are 20.23% and -29.57% respectively. The predicted for 2023 and 2024 are 14696 and 15052 respectively.

The ARIMA (2,1,0) model can be used effectively by the Coconut Development Authority, Export Development Board, Sri Lanka, and the relevant authorities for decision-making, and forecasting. The ARIMA (2,1,0) model can be used effectively by the Coconut Development Authority, Export Development Board, Sri Lanka, and the relevant authorities for decision-making, and forecasting. However, it is suggested to develop the model further to reduce the percentage error, by considering the possible natural and social changes that might take place impacting the coconut and its related industries.

Also, as per a discussion with the individuals employed at Coconut related authorities in the country, (Kimesha Silva Assistant Director at Ministry of Plantation Industries, Sri Lanka), it was found that about 70% of the total fresh coconuts production is consumed domestically, and 30% of it is thrown as residuals without utilizing it efficiently, thus the paper suggests that the government could take measures to change the domestic consumer behavior which so that the wasted nuts could be exported, which would increase of exports income receive from exporting fresh nuts, ultimately resulting in an upsurge of country's GDP.

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