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Development of SARIMA Model to Predict Quarterly Apparel and Textile Export Revenue in Sri Lanka

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ARTICLE INFO

Article History:
Received: 10 September 2023
Accepted: 01 November 2023

Keywords:
Apparel and textile export; Revenue; SARIMA

Citation:

Piyasiri, K.G.V., Kasthuriarachchi, U.P., Nirmani, K. G. R., Tilakaratne, K.I, and Peiris, T. S. G. (2023). Development of SARIMA Model to Predict Quarterly Apparel and Textile Export Revenue in Sri Lanka. Proceedings of SLIIT International Conference on Advancements in Sciences and Humanities, 1-2 December, Colombo, pages 320-325.

ABSTRACT

Apparel and textile exports play a significant role in the Sri Lankan economy. The USA, UK, Italy, Germany, and Belgium are the main markets of apparel and textile exports in Sri Lanka. Advanced knowledge of export revenue is vital important for various reasons. A Seasonal Autoregressive Integrated Moving Average (SARIMA) model of the type (1,1,0) x $(0,1,1)_4$ was developed to model apparel and textile export revenue in Sri Lanka using quarterly data from year 2004 quarter 1 ($2004Q_1$) to year 2021 quarter 4 ($2021Q_4$). The errors of the model were found to be random and have a constant variance. The best fitted model was identified by comparing various statistical indicators, namely, the Akaike info criterion, Schwarz criterion, Hannan-Quinn criterion, Log likelihood criterion and volatility of six possible models decided based on sample ACF and PACF of the stationary series. The model was validated for data from year $2022Q_1$ to $2023Q_1$. The Mean Absolute Percentage Error (MAPE) for the training data set and validation data set were 7.68% and 11.35% respectively. The predicted revenues (Mn USD) for the $2023Q_2$ to $2024Q_4$ are 1074.23, 1263.30, 1222.22, 1206.74, 1058.38, 1265.00 and 1216.58, respectively. The forecasted values for

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https://doi.org/10.54389/PUTK8575

short-term periods can be effectively used by the decision makers for various activities. The model developed is easy to use and reliable.

1. INTRODUCTION

Apparel and textile exports play a pivotal role in Sri Lanka's economy, contributing significantly to the country's overall export revenue. The increase in apparel and textile exports by 22.93% in 2021 with respect to 2020 brought the sector's worth to USD 5.42 billion (Sri Lanka Export Development Board, 2023). As the economic crisis has limited the access to inputs for the sector, the apparel and textile sector is aiming for exports worth USD 8 billion by 2025. The apparel industry is currently the main export industry in Sri Lanka, with over 44% of all exports and nearly 33% of all manufacturing jobs (International Trade Administration, 2022). However, incomes from apparel and textile export declined from 11.9% in October 2021 to October 2022 due to the increase in global inflation (Central Bank of Sri Lanka, 2022). It is important for Sri Lanka's apparel and textile sector to adapt to new trends, understand opportunities, and avoid possible risks as globalization continues to influence the dynamics of international trade.

Nevertheless, few authors have attempted (Hyndman and Athanasopoulos, 2021; Vo et al, 2021) to forecast demand, exports, and other factors in the apparel and textile industries using ARIMA, SARIMA, Holt-Winters model and Fuzzy EPQ model. In Sri Lanka, only one paper (Edirisooriya et al., 2020) used the SARIMA model to forecast the aggregate monthly exports in Sri Lanka and stated the importance of considering the factors affecting the apparel and textile sector to predict trends. However, in almost all the papers, the developed models have not been validated for an independent data set on view of the above explanation, the objectives of this research are to model quarterly export revenue of apparel, validate the model and apply the model to short-term forecast.

2. MATERIALS AND METHODOLOGY

2.1. Secondary Data

The data on quarterly export revenue of Apparel in Sri Lanka was collected from Sri Lanka's Export Development Board data base from 2004 Q1 to 2023 Q1 (Annual Exports Reports – Sri Lanka Apparel,2023).

2.2. Statistical Analysis

In this study, SARIMA models are developed based on Box and Jenkins methodology (Box et al., 2015). Then seasonal ARIMA (p, d, q) x $(P, D, Q)_{s.}$ is represented by,

$$\phi_p(B)\,\Phi_P(B^S)^d\,(1-B^S)^D\,Y_t = \theta_q(B)\,\Theta_Q(B^S)\,\varepsilon_t \quad (1)$$

Where p and q denote the order of autoregression (AR) and the order of moving average (MA) of the non-seasonal part, P and Q denote the order of autoregression (AR) and the order of moving average (MA) of the seasonal part, d & D order of smoothing for non-seasonal and seasonal parts (Shumway & Stoffer, 2017).

3. RESULTS AND DISCUSSION

3.1. Temporal Variability

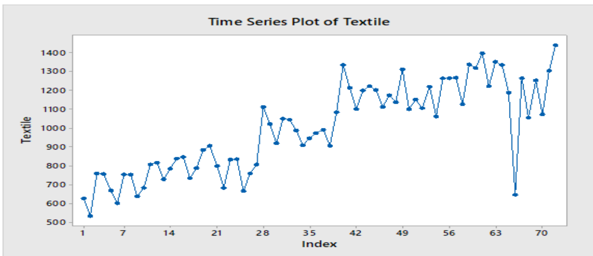


Figure 1. Temporal variability of original series

Figure 1 depicts the temporal variability of quarterly apparel export revenue in Sri Lanka from 2004 Q1 to 2021 Q4. It indicates an identically increasing pattern, confirming that dataset has a trend with seasonality and so it is a non-stationary series.

From 2004 Q1 to 2021 Q4, export revenues range from minimum US$ 535.9 million to maximum US$1439.4 million. The average textile export revenue is US$ 1000.991 million, with a standard deviation of 235.5186. Jarque-Bera statistics confirm that the quarterly export revenue is not significantly deviated from normality (JB statistics = 4.2474, p= 0.1119).

3.2. Stationarity of the Series

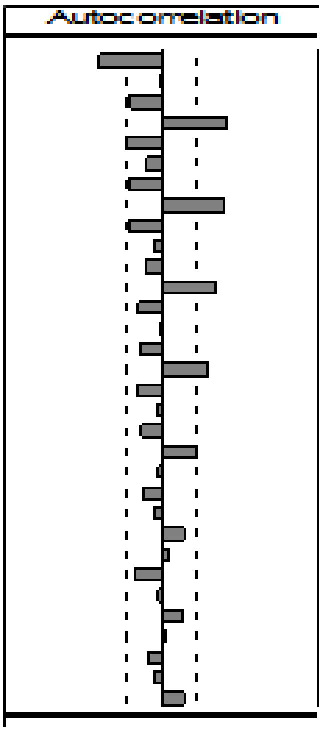
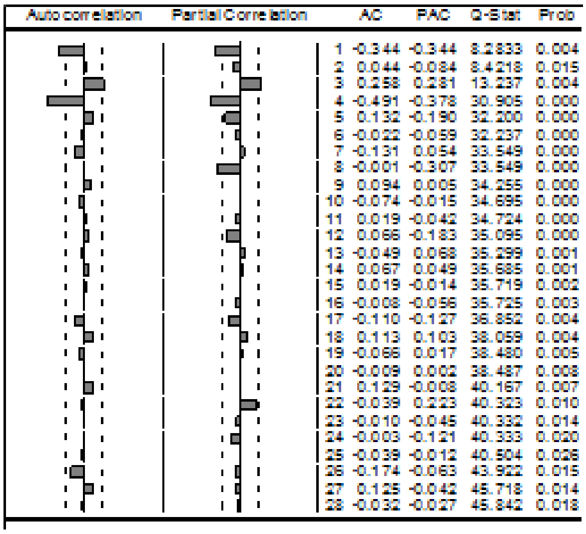


Figure 2. ACF of the 1st difference series

The augmented Dickey-Fuller (ADF) test for the original series revealed that the original series is not significant, as the p value was 0.6108 ($p > 0.05$). Therefore, to make the series stationary, the 1st difference of the original series was taken, and ADF test was carried out. The ADF test reveals that the 1st difference series is stationary, as the corresponding ADF statistics is significant ($p < 0.05$). The correlogram of the first differenced series is shown in Figure 2.



	AC	PAC	Q-Stat	Prob
1	-0.344	-0.344	8.2833	0.004
2	0.044	-0.084	8.4218	0.015
3	0.258	0.281	13.237	0.004
4	-0.491	-0.378	30.905	0.000
5	0.132	-0.190	32.200	0.000
6	-0.022	-0.059	32.237	0.000
7	-0.131	0.054	33.549	0.000
8	-0.001	-0.307	33.549	0.000
9	0.094	0.005	34.255	0.000
10	-0.074	-0.015	34.695	0.000
11	0.019	-0.042	34.724	0.000
12	0.066	-0.183	35.095	0.000
13	-0.049	0.068	35.299	0.001
14	0.067	0.049	35.685	0.001
15	0.019	-0.014	35.719	0.002
16	-0.008	-0.056	35.725	0.003
17	-0.110	-0.127	36.852	0.004
18	0.113	0.103	38.059	0.004
19	-0.066	0.017	38.480	0.005
20	-0.009	0.002	38.487	0.008
21	0.129	-0.008	40.167	0.007
22	-0.039	0.223	40.323	0.010
23	-0.010	-0.045	40.332	0.014
24	-0.003	-0.121	40.333	0.020
25	-0.039	-0.012	40.504	0.026
26	-0.174	-0.063	43.922	0.015
27	0.125	-0.042	45.718	0.014
28	-0.032	-0.027	45.842	0.018

Figure 3. Correlogram of the 4th difference series of f 1st difference series

Though the ADF test is significant, seasonal lags are not stationary since the 4th, 8th, 12th, and 16th lags show significant differences from zero, and those coefficients are decaying since $r_4 < r_8 < r_{12} < r_{16.}$ This confirms series is seasonal with order four. Thus, the series is smoothed using order of four as the length of seasonality is 4, and the ADF test is carried out. It was then found that series obtained 1 short-term difference and 1 long-term difference of the length four and was stationary (Figure 3).

According to Figure 3, in ACF, the 1st & 4th lags are significantly different from zero, while others are not significantly different from zero. In PACF which is shown in the same figure, the 1st, 4th & 8th lags are significantly different from zero, while others are not. Thus, this correlogram is employed to identify orders of AR(p), MA(q), SAR(P) and SMA(Q). Since consecutive lags of seasonal lags (4, 8) in PACF are significant, SAR can be 1, 2, while in non-seasonal lags, since lag 1 is significant, AR can be 1. According to the ACF, since non-seasonal lag 1 is significant MA can be 1, while since lag 4 is significant SMA might be 1. Thus, six models were postulated as parsimonious models (Table 1). All parameters of the six models are significant.

Models	AIC	Schwarz Criteria	Hannan-Quinn Criteria	Volatility	Log likelihood
$(1,1,0) \times (1,1,0)_4$	12.51473	12.64635	12.56681	13670.41	-415.2435
$(1,1,0) \times (0,1,1)_4$	12.41645	12.54807	12.46853	12130.68	-411.9510
$(0,1,1) \times (1,1,0)_4$	12.52607	12.65789	12.57815	13812.67	-415.6233
$(0,1,1) \times (0,1,1)_4$	12.42850	12.56012	12.48058	12296.41	-412.3547
$(1,1,0) \times (2,1,0)_4$	12.42665	12.59118	12.49175	11991.40	-411.2927
$(0,1,1) \times (2,1,0)_4$	12.41917	12.58427	12.48427	11822.38	-411.0421

Table 1. Comparison of different statistics among six possible models

Among those possible models (Table 1), the lowest values of AIC, SC, and HQC, and lower volatility and the maximum log likelihood can be identified from the model SARIMA $(1,1,0) \times (0,1,1)_4$. Thus, the SARIMA $(1,1,0) \times (0,1,1)_4$ is the best fitted model. The best fitted model can be written as,

$$(1 + 0.43409B)(1 - B)(1 - B^4)y_t = (1 + 0.7688B^4)e_t - 0.195512 \qquad (2)$$

The forecast values for the training data set along with ± 2SE is shown in Figure 4.

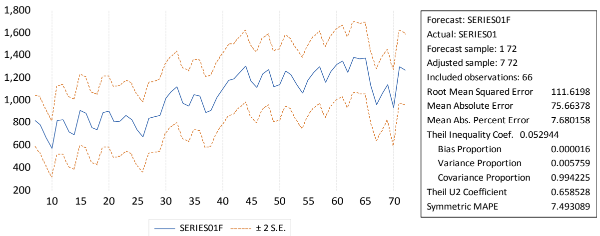


Figure 4. The forecast and its 95% confidence limits for the training data set

According to Figure 4, the Theil Inequality Coefficient (U) was 0.053 with a minute bias proportion (0.00002). Since the U was closer to 0, it indicated that the predicting power of the model was good. The percentage error for the training set varies between -19% to 24% with exceptional value of -75% in the year 2020 Q2. This could be due to the low production during COVID-19 lockdown, which may not detect the model. This can be considered as an outlier. However, in this model, we did not ignore the outliers to check the model could be improved. Furthermore, it should be noted that 77% of error percentages lie between -9% to 13%. And the MAPE (Figure 4) is 7.68%.

3.4. Residual Diagnostic

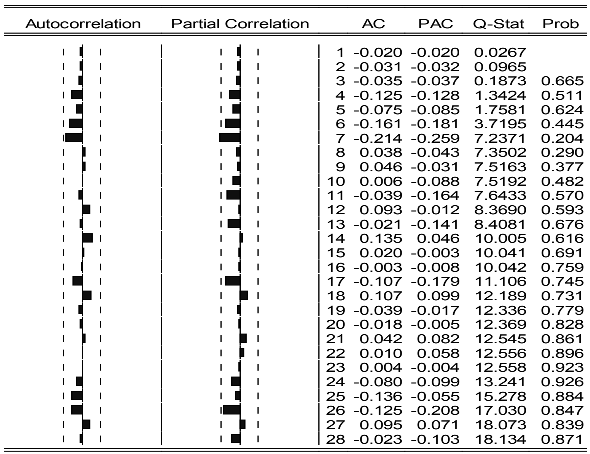


Figure 5. ACF and PACF of the residuals of the best fitted model

According to Figure 5, the Q statistic of residuals probabilities was not statistically significant (p values > 0.05), and it can be concluded with 95% confidence that errors are randomly and identically distributed. The constant variance for the residual was also confirmed due to the nonsystematic

pattern of the scatter plot between predicted values and residuals.

3.5. Validation of the model for the independent data set

Using the model 1, the values from the 2022Q1 to 2023Q1 was computed and compared with actuals (Figure 6).

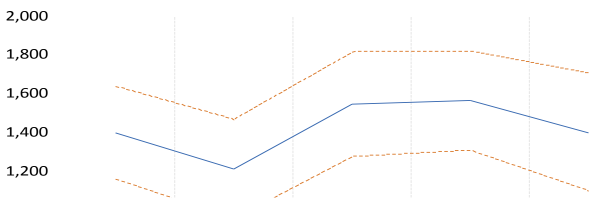


Figure 6. The forecasts and its confidence limits for the validation data

According to the temporal variability of the observed original series and the temporal variability of the forecasted series in Figure 6, the percentage errors of independent points (2022

Q1 (73) – 2023 Q1 (77)) vary from -21% to 13% (separately calculated), and MAPE (Figure 7) is only 11.35%. The Theil Inequality Coefficient (U=0.065) is closer to 0 with a minute bias proportion (0.156), indicating that the model's predicting power was good.

Year	Quarter	Predicted Revenue
2023	Q2	1074.23
2023	Q3	1263.30
2023	Q4	1222.22
2024	Q1	1206.74
2024	Q2	1058.38
2024	Q3	1265.00
2024	Q4	1216.58

Table 2. Predicted values for coming quarters.

Based on the best fitted model (1), the values for the period from 2022 Q2 to 2023 Q1 were predicted (Table 2). These values can be effectively used by the policy makers for various activities of the apparel industry.

4. CONCLUSION AND RECOMMENDATION

In this study, a SARIMA model of the type (1,1,0) x $(0,1,1)_4$ was developed and validated to forecast apparel and textile export revenue in Sri Lanka from quarter 2 of 2023 to quarter 4 of 2024. It can be concluded with 95% confidence that the model accurately captured seasonal patterns and trends in the historical data (2004 Q1 to 2023 Q1), providing valuable insights for industry stakeholders. The best fitted model was tested on an independent data set, and its goodness was proven. Furthermore, the errors of the model were found to be random, identical, and independent. The estimated parameters of the model exhibited statistical significance, indicating their contribution to forecasting accuracy. The findings of this study have practical implications for industry stakeholders, supporting their growth and competitiveness in the global market. The forecasted values provide valuable insights into future apparel export revenue trends, enabling better strategic planning, decision-making and forward contracting.

ACKNOWLEDGEMENT

We would like to convey our heartfelt gratitude to the "Sri Lanka Apparel-Joint Apparel Association Forum Sri Lanka (JAAFSL)" for giving us the secondary data we used in this research.

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