MODELING AND FORECASTING USING ARIMA: An Empirical Study of GDP in Sri Lanka

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Abstract

An autoregressive integrated moving average (ARIMA) model is useful to analyze time-series data either for better understanding or for forecasting future points in the series. This paper aims to model and forecast the GDP of Sri Lanka based on the Box-Jenkins approach based on the annual data from 1971 to 2021. Box – Jenkins technique is a relatively advanced time series forecast method it is applied in this paper to forecast GDP at the million US$ in Sri Lanka. The study attempt to study and model to forecast the GDP of Sri Lanka using an appropriate forecasting model. After testing the stationarity of the data, the series were stationary at the first difference after calculating the logarithm of the data. From the Correlogram of ACF, we determined the appropriate ARIMA model which is ARIMA (1,1,1) to forecast GDP. The ARIMA (1, 1, 1) model was seen as a superior fit model for estimating Sri Lanka's GDP at a million US$. According to the values predicted, Sri Lankan GDP shows a higher growth trend in the next few years from 2022 to 2030 at million US$. However, the forecasting result of this model is only a predicted value.

Keywords: Sri Lanka, GDP, ARIMA modelling, Forecasting, Box-Jenkins methodology

1. INTRODUCTION

The gross domestic product GDP is used as a way of national evaluation, as well as a way of measuring economic progress. The GDP of a country represents the market value of all goods and services produced by the economy during the period measured. GDP is the aggregate monetary or market value of all services and goods produced within a country's borders in any given year. It is an important indicator of a country's economic power and an important index to measure the overall economic situation of a country. It mirrors the country's economic strength, structural layout, and market scale. GDP is a key tool to guide policy-makers, investors, and businesses in strategic decision-making. The calculation of a country's GDP includes all private and public consumption, government expenditures, investments, additions to private inventories, paid-in construction costs, and the foreign balance of trade. The growth rate of real GDP is often used as an indicator of the general health of the economy. The present study attempt to study and model to forecast the GDP of Sri Lanka using an appropriate forecasting model.

2. THE OBJECTIVE OF THE STUDY:

The main objective of the present study is to select a better model and forecasting GDP on the overall economy of Sri Lanka for the future development of the Sri Lankan economy. The following sub-objectives were also formulated for this study.

- To verify the stationarity or not in the data of GDP in current price over the period.
- To study autocorrelation in the observed time series of GDP at the current price.
- To forecast GDP in the current price using an appropriate ARIMA Model.
- To test model fitness using AIC and BIC and the goodness of fit models.

3. OVERVIEWS OF SRI LANKAN GDP

Sri Lanka is a nation with lower-middle-income country status. She gained independent status in 1948. Sri Lanka faced many challenges in improving its economic development after gaining independence. in 1956, the succussive government implemented a state-led inward-looking approach. That was named a welfare state model. However, the economy failed to achieve the expected performances through closed economic policies due to limitations of markets, lack of technical expertise, low productivity, and increase in production costs (Menike, 2018). In 1977, the Sri Lankan Government introduced open economic policies centered on reduction of fiscal deficit, liberalized trade, privatization, deregulated foreign investments, and export-based industrialization. This policy reform increased the growth rate and reduced unemployment in the following years. In 1993, GDP marked a healthy 7 per cent growth due to the privatization and export-oriented strategy of the Sri Lankan government. However, GDP growth was recorded as negative 1.5 per cent in 2001. Domestic economic problems, political instability as well as terrorist attacks in the United States were the main reasons for this negative performance. Economists say that economic growth increases the wealth of a nation. In the 1980s, successive governments failed to enjoy the benefit of freedom to design long-term macroeconomic policies to have sustained growth in the economy (Herath et al., 2014). The introduction of liberalization policies in Sri Lanka prioritizes domestic investors to reach external markets. Policy reforms introduced in 1977 included reductions and simplifications of tariffs and taxes, which facilitated further expansion of trade in the country. GDP growth is important because it gives information about the size of the economy and how an economy is performing. According to the Central Bank of Sri Lanka, the GDP at constant market prices is Rs. 9,530.6 billion in 2020. Meanwhile, GDP at current market prices was estimated at Rs. 14,973.0 billion in 2020.

4. MATERIALS AND METHODS

Time series analysis and its applications have become increasingly important in Economics. Various modelling approaches were conducted by many scholars to forecast economics time series data. A model that explains the pattern or variation in actual time series data is known as a time series model. An autoregressive integrated moving average (ARIMA) model is used to forecast a time series using past values. In the Econometrics theory. ARIMA models are the most widely used approach to time series forecasting and provide complementary approaches to the problem. ARIMA model is a generalization of an autoregressive moving average (ARMA) model. It aims to describe the autocorrelations in the data (Hyndman & Athanasopoulos, 2018). ARIMA (p, d, q) Model is an econometric model where p, d, q are corresponding orders of auto-regression, integration, and moving average. (Sukhanova & Shirnaeva, 2015).

ARIMA model is theoretically the most commonly used model for the forecasting of short-run forecasts of time series. ARIMA model became popular from Box and Jenkins (1976). Box-Jenkins methodology consists of four serial steps that should be followed when building an ARIMA model. The first step is called identification, and the purpose of this step is to determine appropriate values for p, d, and q. The ACF and the partial autocorrelation function (PACF) with their respective correlograms are used for pattern detection of p, d, and q in the first step. Estimation of the parameters in the model is the second step. Step three is diagnostic checking, which tests the chosen ARIMA model's goodness of fit, usually done by testing if the residuals are white noise. In the case of residuals that are not white noise, steps one, two, and three should be repeated using new values for p, d, and q. However, if the residuals are white noise, the model should be accepted, and it is possible to proceed to step four. Forecasting is the fourth step where the model may be used to predict desired periods for the time series (Gujarati & Porter 2008). Vintu,(2021), Dritsaki, (2015), Wabomba, et. al (2016).

Bhuiyan, et.al (2008) conducted a study on modelling and forecasting of the GDP of Manufacturing Industries in Bangladesh using ARIMA model approach. In 2010, Dongdong (2010) used ARIMA model

Approach to forecast CPI data in China. Empirical results showed that ARIMA (12, 1, 12) model provided a better prediction of the monthly CPI in China. Kiriakidis, Kargas, (2013). Also used the ARIMA model to forecast Greek Gross Domestic Product with different variables. Abonazel, Abd-Elftah (2019) estimated an ARIMA to forecast Egyptian GDP based on the BoxJenkins approach). The four stages of the Box-Jenkins approach are conducted to obtain an appropriate ARIMA model for the Egyptian GDP. They found that the best model is ARIMA (1, 2, 1), because the selected model has the minimum values of MSE, AIC, and BIC. Yang, et al. (2016) applied the ARIMA model to predict the gross domestic product in China and used the model forecast GDP only in a short term.

5. EMPIRICAL ANALYSIS AND RESULTS.

This study used a single set of data for Modeling that comprised annual levels of GDP for Sri Lanka at the current market price. The study covers the period from 1971 to 2021. Table -i and fig. i present the summary and trend of the GDP at the current market price of Sri Lanka in millions of US dollars.

6. THE DATA

The data on GDP in the current price of Sri Lanka were collected. The data comprise on yearly basis from the years 1971 to 2021. In this study, the annual GDP of Sri Lanka at the current price was obtained from the Central bank of Sri Lanka from 1971 to 2021. This means that we have 51 observations of GDP which satisfies the rule of having over 50 observations in the Box-Jenkins approach to time series forecasting (Chatfield, 2016). Based on this data, we will propose the appropriate ARIMA model and then use it to forecast the Sri Lankan GDP for the next few years.

Table-i: **Summary of the Sri Lankan GDP 1971-2021**

Mean	27938.08
Median	13898.00
Maximum	87922.00
Minimum	2365.00
Std. Dev.	29854.53
Skewness	1.062797
Kurtosis	2.476935
Observations	51

Fig.i shows that the GDP at the current price of Sri Lanka is slowly increasing over time up till the year 2021. It can be seen that the GDP of Sri Lanka has an increasing trend with a seasonal pattern over time. GDP of Sri Lanka fell to -3.6% in 2020 compared to 2019. The preliminary analysis of the data was done by use of time plots for the series as shown in Fig. i.

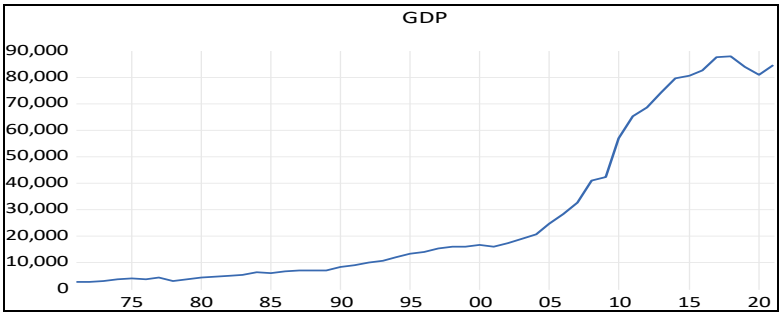
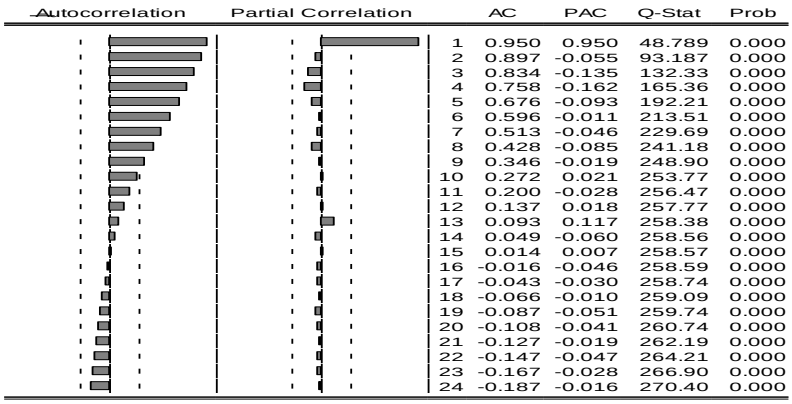


Fig. i: Time Plot of the Sri Lankan GDP 1971-2021

Based on the graphic inspection of the time plots indicates that Sri Lankan GDP is not stationary series. Moreover, the non-stationary behavior of the series is also confirmed by the ACF and PACF plots of the series, as in Fig. ii, since all p-values of the Q-test are less than 0.05. To reach stationary we will take the differencing as practiced in developing the ARIMA model



	AC	PAC	Q-Stat	Prob
1	0.950	0.950	48.789	0.000
2	0.897	-0.055	93.187	0.000
3	0.834	-0.135	132.33	0.000
4	0.758	-0.162	165.36	0.000
5	0.676	-0.093	192.21	0.000
6	0.596	-0.011	213.51	0.000
7	0.513	-0.046	229.69	0.000
8	0.428	-0.085	241.18	0.000
9	0.346	-0.019	248.90	0.000
10	0.272	0.021	253.77	0.000
11	0.200	-0.028	256.47	0.000
12	0.137	0.018	257.77	0.000
13	0.093	0.117	258.38	0.000
14	0.049	-0.060	258.56	0.000
15	0.014	0.007	258.57	0.000
16	-0.016	-0.046	258.59	0.000
17	-0.043	-0.030	258.74	0.000
18	-0.066	-0.010	259.09	0.000
19	-0.087	-0.051	259.74	0.000
20	-0.108	-0.041	260.74	0.000
21	-0.127	-0.019	262.19	0.000
22	-0.147	-0.047	264.21	0.000
23	-0.167	-0.028	266.90	0.000
24	-0.187	-0.016	270.40	0.000

Fig. ii: Correlogram of GDP of Sri Lanka 1977-2021

The examination of the correlogram in fig.ii confirms that the Sri Lankan GDP time series data is non-stationary. This kind of non-stationary time series which contains a seasonal trend can often be carried out differencing. Before the analysis using the Box-Jenkins methodology, the data has to be transformed to achieve stationarity. After the test of Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test for the series, the results showed that the GDP series was still non-stationary. Therefore, the first-order difference was taken, for the GDP series producing a new variable DGDP.

Table. ii : Unit Root Tests of LGDP

Variable	ADF		PP	
	Level I	1st Diff.	Level I	1st Diff.
GDP	-2.553140 (0.3026)	-4.533661 (0.0036)	-1.333489 (0.8676)	-4.716463 (0.0021)

As per the ADF and PP test GDP series is stationary at the first defending level.

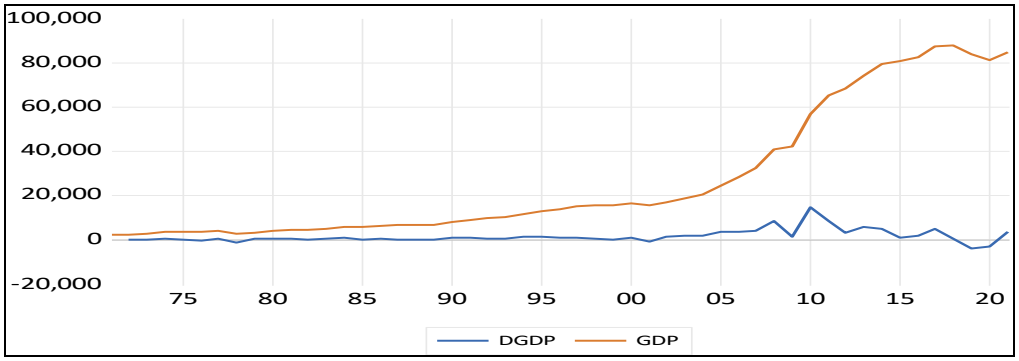


Fig. iii: Time Plot of the GDP and DGDP

7. MODEL IDENTIFICATION

To determine the proper model, it is necessary to carry out the Autocorrelation Function (ACF) and partial correlation function (PACF). This test reflects how the observations in a time series are related to each other. The Correlogram test was carried out to meet the condition mentioned above. ACF and PACF approaches were performed to identify the model.

Table. iii: **Model Selection Criteria Table**

Model	LogL	AIC*	BIC	HQ
(1,1)(0,0)	-461.786134	18.631445	18.784407	18.689694
(1,2)(0,0)	-461.095996	18.643840	18.835042	18.716651
(2,1)(0,0)	-461.618659	18.664746	18.855949	18.737557
(2,0)(0,0)	-462.777455	18.671098	18.824060	18.729347
(1,0)(0,0)	-464.095114	18.683805	18.798526	18.727491
(2,2)(0,0)	-461.622306	18.704892	18.934335	18.792265
(0,1)(0,0)	-465.891902	18.755676	18.870397	18.799363
(0,2)(0,0)	-465.247639	18.769906	18.922867	18.828154
(0,0)(0,0)	-470.244618	18.889785	18.966266	18.918909

To forecast the GDP of Sri Lanka, that combination can be made automatically, and an optimal one can be chosen based on minimum AIC and SIC and a maximum coefficient of the determinant. Results indicated that the ARIMA (1, 1, 1) is a good fit model for forecasting GDP. Table. iii indicates the model selection criteria for this study.

8. ESTIMATION AND SELECTION OF ARIMA MODEL

Modelling results of an ARIMA (1,1,1) process have been estimated by use of the Gaussian MLE Criterion and are presented in Tables. iv and v. Based on the number of the significant variables in the model, Sigma value, AIC, and SIC values ARIMA (1,1,1) model was selected as the best fit model for forecasting. Table;4 shows the estimated parameters of the ARIMA (1,1,1) model. All coefficients were statistically significant at 5 percent in the selected model.

Table. iv: Results of ARIMA (p, d, q) Models

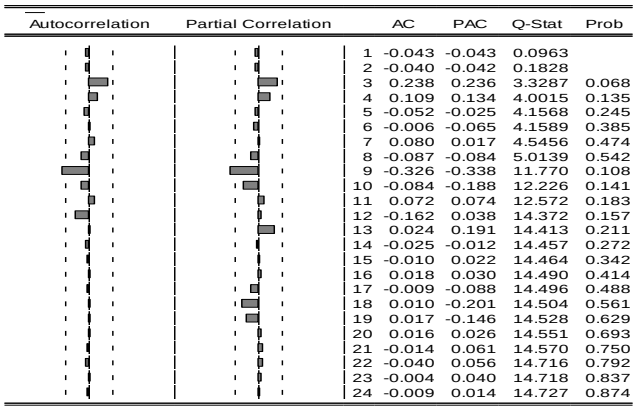
No	Model	No of Sig. Variable	SIGMAS	Adj R^2	SER	AIC	SIC
1	**ARIMA (1,1,1)**	**03**	**6109050**	**0.246817**	**2576.872**	**18.63145**	**18.78441**
2	ARIMA (2,1,1)	03	6645713	0.180652	2687.676	18.71221	18.86517
3	ARIMA (2,1,2)	00	6984798	0.138845	2755.390	18.76584	18.91881
4	ARIMA (1,1,0)	01	6723087	0.188748	2674.806	18.68380	18.79853
5	ARIMA (0,1,1)	02	7237575	0.126667	2774.806	18.75568	18.87040

Table. v: **Parameter estimates of ARIMA (1,1,1)**

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1475.729	2024.969	0.728766	0.4698
AR(1)	0.844643	0.182329	4.632511	0.0000
MA(1)	-0.516122	0.243154	-2.122614	0.0392
SIGMASQ	6109050.	687986.3	8.879611	0.0000

9. DIAGNOSING THE MODEL

After estimating the models, diagnostic checking would be necessary to confirm that the estimated models are reasonably suitable and statistically significant for forecasting. The Box-Jenkins model diagnostics are based on the assumption that a good model should have a stationary error term that follows a white noise process. In the process of diagnostic checking, the nature of the systematic pattern of the residuals is examined. One of the simple diagnostic methods is to obtain the correlograms of ACF and PACF of the residuals of the selected ARIMA model (1,1,1). Fig. iv illustrates the correlograms of both ACF and PACF. It gives the impression that the residuals estimated for the ARIMA model (1,1,1) are purely random. The Q statistic of Ljung–Box for all the 24 lags has values greater than 0.05 thus the null hypothesis cannot be rejected, therefore, there is no autocorrelation for the examined residuals of the series



	AC	PAC	Q-Stat	Prob
1	-0.043	-0.043	0.0963	
2	-0.040	-0.042	0.1828	
3	0.238	0.236	3.3287	0.068
4	0.109	0.134	4.0015	0.135
5	-0.052	-0.025	4.1568	0.245
6	-0.006	-0.065	4.1589	0.385
7	0.080	0.017	4.5456	0.474
8	-0.087	-0.084	5.0139	0.542
9	-0.326	-0.338	11.770	0.108
10	-0.084	-0.188	12.226	0.141
11	0.072	0.074	12.572	0.183
12	-0.162	0.038	14.372	0.157
13	0.024	0.191	14.413	0.211
14	-0.025	-0.012	14.457	0.272
15	-0.010	0.022	14.464	0.342
16	0.018	0.030	14.490	0.414
17	-0.009	-0.088	14.496	0.488
18	0.010	-0.201	14.504	0.561
19	0.017	-0.146	14.528	0.629
20	0.016	0.026	14.551	0.693
21	-0.014	0.061	14.570	0.750
22	-0.040	0.056	14.716	0.792
23	-0.004	0.040	14.718	0.837
24	-0.009	0.014	14.727	0.874

Fig. iv: Correlogram of Residuals

After the diagnostic checking, the forecast of GDP could be done using the selected model. This can be done by removing the first difference to get the values of GDP on the level.

10. FORECASTING

Fig. vi shows the plot for the nine-year forecast of the GDP by fitting the ARIMA (1, 1, 1) model to the time series data. The model is used to analyze the fitting effect with the GDP value in 2020

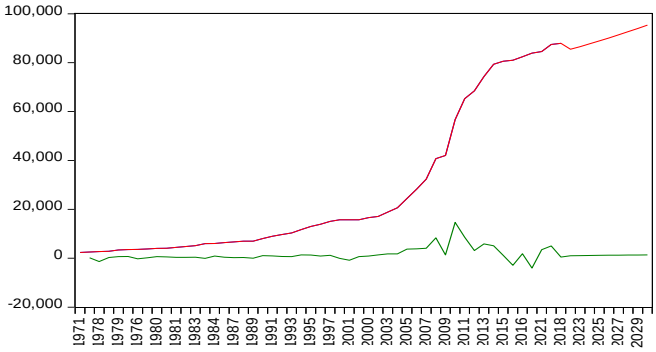


Fig. v: **forecasting of Sri Lankan GDP at US$ million**

Table- vi: Forecasted Value of GDP in Million US Dollars

2022	85,995
2023	87,470
2024	88,946
2025	90,421
2026	91,897
2027	93,373
2028	94,848
2029	96,324
2030	97,800

11. CONCLUSION

This paper aims to model and forecast the GDP of Sri Lanka based on the Box-Jenkins approach based on the annual data from 1971 to 2021. Box – Jenkins technique is a relatively advanced time series forecast method it is applied in this paper to forecast GDP at the million US$ in Sri Lanka. The study attempt to study and model to forecast the GDP of Sri Lanka using an appropriate forecasting model. After testing the stationarity of the data, the series were stationary at the first difference after calculating the logarithm of the data. From the Correlogram of ACF, we determined the appropriate ARIMA model which is ARIMA (1,1,1) to forecast GDP for the years 2022, 2023, 2024,2025,2026,2027,2028,2029 and 2030 respectively. this study could not take into consideration the impact of the COVID-19 pandemic on forecasting the values of GDP. The ARIMA (1, 1, 1) model was seen as a superior fit model for estimating Sri Lanka's GDP at a million US$. According to the values predicted, Sri Lankan GDP shows a higher growth trend in the next few years from 2022 to 2030 at million US$. However, the forecasting result of this model is only a predicted value. Any adjustments in Sri Lankan economy macroeconomic variable may change the forecasting of GDP.

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