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Forecasting GDP growth rates of Bangladesh: an empirical study

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Abstract

Background/Objectives: This study aims to apply time series tools ARIMA and Exponential smoothing methods to model and forecast GDP growth rates in the economy of Bangladesh. Forecasting of GDP growth rate is an important topic in macroeconomics.
Methods/ Statistical analysis: The data was collected from World Development Indicators (WDI) and it has been collected over a period of 37 years by WDI, World Bank. We applied Phillips–Perron (PP) and Augmented Dickey–Fuller (ADF) tests to investigate the stationary character of the data. Stata and R statistical software was used to construct a class of Autoregressive Integrated Moving Average (ARIMA) and exponential smoothing methods to model and forecast the GDP growth.
Findings: We applied several ARIMA (P, I, Q) models and applied the ARIMA (1,1,1) model as best for forecasting. This ARIMA (1,1,1) model was chosen based on the minimum values of the Akaike information criterion (AIC) and the Bayesian information criterion (BIC). Also, we applied the Exponential Smoothing measurements to forecast the GDP growth rate. In addition, among all the Exponential Smoothing models, the triple exponential model better analyzed the data based on lowest Sum of Square Error (SSE) and Root Mean Square Error (RMSE). Using these models, the numeric figure of future GDP growths are forecasted. Statistical outcomes illustrate that Bangladesh's GDP growth rate is an increasing trend that will continue rising in the future.
Improvements/Applications: This finding will help policymakers and academicians to formulate economic and business strategies more precisely.
Keywords: ARIMA, Time Series, Exponential Smoothing, Forecasting GDP growth rate, GDP growth in Bangladesh.

1. Introduction

GDP is the combined value of all economic activities in a country; it captures the broadest coverage of the economy better than any other macroeconomic indicators. GDP is often considered the best measure of how well the economy is performing. For these reasons GDP growth have become one of the most concerning amongst modern macroeconomic indexes. The growth is regarded as the most important indicator for assessing national economic development, economic strength, and for judging the operating status of the macro economy [1]. Since Adam Smith, economic growth has been an important topic in economic indicators and an important component of mainstream economics. The assessment of the present and future state of the economy is an important element in macroeconomic forecasting for long-term analysis. Economic researchers are particularly interested in GDP forecasts for assessing and predicting the functional status of the economy of developing countries. Forecasting future economic trends and outcomes is an essential component of the decision-making process for financial authorities, policymakers, central banks, and economists for all countries. For the forecasting of time series, we used models that are based on a methodology that was first developed by Box and Jenkins [2], known as Auto-Regressive Integrated Moving Average or ARIMA methodology. Box and Jenkins' ARIMA methodology has been used broadly by many researchers to forecast future GDP growth. The market-based economy of Bangladesh is the 41st largest in nominal terms [3]. The steady increase of its economic growth means that Bangladesh, a less developed country, could be predicted to come out of its economic status quo. Given the new developments in Bangladesh's GDP, economists are often inconclusive about how long the trend will continue.

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2. Literature survey

A large variety of linear and nonlinear models are now available for modeling and forecasting macroeconomic time series data—see, for example, [4-7] for recent overviews. A large dataset gathered from China's Shaanxi GDP from 1952 to 2007 forecasted the country's GDP for the next 6 years [8]. Scrutinized the forecasting of GDP growth for India. They applied an ARIMA (1,2,2) model. Their study displayed that predicted figures follow a growing trend for the succeeding years [9]. Zhao Ying used an ARIMA model with time-series data of actual GDP from 1954 to 2004 in China to analyze and predict the national GDP growth pattern [10] attempted to construct a time series model that was utilized to forecast the gross domestic product of China up to the first quarter of 2009. This paper was based on figures collected from secondary sources from the years1962 to 2008, Lu got ARIMA (4,1,0), which he applied for forecasting purposes [11]. In [12] developed a time series model to forecast the GDP of manufacturing and industries test and forecast GDP for Albania using quarterly data from 2003 to 2013. They applied two important time-series model: ARIMA and VAR. Their paper shows that the group of VAR models provides better results on GDP forecasting than the ARIMA model. In [13] summary, these studies motivated me to carry out this research which analyzes the potential for GDP growth rates in Bangladesh.

1. Research objectives

1. To verify the stationarity or not in the data of GDP growth over the period.
2. To study autocorrelation in the observed time series of GDP growth.
3. To forecast GDP growth using an appropriate ARIMA (P,I,Q) Model.
4. To forecast GDP growth using Exponential Smoothing Methods.
5. To test model fitness using AIC and BIC and the goodness of fit models.

3. Model

To forecast GDP growth, a simple ARIMA model has been taken into consideration in this work. In the early 70s Box and Jenkins popularized the ARIMA model. Four major stages such as identification, estimation, diagnostic checking, and forecasting of time series are included in this iterative process. An ARIMA model can be expressed as

$$Y_t = \alpha + \sum \phi_p Y_{t-p} + \sum \theta_q \varepsilon_{t-q} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1)$$

where, Y_t = GDP growth rate at period t, Y_{t-p}= GDP growth rate at period (t-p),
θ_q = Random shock at period q,ε_{t-q} = Random error term at period t, and (α, ϕ_p, θ_q) are parameters to be estimated. Since 1976, this model has gained enormous popularity due to its versatility in many areas in business, finance, and economics. A standard notation is used of ARIMA (P,I,Q) where the parameters are substituted with integer values to figure out the specific ARIMA model that is optimal for forecasting. The three parameters of the ARIMA (P,I,Q) model are defined as follows: P equals the number of lag observations included in the model, also called the lag order. Iis called the degrees of differencing or the number of times that the raw observations are differenced. The order of moving average is here Q. After establishing ARIMA, the next step is forecasting the growth rate.

1. Accuracy level
2. Data and information availability
3. The time horizon for forecasting

4. Data and Methods of analysis

To forecast GDP growth, data on this macroeconomic variable was collected from 1982 to 2018 from the World Development Indicators (WDI), World Bank. It is a single set of data for modeling that was comprised of annual levels of GDP growth for Bangladesh. The data file consists of 37 observations. A graphical representation of data reveals that GDP series follows an increasing pattern over this period (Figure 1).

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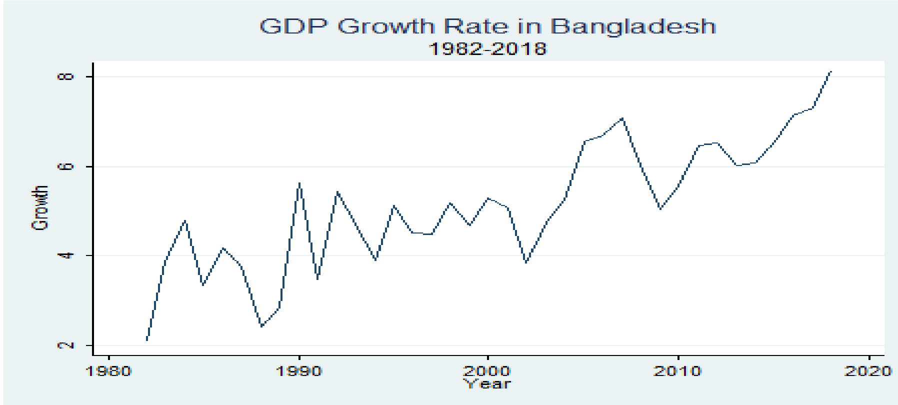
Figure 1a. Upward curve of GDP growth rates in Bangladesh over a period of 1982-2018



Source: Compiled from data

Figure 1b. Upward curve of GDP growth rates in Bangladesh over a period of 1982-2018 with fitted line

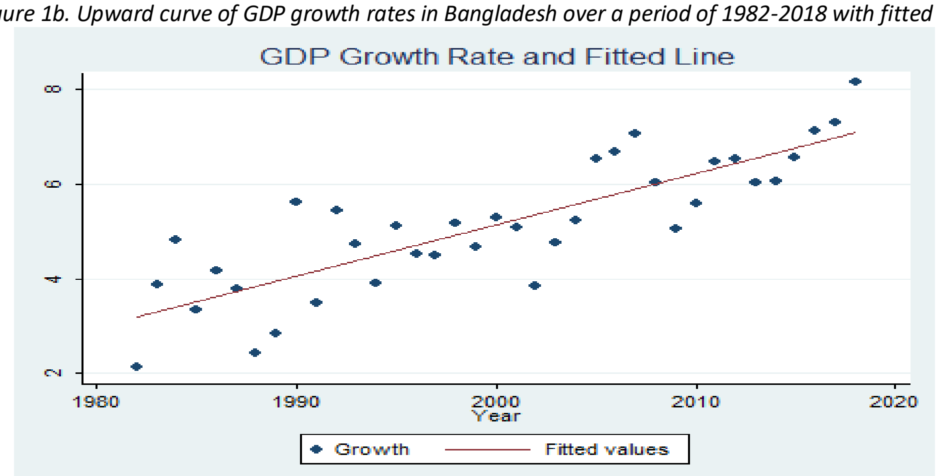


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Table 1. *Results of the ADF Test on GDP Growth (Level)*

Variable	Hypothesis	t-statistic	P*
GDP growth	GDP growth has a unit root	-2.69	0.0753

*MacKinnon (1996) one-sided p-values
Source: Compiled from data

In [14-15] Figure 1a and 1b, the GDP growth series usually follows an upward trend. This shows that both the mean and the variance are not stable. It does not follow a stationary pattern. Hence, data has been differenced to convert them from non-stationary to stationary. Furthermore, test has been conducted on this differenced GDP series of 37observations.

Table 2. *Results of the Phillips-Perron test on GDP growth (Level)*

Variable	Hypothesis	t-statistic	P*
		Z(rho)=-10.59	
GDP growth	GDP growth has a unit root	Z(t)=-2.71	0.0723

*MacKinnon (1996) one-sided p-values
Source: Compiled from data

The results in Tables 1-2 confirm that 37 observations of GDP growth series follow a nonstationary pattern, which help us to specify the Integrated (I) term in the ARIMA model.

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Table 3. Results of the ADF test on GDP growth (First Difference)

Variable	Hypothesis	t-statistic	P*
GDP growth	GDP growth has no unit root	-6.085***	0.000

*MacKinnon (1996) one-sided p-values

Source: Compiled from data

In the Tables 3-4, the outcomes show that real GDP is stationary in the first difference. Which is also highly significant at 1% significance levels? The next steps are the specification of two more terms (P,Q) in the ARIMA model: autoregressive (AR) and moving average (MA). In the Figure 2, we showed a correlogram of the 37 observations of GDP growth series, which deals with autocorrelation of GDP and its diverse lags with respective t-statistics. Figure 3 shows that there is a significant spike at ACF at lag 1, and after the first lag, the ACFs slowly decline. We can conclude that it is non-stationary time series.

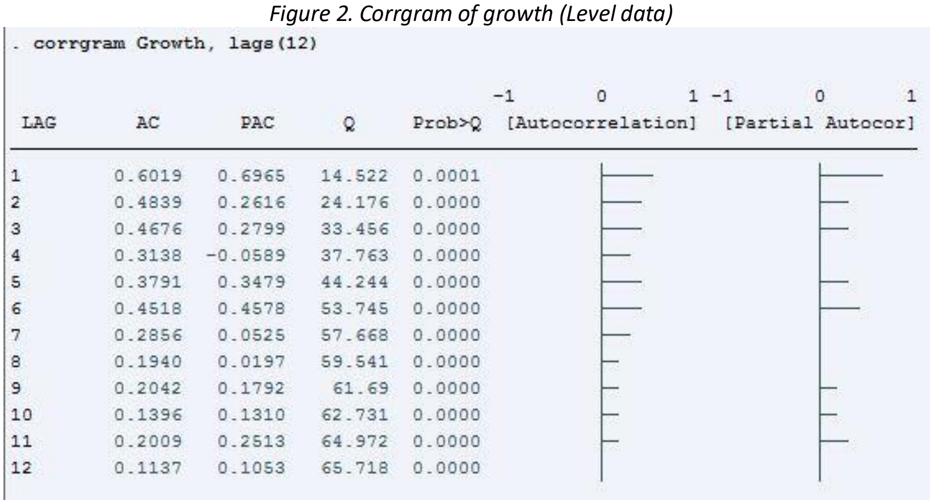
Table 4. *Results of the phillips-perron test on gdp growth (First Difference)*

Variable	Hypothesis	t-statistic	P*
		Z(rho)=-25.308***	
GDP growth	GDP growth has no unit root	Z(t)=-6.257***	0.000

*MacKinnon (1996) one-sided p-values

Source: Compiled from data

Figure 2. Corrgram of growth (Level data)



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. corrgram Growth, lags(12)
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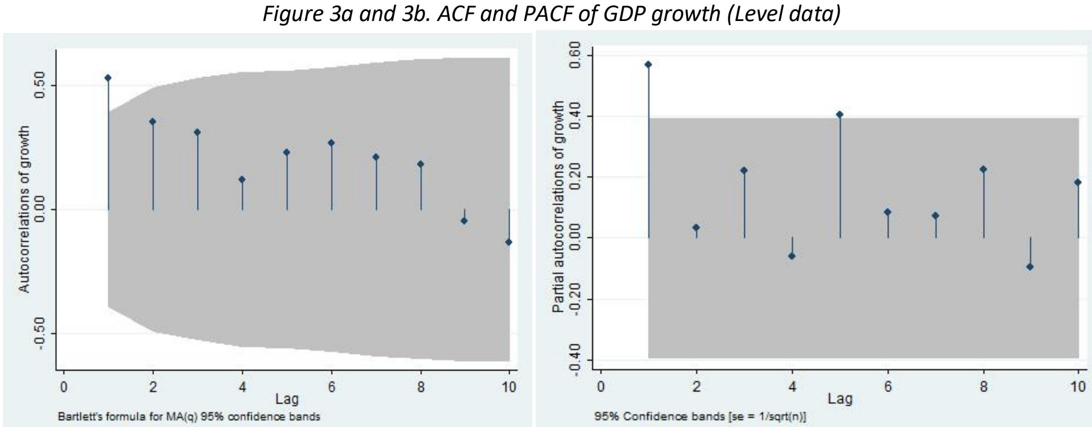
LAG	AC	PAC	Q	Prob>Q
1	0.6019	0.6965	14.522	0.0001
2	0.4839	0.2616	24.176	0.0000
3	0.4676	0.2799	33.456	0.0000
4	0.3138	-0.0589	37.763	0.0000
5	0.3791	0.3479	44.244	0.0000
6	0.4518	0.4578	53.745	0.0000
7	0.2856	0.0525	57.668	0.0000
8	0.1940	0.0197	59.541	0.0000
9	0.2042	0.1792	61.69	0.0000
10	0.1396	0.1310	62.731	0.0000
11	0.2009	0.2513	64.972	0.0000
12	0.1137	0.1053	65.718	0.0000

Source: Compiled from data

Figure 3a and 3b. ACF and PACF of GDP growth (Level data)



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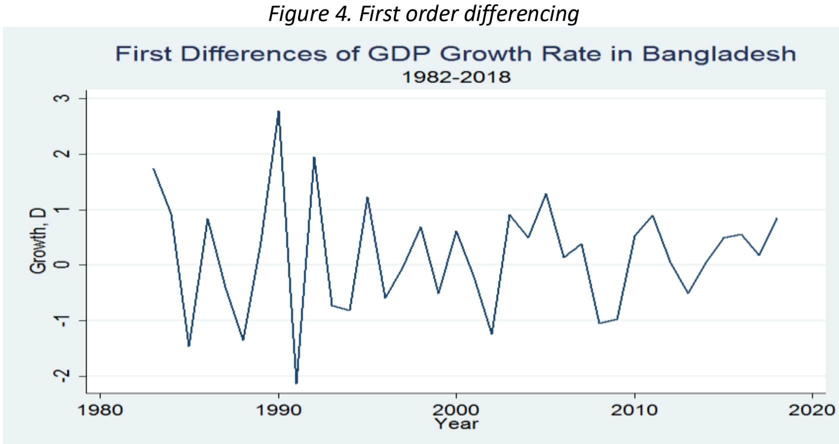
Again, from Figure 3, Partial Autocorrelation (PACF) of the difference series is estimated; we see that it has a significant spike at lag 1. So, we can accept the null hypothesis that the real GDP rate series of 37 observations is non-stationary. Since the ACF and PACF have spikes at lag 1, the differences can be applied for this model. Figure 4 shows that after taking a first order difference (period to period change), the time series seems to have been made stationary; there is no clear upward or downward trend. As a consequence, we can apply this data for determining an ARIMA (P,I,Q) model.

Figure 4. First order differencing



Source: Compiled from data

Figure 5a and 5b.ACF and PACF after taking differences

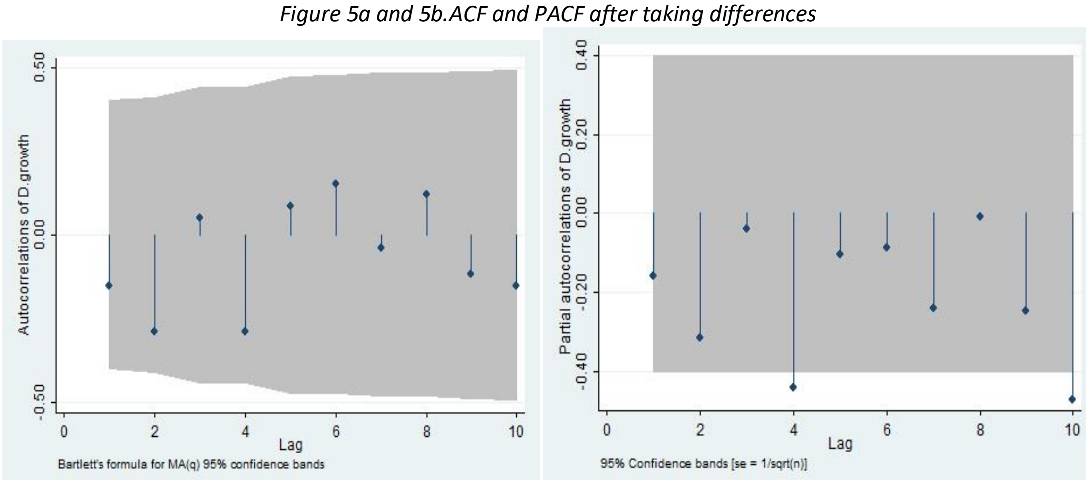


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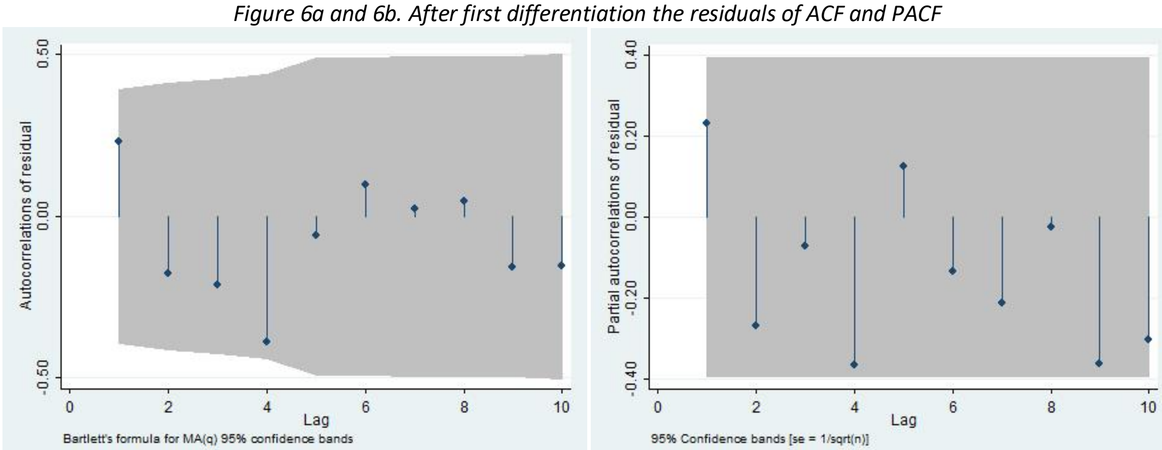
Figure 6a and 6b. After first differentiation the residuals of ACF and PACF



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From Figure 5, it clearly shows that the ACF and PACF first difference series has no significant spikes at any lags. The conclusion is now our time series is stationary. ARIMA models with first differences, therefore, are recommended for the time series. In Figure 6, after first differentiation the residuals of ACF and PACF show that the GDP growth series has no problem with residuals. There are no spikes which indicate a positive sign for using this model for forecasting.

Table 5. *Several ARMA models*

(1)	(2)	(3)	(4)	(5)	
growth	growth	growth	growth	growth	growth
_cons	5.252*	5.130***	5.128***	5.160***	5.122***
(2.57)	(17.22)	(7.17)	(4.92)	(14.26)	
ARMA					
L.ar	0.970***		0.771***	0.591***	
	(13.09)		(6.03)	(3.42)	
L2.ar		(1.56)			0.264
L.ma	-0.565*	0.590***		0.645***	
(-2.51)	(4.59)		(4.08)		
L2.ma				0.189	
(0.98)					
sigma					
_cons	0.930***	1.135***	0.994***	0.961***	1.106***
(7.60)	(7.23)	(6.93)	(7.20)	(6.71)	
N	37	37	37	37	37
AIC	109.3	120.8	111.4	111.3	120.8
BIC	115.7	125.6	116.3	117.7	127.3
t statistics in parentheses					
* p<0.05, ** p<0.01, *** p<0.001					

Source: Compiled from data

In the Table 5-6, various ARMA and ARIMA models with several orders of autoregressive, difference terms, and moving average were compared based on their performance. The statistical values were checked, and verified by using test such as AIC and BIC. ARIMA (1, 1, 1) are better choices based on AIC, BIC, and significant level. Thus, the ARIMA (1,1,1) model is used in this paper for future forecasting. The 10-year forecast of Bangladeshi GDP growth rates are presented in Table 7. The projected growth rate indicates that Bangladeshi GDP growth will continue to get higher.

Table 6. Several ARIMA models

(1)	(2)	(3)	(4)	(5)	
(1,1,1)	(1,1,0)	(2,1,0)	(2,1,2)	(2,1,1)	
Growth _cons	0.109***	0.150	0.133	0.108***	0.108***
(6.60)	(1.23)	(1.44)	(6.73)	(5.37)	
ARMA					
L.ar	0.126***	-0.358*	-0.493**	-0.805***	0.134
(3.82)	(-2.20)	(-2.71)	(-3.84)	(0.77)	
L2.ar	-0.322*	0.0361	-0.129		
(-2.00)	(0.18)	(-0.82)			
L.ma	-1.000**	-0.0328	-1.000		
(.08)	(.05)	(-0.00)			
L2.ma	-0.967*				
(-2.22)					
sigma _cons	0.774***	0.954***	0.905***	0.756***	0.765
(7.30)	(8.87)	(7.34)	(4.59)	(0.00)	
N	36	36	36	36	36
AIC	93.09	104.9	103.4	95.99	96.55
BIC	97.84	109.7	109.7	103.9	104.5
t statistics in parentheses					
* p<0.05, ** p<0.01, *** p<0.001					

Source: Compiled from data

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Table 7. Comparative trend of growth rate for the subsequently 10 years using ARIMA (1,1,1)

Year	Projected Growth Rate	Lower limit	Upper Limit
2019	8.14	8.07	8.26
2020	8.26	8.03	8.50
2021	8.38	8.14	8.63
2022	8.54	8.31	8.78
2023	8.69	8.46	8.93
2024	8.84	8.61	9.08
2025	8.99	8.75	9.23
2026	9.14	8.90	9.38
2027	9.29	9.06	9.50
2028	9.44	9.20	9.68

Source: Compiled from data

Table 7 consists of the projected growth rates for the next 10 years using the ARIMA (1,1,1) model. The third and fourth columns are lower and upper limits of the forecasted growth during the years 2019–2028. There is an expected smooth increase of GDP growth in Bangladesh. Figures 7-8 attempt to forecast the GDP growth rate in Bangladesh for next 10 years with an ARIMA model. In figure 8, we also included the upper and lower bound.

Figure 7. GDP growth forecasting

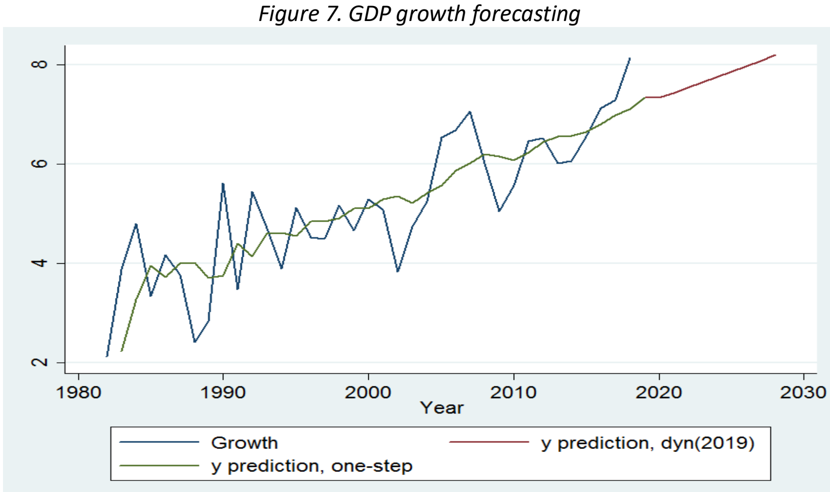

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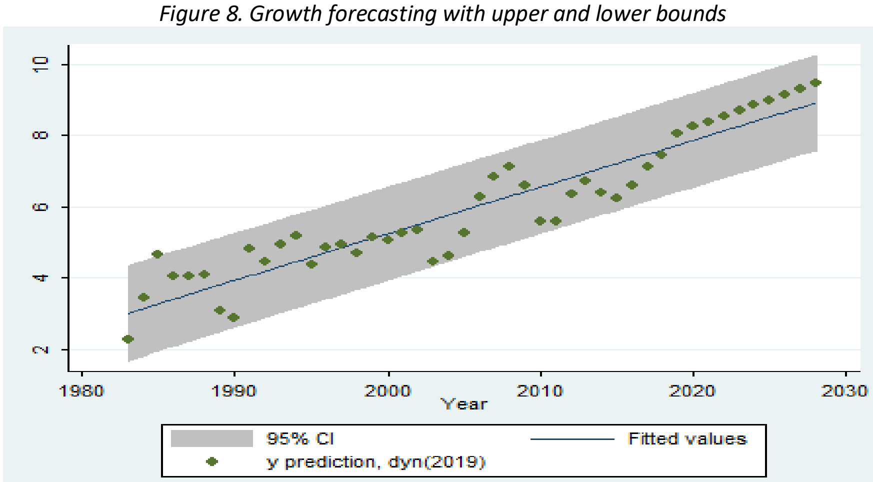
Figure 8. Growth forecasting with upper and lower bounds



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5. Exponential smoothing

Here we also applied exponential smoothing as an alternative to the previous forecasting methods. In this paper, we applied three exponential smoothing methods to smooth data. All methods provide long-term forecasts and dynamic estimation. The triple and double exponential smoothing provides several advantages and additional options.

The simple or single exponential smoothing method is appropriate for forecasting data without trend or seasonal pattern:

$$S_t = \alpha X_t + (1-\alpha)\, S_{t-1}$$

Here α, a smoothing factor, is applied here to manage the speed which the updated forecast will adapt to local levels of the time series and $0<\alpha<1$. When $\alpha=1$, the simple exponential smoothing method is equivalent to the naive no change extrapolation method. Conversely, when $\alpha=0$, the forecast will be a constant taking its value from the starting value for Level.

The double or halt exponential smoothing method is the most popular. It was proposed by Holt and extended simple exponential smoothing to allow forecasting of data with a trend:

$$F_t=\alpha X_t + (1-\alpha)\,(F_{t-1}+b_{t-1})$$
$$b_t= \gamma\,(F_t-F_{t-1}) + (1-\gamma)b_{t-1}$$
$$F_{t+m}= F_t + b_t m$$

Here α and γ, the starting values for level and trend, are required for double exponential method, and $0<\alpha,\ \gamma <1$.

The triple or Holt-Winters seasonal method comprises the three smoothing equations—one for the level, one for trend and one for the seasonal component:

$$S_t=\alpha\frac{Yt}{St-s}+ (1-\alpha)\,(S_{t-1}+b_{t-1})$$
$$b_t = \gamma(S_t-S_{t-1}) + (1- \gamma)b_{t-1}$$
$$I_t= \beta\frac{Yt}{Lt}+(1- \beta)\, I_{t-s}$$
$$F_{t+m} = (S_t+b_t m)\, I_{t-s+m}$$

The triple exponential smoothing method includes starting values for Level, Trend, and Seasonality, where α, β and γ are the smoothing factors, and $0<\alpha,\ \beta,\ \gamma <1$. Here α = smoothing coefficient for level, γ =Trend smoothing coefficient, β = Seasonality smoothing coefficient. F_{t+m}=Smoothed forecast value for Y.

Table 8. *Forecast the GDP growth in Bangladesh by three smoothing methods (2019-2028)*

Year	GDP growth		
	Single Exponential Smoothing	Double Exponential Smoothing	Triple Exponential Smoothing
2019	7.42	7.44	7.64
2020	8.03	8.44	8.33
2021	8.26	8.66	8.56
2022	8.38	8.67	8.63
2023	8.54	8.76	8.77
2024	8.69	8.87	8.90
2025	8.84	9.008	9.04
2026	8.99	9.14	9.18
2027	9.14	9.29	9.32
2028	9.29	9.44	9.46

Source: Compiled from data

Table 8 presents 10 years of forecasted GDP growth rate using the fitted single, double, and triple exponential smoothing model. Different values of *α,* β, γ have been tried to obtain the most accurate fitted model.

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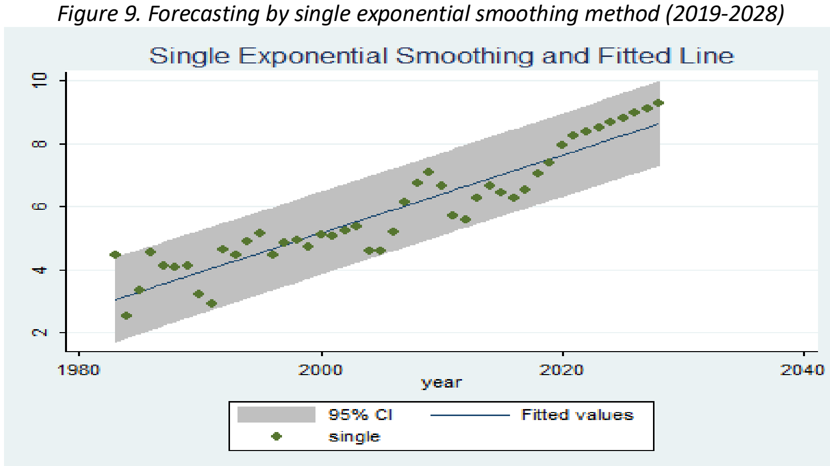
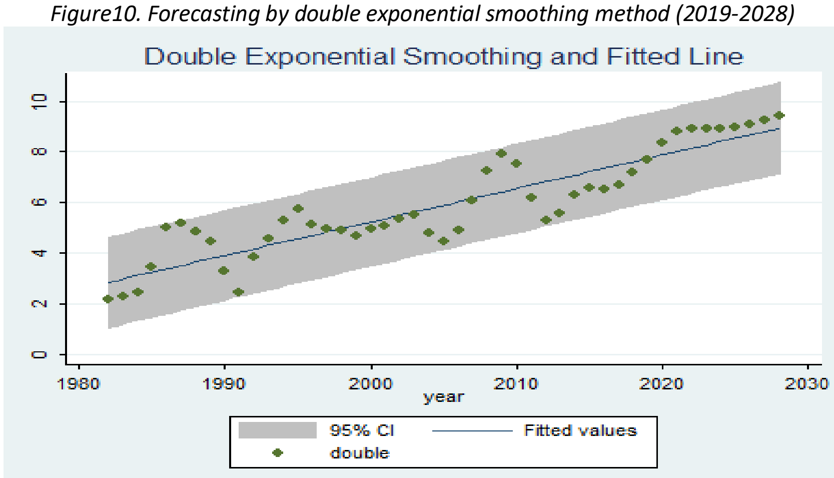
The optimality and accuracy of smoothing coefficients (α, β, and γ) have been measured through Sum of Square Error (SSE) and Root Mean Square Error (RMSE), which minimizes residuals, is the best optimal solution. Graphs of the smoothed series are shown in Figures 8 through 10, which are closely fitted to actual values.

Figure 9. Forecasting by single exponential smoothing method (2019-2028)



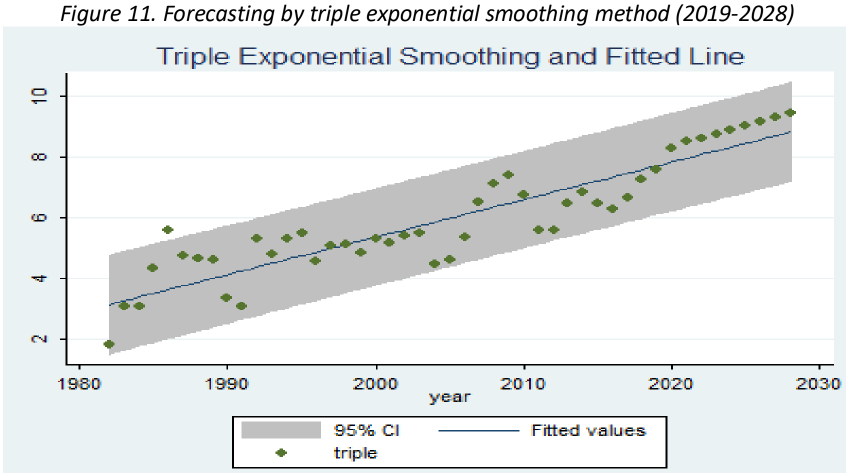
Source: Compiled from data

Figure10. Forecasting by double exponential smoothing method (2019-2028)



Source: Compiled from data

Figure 11. Forecasting by triple exponential smoothing method (2019-2028)



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In Figures 9 through 11, three different forms of exponential smoothing are shown, known as single, Holt or double, and holt-winter's smoothing or triple. The first one finds a normal smooth approximation. The second extracts a linear trend, and the third one considers seasonality (regularly recurring). All graphs show an increasing trend.

Table 9. Error comparison in three different exponential smoothing models

% error	Single Exp Smoothing	Double Exp Smoothing	Triple Exp Smoothing
SSE	14.53	13.11	7.6374
RMSE	.762	.724	.552

Source: Compiled from data

In Table 9, the triple exponential smoothing yields the minimum values of the *SSE and RMSE* for the subsequently 10 years. So, it can be concluded that the triple exponential model fits the data better than both double and single exponential model. To estimate optimal values of smoothing constants, forecasts are computed with several values of *α,* β, and γ, with increments. Three forecasting accuracy techniques, such as SSE and RMSE, are used to select the most accurately predict for the next few years. This is because GDP growth data contains both trend and seasonal components which are only fully considered in a triple exponential model. Among models with very different error statistics, we can choose whether we would prefer a little more responsiveness or a little more smoothness in the forecasts. Empirical evidence suggests that, if the data have already been adjusted for growth, then it may be imprudent to choose triple exponential smoothing for forecasting.

6. Conclusion

Forecasting macroeconomic indicators present a clear picture of what the situation of the economy will be in the future. Having the relevant models to forecast these macroeconomic variables is significant for policymakers and the government in allocating resources efficiently to formulate better policies. This paper forecasts increasing growth in Bangladesh's GDP beginning in 2019. First, an ARIMA model with stationary tests has been applied to forecast GDP growth rate for 10 years ahead by employing time-series data throughout the period from 1982 to 2018. ARIMA (1,1,1) model is best fitted based on the AIC and BIC. Next, this process applied Exponential Smoothing methods. From Table 9, it can be concluded that the triple exponential model fits the data better than both the single and double exponential models because of the lowest Sum of Square Error (SSE) and Root Mean Square Error (RMSE).According to the preceding estimated and forecasted values, GDP growth in Bangladesh shows an upper growth trend in the successive years. However, the forecasting result of these ARIMA and exponential smoothing models are only a series of predicted values; the national economic indicators of Bangladesh are a dynamic, mixed, and complex system. As a developing country, Bangladesh has experienced a lot of development interruptions, unexpected shocks, and other economic disturbances. Additionally, natural hazards can also cause a relative change in macroeconomic indicators. Expectantly, the results of this study have some important implications for academicians, policymakers, finance authorities, and researchers. Also, this study will encourage them to conduct further studies about forecasting GDP growth in Bangladesh. The findings will be better if future researchers will take consideration of the other models such as the State Space model, Markov Switching model, Vector Autoregressive (VAR) model, and Vector Error Correction Model (VECM). On the other hand, it would be more robust to expand this research by including factors that may have control on GDP growth such as population growth rate, the development of technology, the industrial production, the human capital, political stability, oil price, net exports, and the immigration rate.

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