

## Forecasting the Growth Rate of GDP and its Indicators Remittance and Labor Force Participation of Bangladesh using VECM and ARIMA Models

Akash Saha and Murshida Khanam\*

*Department of Statistics, University of Dhaka, Dhaka-1000, Bangladesh.*

(Received: 13 June 2022 ; Accepted: 25 August 2022 )

### Abstract

The present study used VECM model and ARIMA model for modeling the growth rate of GDP, Remittances and total Labor Force Participation. All of the data of this study are collected from the World Bank Database with indicators as the time series variable from 1999 to 2020. The stationarity of the time series variables has been tested by the Augmented Dickey-Fuller test and investigated that they become stationary at first difference. The lag selection criteria has been applied to find out the no. of lags needed to be included in the model. Lag 2 has been selected for this study. VEC model has been applied in the time series data. Also the ARIMA model imposed on these time series variables. These two models have been used for forecasting. Among the predictions obtained by these two models the better one has been selected by using RMSE, MAPE and MAE. It has been found that for growth rate of GDP and total Labor Force Participation, the ARIMA model is more preferable but for Remittance, VECM is desirable. It has been found that the Remittance and Labor Force have significant positive impact on the growth of GDP. Also, a long run relationship has been found among the growth rate of GDP, Remittances and total Labor Force Participation.

**Keywords:** Growth rate of GDP, Remittance, Labor force participation, Co-integration, VECM, ARIMA, Forecasting.

### I. Introduction

Among the South Asian Countries, Bangladesh is one of the main sources of migrant workers and remittance from them is an important element for Economic growth<sup>1</sup>. This remittance is helping to improve the growth rate of GDP to a great extent. From the budget share of Bangladesh, Budget from 1976 to 2020, it is clear that the budget share for remittance is increasing at a significant rate<sup>2</sup>. So, from the information of the previous years, it can be said that in future, remittance will play a good role in our Economic system. Giving the attention to the remittance and promoting this can encourage our young generation to make them active in our Economic growth system through their Remittance. It will contribute to a great extent in our economic growth in future. As the Economic production, investments and the opportunities mostly rely on the GDP, therefore the measurement of GDP is a crucial topics of any country's economic system. The improvement of Economic growth specifies improvement in Economic production, increase in investment and more opportunities. The growth of the GDP is the measure of the Economic investment. The growth of the GDP not only improves the life standard but also creates many jobs opportunities in different sectors. On the other hand, the percentage share of GDP by the total no. of Labor Force Participation is significant. In 2020, the Remittance has 6.71 percent of share on the GDP which was 4.92 in 2019. It makes clear that this sector is improving. In the year 2021, this share was 7.1 percent. In Nepal, another Asian developing country, the registered

share of Remittance on the GDP is 24.3 percentage<sup>3</sup>. So, it should keep in mind that Remittance is going to be a key factor if the proper maintenance can be done. On the other hand, for the potential growth of the economy Labor force is one of the determined factors. So, growth of this factor is an important thing.

So, from the above discussion, it can be said that the current study is a good academic exercise to produce a findings regarding the forecasting GDP and its indicators Remittances and Labor Force Participation. The objectives of this study are as follows:

To examine the short-run and long-run relationship among remittance, labor force participation and growth of GDP by applying the VECM model.

To forecast the growth rate of GDP, remittance and labor force participation by using VECM and ARIMA model.

To compare the forecasting accuracy of the VECM and ARIMA model by applying MSE, RMSE, and MAPE.

To give some recommendations based on the findings that can help the policymakers to improve these sectors in Bangladesh.

### II. Literature Review

Paudal and Perera<sup>4</sup> conducted a study using the data from World Bank for a time period 1950 to 2016 and explored the preference of labor force participation on the economic

\* Author for Correspondence. e-mail: murshida@du.ac.bd

growth of Sri Lanka. They have found that the labor force participation has a long run effect over the development of GDP. Fayissa and Nsiah<sup>5</sup> investigated whether the remittances has any kind of effect relative to other sources on the growth of GDP using the data from World Development Indicator for the Latin American Countries. For these countries, if the remittance increased by ten percentage then the GDP increased by 0.15 percentage. Javid et al.<sup>6</sup> observed the reaction of foreign workers' remittance on the economic growth and poverty of Pakistan using Bureau of Emigration and Overseas Employment data. It has been found that the remittance has strong positive and significant effect over the GDP growth. Amir et al.<sup>7</sup> used the dataset from Pakistan Economic Survey, Pakistan Labor Force Survey, Federal Bureau of Statistics, State Bank of Pakistan Annual Reports and 50 years statistics of Pakistan. They found that the labor force participation has a positive contribution on the growth rate of GDP. Wadood et al.<sup>8</sup> explored the relationship between the remittances and the GDP growth using World Development Indicator data. This study has showed that both the time series variables are I(1). That means, they are integrated of order 1. It has been come out that both of these variables are cointegrated at the first rank. It has been found that there exists long-run relationship between remittance and economic growth in Bangladesh. Rahman<sup>9</sup> has examined the effect of total labor force participation and the economic growth of the South Asian countries using secondary dataset from World Bank database. This study suggests that labor force participation plays a very important role in the growth rate of GDP. Haque et al.<sup>10</sup> investigated the relation between economic growth and total labor force participation for both male and female of Bangladesh by collecting data from Bangladesh Bureau of Statistics. It has been found that the total labor force has a positive impact on the economic development. Soava et al.<sup>11</sup> examined employed labor force and remittance over the growth of economy for the 10 European Union (EU) countries using the data for a time period 1996 to 2019. They observed that labor force has a positive impact on the economic growth but it varies state to state and share of remittance in the GDP is significantly increasing. Wijaya et al.<sup>12</sup> examined the effect of labor force on the economic growth in Romania by using the data from the Global Economy. In this study, it has been found that the labor force has both direct and indirect effect on the growth of the economy and also this labor force has a long run effect on the growth of GDP. From the above discussion, it can be said that there is a literature gap that conducts any econometric study considering the variables: growth of GDP, Remittance and total Labor Force Participation together. Therefore, this study has been conducted for these three time series variables together. It can also be said that this study will enrich the present literature.

### III. Data

This study used the data of the growth rate of GDP, total no. of Labor Force Participation and Remittance received from 1990 to 2020. All the data of this study have been collected from the World Bank Database<sup>13</sup> with indicator as the time series variable. Here, the growth rate of GDP are in percentage form as it is the rate of increase or decrease that has been calculated from the total GDP of Bangladesh which was observed in million dollar. Total no. of Labor Force Participation observed in million. Lastly, the amount of Remittance received has been observed in million dollar USD.

### IV. Theoretical Background

#### *VAR model and VECM*

The vector autoregressive model is one of the best model to describe the dynamic behavior of the economic and financial model and to forecast. When there exists true simultaneously among two time series variables then the usual procedure cannot be applied and then the vector autoregressive model is used<sup>14</sup>.

Vector Error Correction model is a restricted Vector Autoregressive (VAR) model that is used when cointegration among the time series variables presents. Through the VEC model, a long run relationship among the variables can be detected. Forecasting through the VEC model is very useful because it predicts one variable with the change of other variables by indicating the adjustment speed<sup>15</sup>.

#### *ARIMA model*

For forecasting time series data, ARIMA model has been used which is commonly known as the Box-Jenkins (BJ) methodology. The data can be made stationary by taking first difference method or taking logarithm. A series is called ARIMA (p,d,q) if it is necessary to difference the series d times to make it stationary. After making stationary of the time series data, we can apply ARMA (p,q) model. Here, p denotes the number of autoregressive terms and q denotes the number of moving average terms<sup>16</sup>.

### V. Methodology

#### *Detection of Autocorrelation*

It has been found that at 1 percent level of significance, the Durbin-Watson significance lower value is 1.006 and the upper value is 1.421. But, the calculated value is 1.4153, which is between the lower and upper limits. Also for a 5 percent level of significance, the Durbin-Watson significance lower value is 1.214 and the upper value is 1.650. But, calculated value is 1.4153, which is also between the upper and lower limits. Since the d-test statistic

does not exceed the limit boundary for 5 percent and 1 percent levels of significance, therefore from above two conditions, it can be said that there exists no autocorrelation in the dataset.

#### Heteroscedasticity detection

Brueush-Pagan test and Glejser test have been conducted for the detection of heteroscedasticity.

**Table 1. Brueush-Pagan and Glejser test for heteroscedasticity**

Method	p-value	Decision
Brueush-Pagan	0.1690	Accepted
Glejser	0.2844	Accepted

Using the test results, it can be said that both the results are greater than 5 percent level of significance. So null hypothesis may not be rejected, that is there exists no heteroscedasticity in the data set<sup>16</sup>.

#### Multicollinearity detection

The tolerance level for the VIF test is 10. The obtained result is 5.69. So, it can be said that multicollinearity in the data is absent. So, we may not reject null hypothesis at 5 percent level of significance that is there exist no multicollinearity. And also the tolerance level is 0.1757 which is also very low, which summarize that data is free from multicollinearity<sup>16</sup>.

#### Test for normality

The Jarque Bera normality test has been applied to the residual to check if it follows normality assumptions or not.  $H_0$ : the residuals are normally distributed to our fitted model.

$H_1$ : the residuals are not normally distributed to our fitted model.

It has been found that the P-Value of the Jarque Bera normality test statistic is 0.8745.

Considering the 5% level of significance, it has been found that the null hypothesis may not be rejected. So, it can be considered that the residuals are normally distributed<sup>16</sup>.

#### Stationary test

From the Unit root test, it has been found that the data of the growth rate of GDP is not stationary. To make it stationary, the first difference has been taken. Again, the Unit root test has been performed. It has been found that the test statistic value is -5.3446 and its corresponding p-value is 0.000. Thus, it can be said that the growth rate of GDP is stationary at first difference. Similarly, it has also been

found that the total labor force participation and remittances are stationary at first difference<sup>16</sup>.

#### Lag selection

**Table 2. Information criteria for different no. of lags**

No of lags	LR	AIC	SBIC	HQIC
0	NA	82.44766	82.59164	82.49048
1	184.7892	75.08001	75.65594*	75.25127
2	21.80443*	74.65646*	75.66433	74.95615*
3	6.84915	74.92023	76.36005	75.34837

From the above result, it can be said that AIC and HQIC show that the appropriate lag is 2, but SBIC gives them as 1. The likelihood ratio shows that the proper lag is 2. LR, AIC, and HQIC all show 2 lags except SBIC. As most of the tests support two lags except SBIC, so, lag 2 is to be selected for our further study.

#### Cointegration analysis

**Table 3. Result of Johansen co-integration using trace test**

Null hypothesis	Alternative hypothesis	Test statistics	Critical value
$r=0$	$r>0$	30.256	29.797
$r\leq 1$	$r>1$	11.843	15.494
$r\leq 2$	$r>2$	1.048	3.841

From the above table, it can easily be said that for the first set of hypothesis test, the value of the test statistic for the Trace test is 30.256 and the critical value is 29.797 at 5 percent level of significance. So, the value of the test statistic exceeds the critical value. That means the null hypothesis may be rejected at 5% level of significance. So, there exists cointegration. For the no. of the rank of the cointegration, further tests are needed to be required. For the second set of test, the value of the test statistic is 11.843 and the critical value is 15.491. So, the value of the test statistic does not exceed the critical value. It means that the null hypothesis cannot be rejected at 5 percent level of significance. Form Trace test it is clear that no. of the rank of cointegration is one. So, there exists one cointegration equation that measures the long-term relationship among the time series variables.

#### Vector Error Correction Model (VECM)

So, for two lag and one cointegration rank the equations for growth rate of GDP, Remittance and Labor Force Participation is as follows:

$$1. D(\text{growthGDP}) = \alpha_1 - \beta_{11}D(\text{growthGDP}(-1)) - \beta_{12}D(\text{Remittance}(-1)) + \beta_{13}D(\text{LaborForce}(-1)) - \epsilon_1 ECT_{t-1}$$

2.  $D(\text{Remittance}) = \alpha_2 - \beta_{21}D(\text{growthGDP}(-1)) - \beta_{22}D(\text{Remittance}(-1)) + \beta_{23}D(\text{LaborForce}(-1)) - \epsilon_2 \text{ECT}_{t-1}$
3.  $D(\text{LaborForce}) = \alpha_3 - \beta_{31}D(\text{growthGDP}(-1)) - \beta_{32}D(\text{Remittance}(-1)) - \beta_{33}D(\text{LaborForce}(-1)) - \epsilon_3 \text{ECT}_{t-1}$

The equation of error correction term (ECT) is:

$$\text{ECT}_{t-1} = -7.5703 + 1.0000 \text{ growthGDP}_{t-1} - 0.000142 \text{ Remittance}_{t-1} + 0.055631 \text{ LaborForce}_{t-1}$$

Therefore, the equations for VEC model are:

1.  $D(\text{growthGDP}) = -0.07425 - 0.11547 D(\text{growthGDP}(-1)) - 0.00040D(\text{Remittance}(-1)) + 0.266697 D(\text{Labor Force}(-1)) - 0.400785 \text{ECT}_{t-1}$
2.  $(\text{LaborForce}) = 1.871436 - 0.11688 D(\text{growthGDP}(-1)) - 0.00076 D(\text{Remittance}(-1)) - 0.251301 D(\text{LaborForce}(-1)) + 0.144042 \text{ECT}_{t-1}$
3.  $D(\text{Remittance}) = -25.61898 - 289.4865 D(\text{growthGDP}(-1)) + 0.81487 D(\text{Remittance}(-1)) + 379.8347 D(\text{Labor Force}(-1)) + 782.3833 \text{ECT}_{t-1}$

For the first equation the equilibrium for the growth of GDP is 0.4000785; so it can be said that the growth of GDP will be equilibrium in the long run and the speed to reach the equilibrium point is 40%. The coefficients for growth of GDP is 0.11547, 0.00040 and 0.266697. All the coefficients are insignificant at 5% level of significance. The R<sup>2</sup> value for this model is 34%. As the value of R<sup>2</sup> is much lower and the coefficients are insignificant. Thus it can be concluded that the model is not much adequate.

For the second equation the equilibrium for the total Labor Force Participation is 0.1440; so it can be said that the Labor Force Participation will be equilibrium in the long run and the speed to reach the equilibrium point is 14%. The coefficients for growth are 0.11688, 0.00076 and 0.2513. Among these coefficients, 0.1168 and 0.2513 are highly insignificant but 0.00076 is significant at 5% level of significance. The value of R<sup>2</sup> for this model is 47%.

For the third equation, the coefficient for the error correction term is 782.333 and it is significant. The coefficients for Remittance are 289.486, 0.81487, 379.8347 and 25.618998. Among these, 379.8347 is highly insignificant but other three coefficients 289.486, 0.81487 and 25.618998 are significant at 5% level of significance. The R<sup>2</sup> value for this model is 52%. Since R<sup>2</sup> of this model is higher than the other models and more coefficients are highly significant, it can be said that this model is considered as a good model.

*Adequacy for VECM*

To find the adequacy of the VECM, two tests are required: one is Autocorrelation test and the other one is Heteroscedasticity test. From autocorrelation test, it has been found that the value of the test statistic is 1.0066 (by using the method of Likelihood Ratio) and its corresponding p-value is 0.4485. So, null hypothesis is accepted at 5% level of significance and it can be said that there is no autocorrelation in VEC model. This refers that no. of lags included in the model is suitable for further process and therefore the forecasting will not give wrong information. For heteroscedasticity test, it has been found that the test statistic value is 62.923 (from chisquare method) and its corresponding p-value is 0.0728. So, we may accept our null hypothesis at 5% level of significance. That means that the residuals are homoscedastic.

*ARIMA Model*

According to analysis it has been found that the ARIMA (4,1,1) model is the selected ARIMA model for the growth rate of GDP. On the other hand, ARIMA (1,1,0) is the selected ARIMA model for Remittance. Finally, ARIMA (3,1,1) is the selected AIRMA model for Labor Force Participation.

*Forecasting on the basis of VECM and ARIMA*

**Table 4. Forecasted values of the growth rate of GDP**

Year	Forecast using VECM	Forecast using ARIMA
2021-22	4.835057	7.22499
2022-23	5.021065	7.32033
2023-24	6.059730	7.39681
2024-25	7.334494	7.49235
2025-26	8.059879	7.57736
2026-27	7.780773	7.66202
2027-28	6.673812	7.75610
2028-29	5.451864	7.84066
2029-30	4.921717	7.93048
2030-31	5.469002	8.02048

For both the models, VECM and ARIMA, the values of MAE, MASE and MAPE are as follows:

**Table 5. Errors for different models**

Method	VECM	ARIMA
MAE	1.77768	0.6777
MAPE	19.86164	13.6278
RMSE	1.347594	0.9699

So, from the error values it is clear that, for the ARIMA model, MAE, MAPE and RMSE have lower values than the VECM model. As all the shreds of evidence show that ARIMA is giving lower error, therefore it gives the better

forecast values. So, for the growth rate of GDP, ARIMA model suits better than the VECM model. Therefore, it can be said that for prediction the predicted values from ARIMA model is more reliable.

**Table 6. Forecasted values of the Remittance (in million USD)**

Year	Forecast using VECM	Forecast using ARIMA
2021-22	23062.86	44344.88
2022-23	22596.28	46069.94
2023-24	20740.92	47795.85
2024-25	19090.47	49522.46
2025-26	19152.12	51249.66
2026-27	21376.95	52977.34
2027-28	24840.63	54705.42
2028-29	27797.73	56433.83
2029-30	28778.63	58162.51
2030-31	27540.35	59891.42

For both the models, VECM and ARIMA, the values of MAE, MASE and MAPE are as follows:

**Table 7. Errors for different models**

Method	VECM	ARIMA
MAE	2423.433	11834.25
MAPE	279.13	198.0805
RMSE	3112.168	13701.74

From the above table, it can be said that, VECM has less MAE and RMSE but ARIMA has less MAPE. Therefore, it can be said that the VECM has the minimum error than ARIMA model by considering the values of MAE and RMSE. Accordingly, it can be concluded that for the forecasting of the Remittance, VECM model is preferable over the ARIMA model.

**Table 8. Forecasted values of the Labor Force Participation (in million)**

Year	Forecast using VECM	Forecast using ARIMA
2021-22	66.682	69.999
2022-23	67.187	71.125
2023-24	68.972	72.263
2024-25	71.596	73.440
2025-26	74.063	74.607
2026-27	75.453	75.762
2027-28	75.511	76.883
2028-29	74.828	78.013
2029-30	74.488	79.153
2030-31	75.385	80.325

For both the models, VECM and ARIMA, the values of MAE, MASE and MAPE are as follows:

**Table 9. Errors of different models**

Method	VECM	ARIMA
MAE	1.271	0.645
MAPE	2.447	1.091
RMSE	1.501	0.925

So, from the error values it is clear that, for the ARIMA model MAE, MAPE and RMSE have lower values than the VECM model. From all of the evidences, it can be concluded that the ARIMA model has lower error and thus it gives better value regarding forecasting. So, for Labor Force Participation ARIMA model suits better than the VECM model and so predicted values from the ARIMA model are more reliable.

## VI. Conclusion

From the Johansen cointegration test, it has been found that the cointegration exists among the time series variables and that is of rank one. It represents the presence of long run relationship among the time series variables and it is statistically significant. That means, change in Remittance and Total Labor Force Participation can improve the growth rate of GDP after a long time period.

From the normalize cointegration equation, it has been found that the coefficients are negative (-13.879 for Remittance and -14344.47 for Labor Force) and have significant effect, which indicates that the Remittances and Total Labor Force Participation have positive impact on the growth of GDP in the long run and this impact is statistically significant. Therefore, one of the major findings of this study is, the Remittance and Total Labor Force Participation have statistically significant positive impact on the growth of GDP in the long run.

For the growth rate of GDP the ARIMA model is more preferable than the VECM model as the error statistics gives the minimum result for the ARIMA model compared to VECM. The  $R^2$  for VECM is 34 percent but for ARIMA the  $R^2$  is 48 percent. So, for the growth of GDP the ARIMA model is more acceptable for analyzing and forecasting purpose.

For Remittance the suitable model is VECM. The error statistics gives the minimum results for the VECM compared to the ARIMA model. The  $R^2$  value for the VECM is 52 percent and for ARIMA the  $R^2$  value 30 percent. Therefore, for remittance to analyze and prediction of the future values the VECM is recommended.

For the total no. of Labor Force Participation, the ARIMA model is the most preferred model. From the value of the error statistics it can be said that the ARIMA model is the best fitted model. The ARIMA model has the higher  $R^2$  value compared to the VECM. The  $R^2$  value for ARIMA model is 56% and for VECM is 47.9%. Therefore, for the total Labor Force Participation the ARIMA model is the best chosen model for future prediction.

## VII. Recommendations

As the remittance has a positive significant impact on the growth rate of GDP, so the increase of Remittance can be helpful for economic growth and decreasing of the Remittance is considered a big problem for the country. So, for the increase of the Remittance, some steps needed to be taken by the Government such as making the ways of money transfer faster and safer, creating an easier investment environment and making a good infrastructural remittance facility. These ways may rise the remittance flow in the country and become helpful for the growth of the economy.

Total Labor Force Participation has also a positive significant effect on the growth rate of GDP. But this increased Labor Force will not be helpful for the country's economy if they are not be able to involve in any type of work. So, opportunities needed to be enlarged and new sectors have to be created so that these individuals can be able to work and make a contribution to the country's economy.

As Remittance and total Labor Force Participation have significant effect on the growth rate of GDP, so if the Labor Force of our country can get the opportunities to work outside of the country, then it will be more helpful for our country. Because it can create an active Labor Force and can increase Remittance at the same time. Consequently, GDP will be expected to be increased.

## References

1. Azad, A. 2019. Recruitment of migrant Workers in Bangladesh: elements of human trafficking for labor exploitation. *Journal of human trafficking*, **5(2)**, 130-150.
2. Mannan, D. K. A. and G.K. Wei, 2006. International Remittances, Household Spending and Investment: A Case study of Bangladesh. *Asian Migration and Diaspora Studies*, **12(2)**, 36-54.
3. <https://databank.worldbank.org/source/world-development-indicators/preview/on>
4. Paudel, R.C. and N. Perera, 2009. Foreign debt, Trade Openness, Labor Force and Economic Growth: Evidence from Sri Lanka. *Journal of Applied Economics*, **8**, 57-64.
5. Fayissa, B., & C. Nsiah, 2010. Can Remittances Spur Economic Growth and Development? Evidence from Latin American Countries. Department of Economics and Finance Working Paper Series, Murfreesboro, TN: Middle Tennessee State University.
6. Javid, M., U. Arif, and A. Qayyum, 2012. Impact of Remittances on Economic Growth and Poverty. *Academic Research International*, **2(1)**, 433-447.
7. Amir, H., M. Khan, and K. Bilal, 2015. Impact of Educated Labor Force on Economic Growth of Pakistan: A Human Capital Perspective. *European Online Journal of Natural and Social Sciences*. **4(4)**, 814-831.
8. Wadood, N. S. and A. Hossain, 2015. Impact of Overseas Remittances on Economic Growth: Evidences from Bangladesh. MPRA Paper 81657, University Library of Munich, Germany.
9. Rahman, M. M. 2018. Impact of Labour Force Participation on Economic growth in South Asian Countries.
10. Haque, A. U., G. Kibria, M.I. Selim, and D.Y. Smrity, 2019. Labor Force Participation Rate and Economic Growth: Observations for Bangladesh. *International Journal of Economics and Financial Research*. **5(9)**, 209-213.
11. Soava, G., A. Mehedintu, M. Sterpu, and M. Raduteanu, 2020. Impact of Employed Labor Force, Investment and Remittances on Economic Growth in EU.
12. Wijaya, A., J. Kasuma, T. Tasente, and D. C. Darma, 2021. Labor Force and Economic Growth based on demographic pressures, happiness and human development. *Journal of Eastern European and Central Asian Research (JEECAR)*. **8(1)**, 40-50.
13. <https://databank.worldbank.org/source/world-development-indicators/preview/on>
14. Sims, C. A. 1980. Macroeconomics and reality. *Econometrica: Journal of the Econometric Society*. **1-48**.
15. Yule, G. U. 1926. Why do we sometimes get nonsense-correlations between Time-Series? –A study in sampling and the nature of time-series. *Journal of the Royal Statistical Society*. **89(1)**, 1-63.
16. Gujarati, D.N. 2003. Basic Econometrics, 4<sup>th</sup> Edition New York: McGraw Hill Book Co.