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ARIMA methodology**

NYONI, THABANI

University of Zimbabwe, Department of Economics

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Modeling and Forecasting Remittances in Bangladesh Using The Box-Jenkins ARIMA Methodology

Nyoni, Thabani

Department of Economics

University of Zimbabwe

Harare, Zimbabwe

Email: nyonithabani35@gmail.com

Abstract

This paper uses annual time series data on remittances into Bangladesh from 1976 to 2017, to model and forecast remittances using the Box – Jenkins ARIMA technique. Diagnostic tests indicate that REM is I (2). The study presents the ARIMA (2, 2, 0) model for predicting remittances in Bangladesh. The diagnostic tests further show that the presented parsimonious model is stable and acceptable for predicting remittances in Bangladesh. The results of the study apparently show that remittances inflows into Bangladesh are on a downwards trajectory. The paper suggests the need for strengthening Bangladesh's emigration policy in order to improve remittances inflows into Bangladesh.

Key Words: Bangladesh, Forecasting, Remittances

JEL Codes: C53, F24

I. Introduction

Remittances as a building block of economic development in the developing countries continue to attract global attention in the recent time (Adebayo, 2013). Remittance is the better instrument to remove poverty (Martin, 1994; Murshid *et al*, 2001) and in fact, at present, remittances play a crucial role in the economy of Bangladesh (Hossain & Abdulla, 2017) and this has already been empirically confirmed by Siddique *et al* (2010) and Paul & Das (2011) amongst others. Between 1976 and 2010, a total of 6.8 million people emigrated temporarily from Bangladesh (BMET, 2010). Given restricted labor mobility across countries, Bangladesh's emigration figure is quite significant. Revenues from remittances in the country exceed various types of foreign exchange inflow, particularly official development assistance and net earnings from exports. Remittance inflows to Bangladesh are increasing at an average annual rate of 19% in the last 30 years from 1979 to 2008 (Hussain & Naem, 2009). Income from remittances has recently exceeded the 10-billion dollar mark, which has been 11.8% of the country's Gross Domestic Product (GDP) in 2009 (BBS, 2010). At present, the remittance of Bangladesh is the largest source of foreign exchange earning of the country and apparently plays a critical role in alleviating the foreign exchange constraint and supporting the balance of payments, enabling imports of capital goods and raw materials for industrial development (Islam *et al*, 2018). The main purpose of this study is to model and predict remittances inflow in Bangladesh using ARIMA models.

II. Previous Related Studies

In an African study, Adebayo (2013), examined remittances inflow into Nigeria using annual data from 1977 to 2009 and employed the ARIMA technique and revealed that remittances into Nigeria in the coming years will grow at an average of 6% per annum with its size as a percentage of GDP expected to reach about 11.4% by 2019. Hossain & Abdulla (2017) forecasted remittances of Bangladesh by ARIMA and Neural Network models and used data over the period 1987 to 2015 and established that the fluctuations of the forecasted series to original series by Neural Networks are less compared to ARIMA. In a recent study, Islam et al (2018) forecasted remittances of Bangladesh using ARIMA and GARCH models with data set ranging over the period January 1998 to December 2003 and found out that the ARIMA (0, 1, 1)(0, 2, 1)₁₂ and the GARCH (2, 1) model appeared to be the best one.

III. Materials & Methods

Box – Jenkins ARIMA Models

One of the methods that are commonly used for forecasting time series data is the Autoregressive Integrated Moving Average (ARIMA) (Box & Jenkins, 1976; Brocwell & Davis, 2002; Chatfield, 2004; Wei, 2006; Cryer & Chan, 2008). For the purpose of forecasting remittances in Bangladesh, ARIMA models were specified and estimated. If the sequence $\Delta^d REM_t$ satisfies an ARMA (p, q) process; then the sequence of REM_t also satisfies the ARIMA (p, d, q) process such that:

$$\Delta^d REM_t = \sum_{i=1}^p \beta_i \Delta^d REM_{t-i} + \sum_{i=1}^q \alpha_i \mu_{t-i} + \mu_t \dots \dots \dots [1]$$

which we can also re – write as:

$$\Delta^d REM_t = \sum_{i=1}^p \beta_i \Delta^d L^i REM_t + \sum_{i=1}^q \alpha_i L^i \mu_t + \mu_t \dots \dots \dots [2]$$

where Δ is the difference operator, vector $\beta \in \mathbb{R}^p$ and $\alpha \in \mathbb{R}^q$.

The Box – Jenkins Methodology

The first step towards model selection is to difference the series in order to achieve stationarity. Once this process is over, the researcher will then examine the correlogram in order to decide on the appropriate orders of the AR and MA components. It is important to highlight the fact that this procedure (of choosing the AR and MA components) is biased towards the use of personal judgement because there are no clear – cut rules on how to decide on the appropriate AR and MA components. Therefore, experience plays a pivotal role in this regard. The next step is the estimation of the tentative model, after which diagnostic testing shall follow. Diagnostic checking is usually done by generating the set of residuals and testing whether they satisfy the characteristics of a white noise process. If not, there would be need for model re – specification and repetition of the same process; this time from the second stage. The process may go on and on until an appropriate model is identified (Nyoni, 2018).

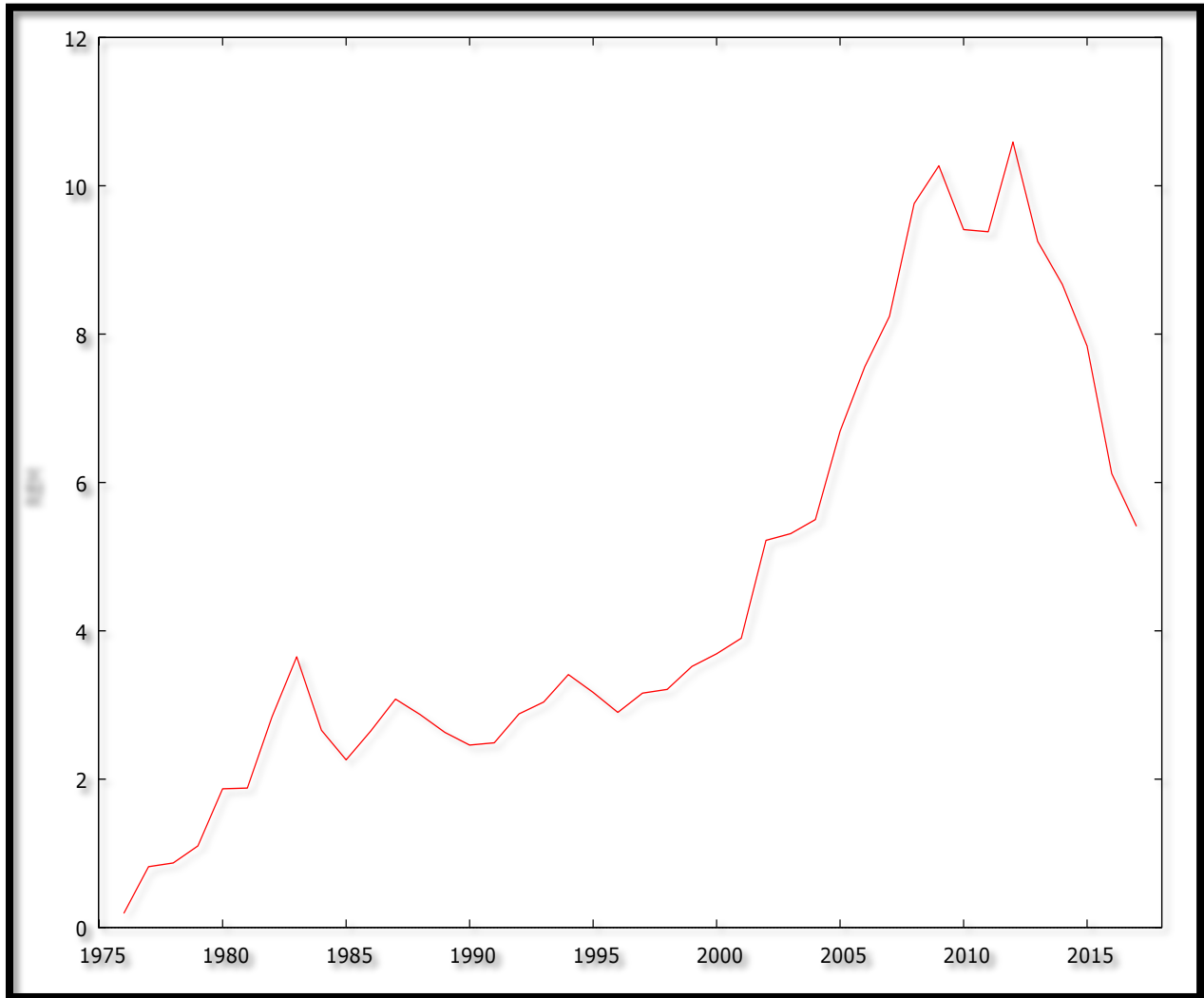
Data Collection

This study is based on a data set of annual remittances (REM) as a percentage of GDP into Bangladesh ranging over the period 1976 – 2017. All the data was taken from the World Bank.

Diagnostic Tests & Model Evaluation

Stationarity Tests: Graphical Analysis

Figure 1



The Correlogram in Levels

Autocorrelation function for REM ***, **, * indicate significance at the 1%, 5%, 10% levels.

Table 1

LAG	ACF	PACF	Q-stat. [p-value]
1	0.9421 ***	0.9421 ***	40.0048 [0.000]

2	0.8713	***	-0.1448	75.0760	[0.000]
3	0.7916	***	-0.1062	104.7669	[0.000]
4	0.6901	***	-0.2299	127.9282	[0.000]
5	0.5901	***	-0.0111	145.3182	[0.000]
6	0.4865	***	-0.0835	157.4695	[0.000]
7	0.3885	**	0.0174	165.4391	[0.000]
8	0.3030	**	0.0287	170.4308	[0.000]

The ADF Test in Levels

Table 2: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-2.0743486	0.2557	-3.615588	@ 1%	Non-stationary
			-2.941145	@ 5%	Non-stationary
			-2.609066	@ 10%	Non-stationary

Table 3: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-4.344397	0.0078	-4.243644	@ 1%	Stationary
			-3.544284	@ 5%	Stationary
			-3.204699	@ 10%	Stationary

Table 4: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-1.286144	0.1795	-2.627238	@ 1%	Non-stationary
			-1.949856	@ 5%	Non-stationary
			-1.611469	@ 10%	Non-stationary

As shown in figure 1 and tables 1 – 4, REM is non-stationary in levels.

The Correlogram (at 1st Differences)

Autocorrelation function for d_REM ***, **, * indicate significance at the 1%, 5%, 10% levels.

Table 5

LAG	ACF	PACF	Q-stat. [p-value]
1	0.3037 *	0.3037 *	4.0664 [0.044]
2	0.0490	-0.0477	4.1748 [0.124]
3	0.3496 **	0.3848 **	9.8442 [0.020]
4	0.0712	-0.2009	10.0855 [0.039]

5	-0.0528	0.0379	10.2221 [0.069]
6	0.1199	-0.0051	10.9465 [0.090]
7	-0.0857	-0.1424	11.3278 [0.125]
8	-0.3574 **	-0.3093 **	18.1527 [0.020]

ADF Test in 1st Differences

Table 6: 1st Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-4.386777	0.0012	-3.605593	@1%	Stationary
			-2.936942	@5%	Stationary
			-2.606857	@10%	Stationary

Table 7: 1st Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-1.215515	0.8929	-4.219126	@1%	Non-stationary
			-3.533083	@5%	Non-stationary
			-3.198312	@10%	Non-stationary

Table 8: 1st Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-4.389181	0.0001	-2.624057	@1%	Stationary
			-1.949319	@5%	Stationary
			-1.611711	@10%	Stationary

Based on table 7 which points to non-stationarity of the REM series in 1st differences, the study will proceed to test for stationarity after taking 2nd differences.

The Correlogram (at 2nd Differences)

Autocorrelation function for d_d_REM ***, **, * indicate significance at the 1%, 5%, 10% levels.

Table 9

LAG	ACF	PACF	Q-stat. [p-value]
1	-0.3522 **	-0.3522 **	5.3436 [0.021]
2	-0.3906 **	-0.5875 ***	12.0880 [0.002]
3	0.4273 ***	0.0035	20.3785 [0.000]
4	-0.1266	-0.2022	21.1260 [0.000]
5	-0.1584	-0.0761	22.3304 [0.000]
6	0.2443	0.0197	25.2795 [0.000]

7 0.0570 0.2637 * 25.4448 [0.001]
 8 -0.2620 * 0.0142 29.0492 [0.000]

Table 10: 2nd Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-9.758722	0.0000	-3.615588	@1%	Stationary
			-2.941145	@5%	Stationary
			-2.609066	@10%	Stationary

Table 11: 2nd Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-9.803464	0.0000	-4.219126	@1%	Stationary
			-3.533083	@5%	Stationary
			-3.198312	@10%	Stationary

Table 12: 2nd Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
REM	-9.800207	0.0000	-2.627238	@1%	Stationary
			-1.949856	@5%	Stationary
			-1.611469	@10%	Stationary

Tables 9 – 12 are now consistent in that they all indicate that REM is an I (2) variable.

Evaluation of ARIMA models (without a constant)

Table 13

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 2, 1)	88.67342	0.83743	-0.099525	0.50405	0.67759	13.061
ARIMA (2, 2, 2)	84.03579	0.75728	-0.091833	0.46023	0.60568	11.989
ARIMA (3, 2, 0)	82.3836	0.78881	-0.082236	0.47481	0.61285	12.447
ARIMA (2, 2, 0)	80.98338	0.78638	-0.084635	0.47379	0.61321	12.383
ARIMA (1, 2, 0)	95.71541	0.98518	-0.054574	0.54986	0.76088	14.092
ARIMA (0, 2, 1)	86.67362	0.83764	-0.099554	0.50434	0.67758	13.07
ARIMA (2, 2, 1)	82.87394	0.79013	-0.079765	0.47479	0.61232	12.488
ARIMA (1, 2, 2)	86.87068	0.77317	-0.095322	0.46009	0.64532	11.74

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018). Theil's U must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018). The study will only consider the AIC as the criteria for choosing the best model for forecasting remittance inflows into Bangladesh and therefore, the ARIMA (2, 2, 0) model is carefully selected.

95% Confidence Ellipse & 95% 95% Marginal Intervals

Figure 2 [AR (1) & AR (2) components]

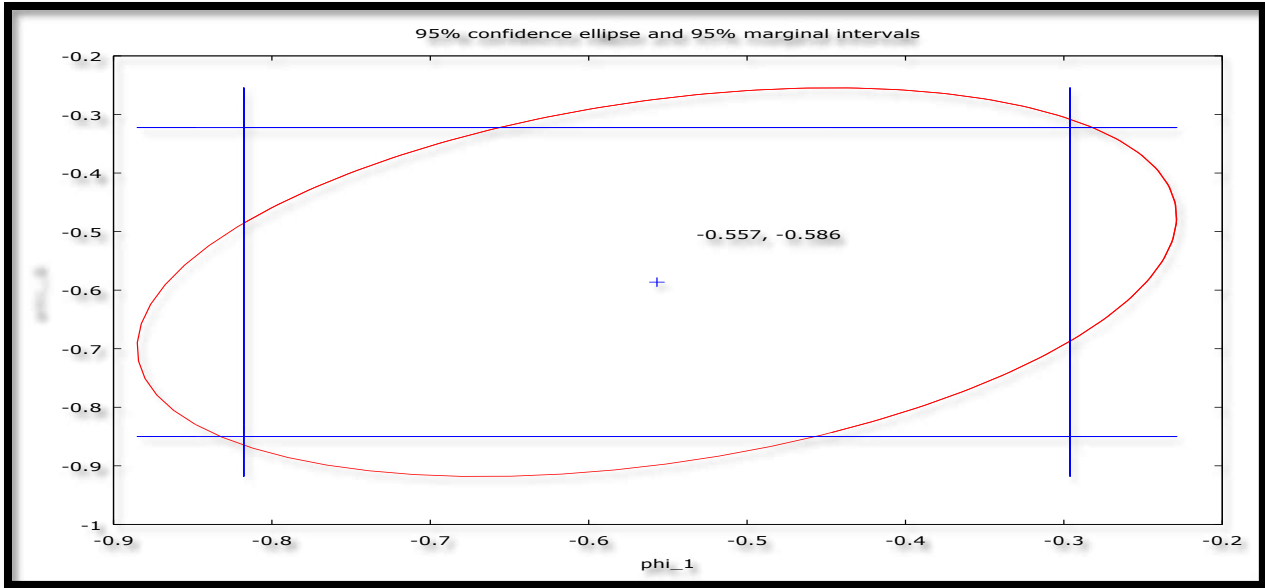
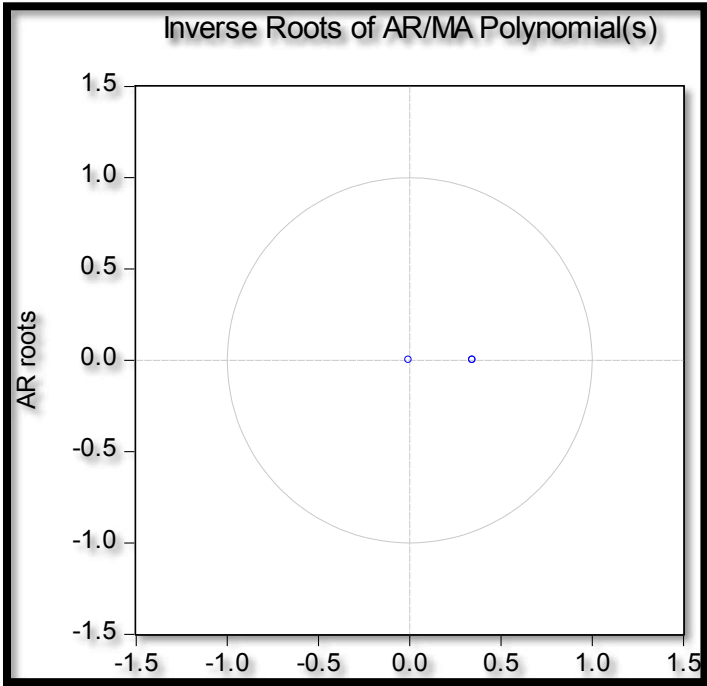


Figure 2 indicates that the accuracy of the forecast given by the ARIMA (2, 2, 0) Model is satisfactory since it falls within the 95% confidence interval.

Stability Test

Stability Test of the ARIMA (2, 2, 0) Model

Figure 3



Since the corresponding inverse roots of the characteristic polynomial lie in the unit circle, it illustrates that the chosen ARIMA (2, 2, 0) model is stable and suitable for predicting remittances in Bangladesh over the period under study.

IV. Findings

Descriptive Statistics

Table 14

Description	Statistic
Mean	4.5814
Median	3.31
Minimum	0.19
Maximum	10.59
Standard deviation	2.9159
Skewness	0.69137
Excess kurtosis	-0.75917

As shown above, the mean is positive, i.e. 4.5814%. The minimum is 0.19% and the maximum is 10.59%. The skewness is 0.69137 and the most striking characteristic is that it is positive, indicating that the REM series is positively skewed and non-symmetric. Excess kurtosis was found to be -0.75917; implying that the REM series is not normally distributed.

Results Presentation¹

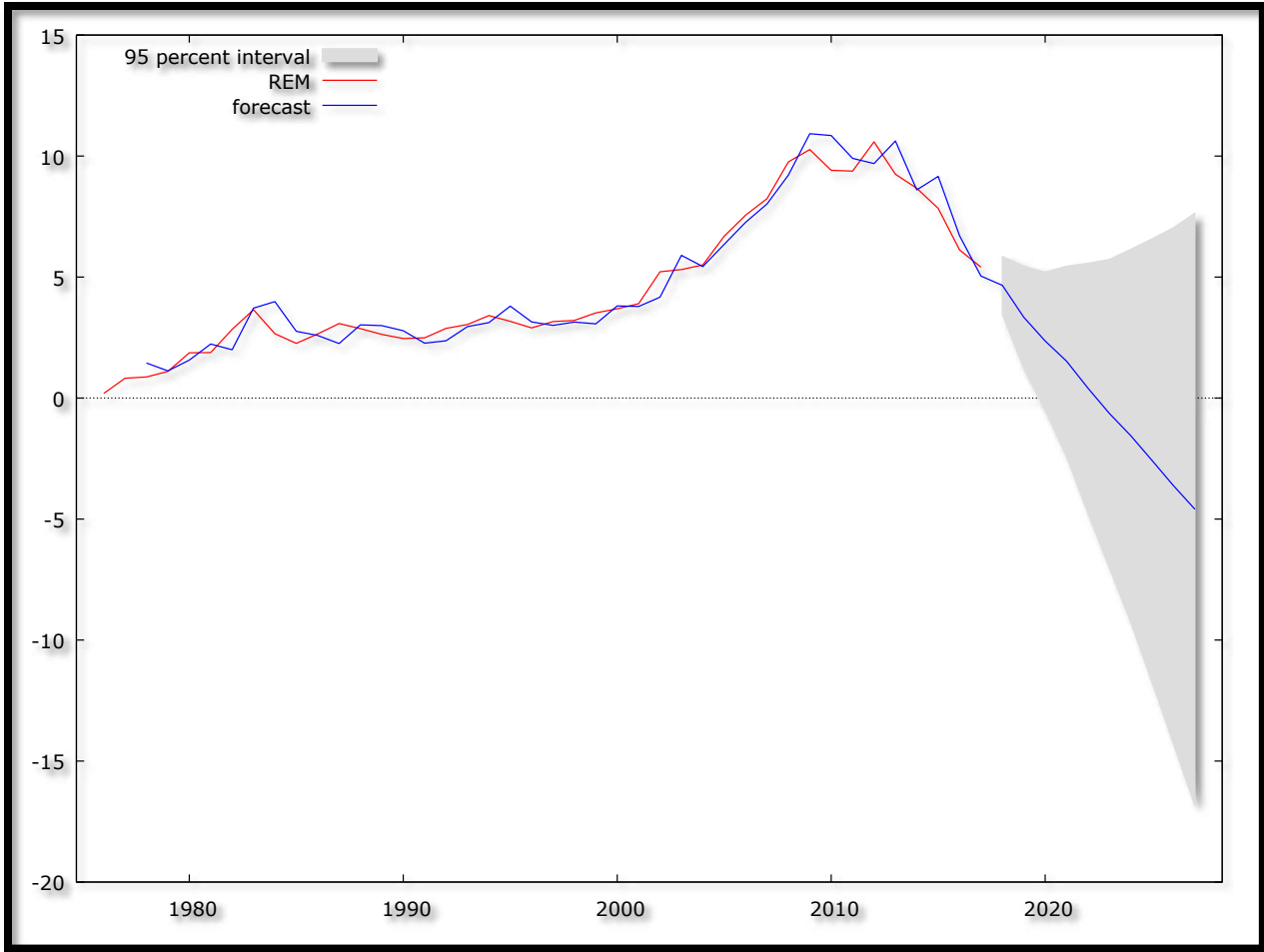
Table 15

ARIMA (2, 2, 0) Model:				
$\Delta REM_{t-1} = -0.556915\Delta REM_{t-1} - 0.586338\Delta REM_{t-2} \dots \dots \dots [3]$				
P:	(0.0000)	(0.0000)		
S. E:	(0.1288)	(0.1303)		
Variable	Coefficient	Standard Error	z	p-value
AR (1)	-0.556915	0.128839	-4.323	0.0000***
AR (2)	-0.586338	0.130323	-4.499	0.0000***

Forecast Graph

Figure 4

¹ The *, ** and *** means significant at 10%, 5% and 1% levels of significance; respectively.



Predicted Annual Remittance Inflow into Bangladesh

Table 16

Year	Prediction	Std. Error	95% Confidence Interval
2018	4.66	0.610	3.46 - 5.86
2019	3.34	1.071	1.24 - 5.44
2020	2.36	1.454	-0.49 - 5.21
2021	1.52	2.003	-2.40 - 5.45
2022	0.41	2.632	-4.75 - 5.57
2023	-0.63	3.248	-7.00 - 5.73
2024	-1.55	3.929	-9.25 - 6.15
2025	-2.58	4.676	-11.75 - 6.58

2026	-3.63	5.442	-14.29 -	7.04
2027	-4.60	6.246	-16.84 -	7.65

Figure 4 (with a forecast range from 2018 – 2027) and table 16, clearly show that remittance inflow into Bangladesh is currently on a downwards trajectory and is unfortunately projected to follow this path at least for the next decade, *ceteris paribus*. The most eye-catching feature of table 16 is that over the period 2023 – 2027, Bangladesh may receive no remittances inflows! This is shown by negative percentage contributions to GDP.

V. Conclusion & Policy Implications

The ARIMA model was employed to investigate annual remittances inflows into Bangladesh from 1976 to 2017. The study planned to forecast remittances for the upcoming period from 2018 to 2027 and the best fitting model was carefully identified. The ARIMA (2, 2, 0) model is stable and most suitable model to forecast remittances inflow into Bangladesh for the next ten years. From the study, it is inferred that Bangladesh as a leader among countries that receive remittances in Asia, may harness its potential adequately to significantly improve the livelihoods of Bangladeshi people. This means that the emigration policy must be strengthened to allow emigrants from Bangladesh (the leaving country) secure enough security and legality to facilitate the quality of the jobs they will engage in the host country, just because the size of their income is closely related to the size of fund to be expatriated to the home country (Bangladesh, in this case) in form of remittances.

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