American Journal of Mathematics and Statistics 2016, 6(4): 190-195
DOI: 10.5923/j.ajms.20160604.08

Modeling and Forecasting Population Growth of Bangladesh

A. B. M. Rabiul Alam Beg[1], Md. Rafiqul Islam[2,*]

[1]James Cook University, Australia
[2]Department of Population Science and Human Resource Development, University of Rajshahi, Bangladesh

Abstract Information about the population growth of a country is an important issue that helps keeping the gross domestic product at a standard level without accelerating inflation rate. This is the condition demanded by the International Monetary Fund (IMF) and World Bank (WB) for allocating funds for the development of the underdeveloped countries like Bangladesh. The population growth is the main target of Bangladesh government to keep the level of growth at a manageable level. This paper proposes an autoregressive time trend (ARt) model for forecasting population growth of Bangladesh. Using data from 1965 to 2003 and using the proposed ARt model this paper finds a downward population growth for Bangladesh for the extended period up to 2043.

Keywords Population growth, Autoregressive time trend (ARt) model, Ordinary least squares (OLS) estimation, Dickey-Fuller unit root test, Cross validity predictive power (CVPP), R^2, Shrinkage

1. Introduction

In the past it is recorded that the population of Bangladesh has had grown at an increasing rate up until 1975. Since then the Government of Bangladesh adopted various policies to control its fast growing population. Policies for example, family planning, educating people, participation of females in the payroll, and a condition on the age at first marriage (year 18 for female and 20 for mate) are in action at present. Bangladesh is a poor country it always depends on foreign aid and donation form received from donor agencies, e.g., IMF, WB, Asian Development Bank (ADB), United Nation Fund for Population Association (UNFPA) and many other smaller donors. These donor countries always put condition to increase the gross domestic product (GDP) per head keeping the inflation at a tolerable level. The government has no option other than those stated above to control its population growth at a manageable level to maintain a healthy per capita GDP. There is another alternative to increase the GDP per person by increasing the domestic product keeping the population at a low level.

Islam and Ali (2004a) reported that natural increase of population of Bangladesh is decreasing from 1974 to 1998. In Bangladesh, Islam and Ali (2004b) showed that intrinsic growth rate for female population is starting to reduce from the period 1961-1974. Islam (2012a) observed that intrinsic growth rate for male population is starting to reduce from the period of 1961-1974 up to the period of 1991-2001.

To reduce the population growth for Bangladesh a forecast model is proposed in this paper. The proposed autoregressive time trend forecast model predicts the population growth from 2004 to through 2043.

This paper is organized as follows. In section 2 data and sources of data and variables of interest are discussed. Section 3 presents the model and the methodology. Empirical results of the forecasts and the forecast model adequacy are given in section 4. Section 5 concludes the paper.

2. Data, Sources of Data and the Variable

Annual data on Bangladesh population from 1965 to 2003 has been taken from the DX-Data base available in the Computer Lab of the School of Business of James Cook University, Australia (provided by Dr. A. B. M. Rabiul Alam Beg while he was visiting the department of Statistics of Rajshahi University, Bangladesh for his sabbatical assignment). The population is measured in thousands. To find out the population growth rate this paper considers the continuously compounded rule as $Pdot_t = 100 * \ln(P_t / P_{t-1})$, where P_t and P_{t-1} are the population at time t and time $t-1$ respectively.

* Corresponding author:
rafique_pops@yahoo.com (Md. Rafiqul Islam)
Published online at http://journal.sapub.org/ajms

3. The Model and the Methodology

Initially a linear time trend model $Pdot_t = \alpha_0 + \alpha_1 t + \varepsilon_t$ for $Pdot$ was fitted with a little success. This linear time trend model is then updated by including autoregressive terms up to lag 2. The following autoregressive time trend model for forecasting population growth is considered in this paper.

AR(2)t:

$$Pdot_t = \alpha_0 + \alpha_1 t + \alpha_2 Pdot_{t-1} + \alpha_3 Pdot_{t-2} + \varepsilon_t \quad (1)$$

Where $Pdot$ is defined as above, ε_t is a random error term with mean zero and constant (unknown) variance. t is the linear time trend term, $Pdot_{t-i}, i = 1,2$ are the lag dependent variables included in (1). α_0, α_1, α_2 α_3 are the parameters to be estimated along with the unknown error variance.

Since this is an autoregressive model we require the condition on the estimated parameters should be $|\alpha_1| < 1$, $|\alpha_2| < 1$, $\alpha_1 + \alpha_2 < 1$, $\alpha_2 - \alpha_1 < 1$ for stability of the model.

For model validation, the cross validation predictive power (CVPP) denoted, ρ_{cv}^2 is computed by $\rho_{cv}^2 = 1 - \frac{(n-1)(n-2)(n+1)}{n(n-k-1)(n-k-2)}(1-R^2)$. Where n is the number of cases, k is the number of regressors in the model, and R^2 is the coefficient of determination of the model. The shrinkage of the model is equal to the absolute value of $\lambda = (\rho_{cv}^2 - R^2)$, (Steven, 1996). Closer the value of λ to zero, better is the prediction. It is noted that this technique was also used as model validation technique (Islam, 2005; 2007a; 2007b; 2008; 2011; 2012b; 2012c; 2013; 2014; Islam and Beg, 2009; 2010; Islam & Hossain, 2013a; 2013b; 2014a; 2014b; Hossain & Islam, 2013; Islam *et al*., 2013; 2014; Hossain et al., 2015; Islam & Hossain, 2015; Islam & Hoque, 2015).

Model (1) is estimated by the ordinary least squares (OLS) method using SHAZAM. The empirical results with discussion are given in section 4.

4. Empirical Results and Discussion of the Results

The OLS estimated parameters of the model (1) are reported in the following Table-1

The estimated coefficients of model (1) are all significant at 10% level except $Pdot_{t-2}$. The $\bar{R}^2 = 0.9253$ indicates that approximately 93% of the total variation in $ydot$ is explained by the explanatory variables of the model. Akaike's information criterion (AIC), Akaike's final prediction error (FPE) and estimated error variance are all small. These values are useful for model's prediction performance.

Although the estimate $\hat{\alpha}_2$ is statistically significant at the conventional level, its value is close to one. In that case Dickey-Fuller unit root test (Dickey & Fuller, 1978, 1981) could not distinguish between the unit root and near unit root. Eventually Dickey-Fuller test concludes that the series is nonstationary. However, the Ljung-Box (1978) Q-statistics pass the model adequacy test. Moreover, the condition of the stability of the AR(2)t process is satisfied. Furthermore, the low values of $\lambda = 0.017399$ indicates that the fitted model provides better predictions for the future years. Consequently, one can adopt this model for forecasting purpose. The forecasts based on the estimated model (1) and the observed population growth values are given in table 2. A graph shows the downward movement of the population growth for the years 1965 to 2043.

In table 2 population growth for the observed data from year 1986 shows a decreasing trend in population growth within the sample. The predicted population growth by the AR(2)t model of this paper shows a decreasing trend from year 1986 to 2043 throughout. This is consistent with the observed trend in population growth from 1986 to 2003.

Table 1. Parameter estimates and other statistics of model (1)

Varaibles	Estimate	t- value(p-value)
Constant	0.50756	1.962(0.058)
T	-0.00603	-1.955(0.059)
$Pdot_{t-1}$	0.99972	5.739(0.000)
$Pdot_{t-2}$	-0.17464	-1.027(0.312)

$\bar{R}^2 = 0.9253$, DW=2.0479, AIC=0.012144, FPI=0.012155, $\hat{\sigma}^2 = 0.01939$

For residuals: Q(4)=0.42(0.981), Q(8)=1.80(0.987), Q(12)=5.96(0.918)

Squared residuals: Q(4)=0.13(0.998), Q(5)=0.16(0.999)

Table 2. The Observed and the predicted growth rate of the population of Bangladesh

Serial number	Year	Estimated population growth (*ydot*)	Predicted population growth AR(2)t Model
1	1965		
2	1966	2.533405	
3	1967	2.547196	
4	1968	2.558382	2.587473
5	1969	2.568673	2.590217
6	1970	2.576571	2.592522
7	1971	2.620341	2.59259
8	1972	2.600554	2.628939
9	1973	2.573604	2.595484
10	1974	2.540233	2.565967
11	1975	2.509056	2.531282
12	1976	2.473456	2.499912
13	1977	2.431386	2.463737
14	1978	2.415483	2.421866
15	1979	2.441338	2.407285
16	1980	2.485034	2.42988
17	1981	2.518408	2.463019
18	1982	2.544477	2.482722
19	1983	2.563792	2.496926
20	1984	2.575829	2.505653
21	1985	2.579146	2.508282
22	1986	2.571531	2.503466
23	1987	2.550125	2.489245
24	1988	2.516294	2.463144
25	1989	2.468493	2.427031
26	1990	2.403571	2.379123
27	1991	1.772876	2.316537
28	1992	1.760417	1.691328
29	1993	1.754103	1.782991
30	1994	1.750128	1.772824
31	1995	1.749164	1.763923
32	1996	1.746092	1.757624
33	1997	1.743462	1.748691
34	1998	1.739659	1.740568
35	1999	1.73709	1.731196
36	2000	1.734141	1.723262
37	2001	1.736082	1.714732
38	1002	1.73889	1.711159
39	2003	1.740318	1.707596
40	2004		1.674635
41	2005		1.636274
42	2006		1.597652
43	2007		1.559709
44	2008		1.522493
45	2009		1.485884
46	2010		1.449755
47	2011		1.414
48	2012		1.378534
49	2013		1.343294

Serial number	Year	Estimated population growth (*ydot*)	Predicted population growth AR(2)t Model
50	2014		1.308227
51	2015		1.273294
52	2016		1.238466
53	2017		1.203719
54	2018		1.169034
55	2019		1.134397
56	2020		1.099798
57	2021		1.065228
58	2022		1.03068
59	2023		0.996149
60	2024		0.961632
61	2025		0.927126
62	2026		0.892627
63	2027		0.858135
64	2028		0.823647
65	2029		0.789163
66	2030		0.754683
67	2031		0.720204
68	2032		0.685727
69	2032		0.651251
70	2033		0.616777
71	2034		0.582303
72	2035		0.54783
73	2036		0.513357
74	2037		0.478885
75	2038		0.444413
76	2039		0.409941
77	2040		0.37547
78	2041		0.340998
79	2042		0.306527
80	2043		0.272056

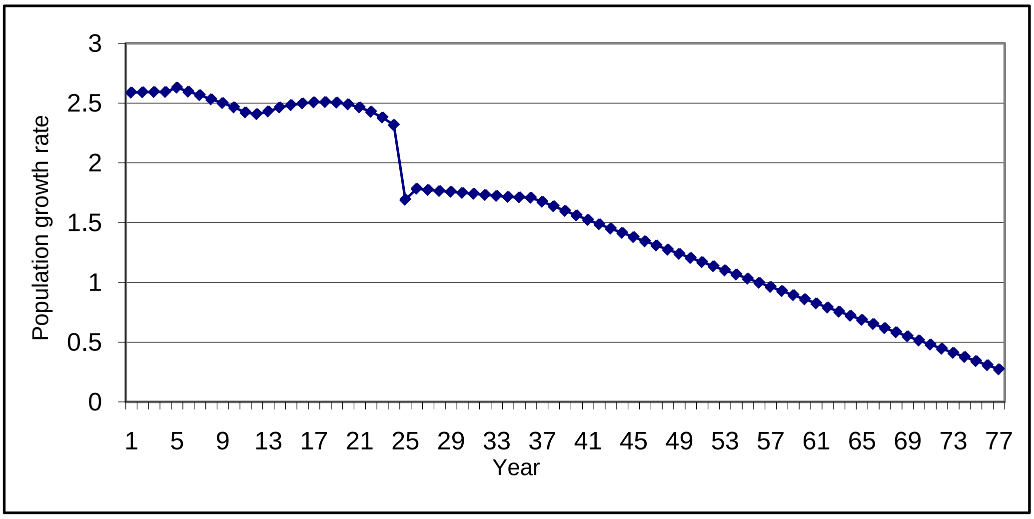

Figure 1. Predicted population growth rate of Bangladesh for the years 1968-2043 indexed by 1, 2……,77

5. Conclusions

In predicting the population growth of Bangladesh for the years 1965 to 2043 we have adopted an autoregressive with time trend model for the observed growth rate. The estimated autoregressive parameters satisfy the stability conditions. Furthermore, based on the Q statistics, $\overline{R}^2$ and t-test values this model is found to be adequate for forecasting the population growth of Bangladesh. The shrinkage parameter λ also produces a small value indicating that the performance of the prediction model is reliable. This model can be used for various policy decisions purpose.

REFERENCES

[1] Dickey, D. and Wayne, A. F. (June 1979) Distribution of the estimates for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association 74, 427-31.

[2] Dickey, D. and Wayne, A. F. (July 1981) Likelihood Ration Statistics for Autoregressive Time Series with a Unit Root. Econometrica, Vol. 49, pp.1057-1072.

[3] Hossain, M. S. & Islam, M. R. (2013) Age Specific Participation Rates of Curacao in 2011: Modeling Approach. *American Open Computational and Applied Mathematics Journal, Vol.* 1(2**)**, pp. 08-21.

[4] Hossain, M. K., Islam, M.R., Khan, M. N. and Ali, M.R**.** (2015). Contribution of Socio-demographic Factors on Antenatal Care in Bangladesh: Modeling Approach, Public Health Research, 5(4): 95-102.

[5] Islam, M. R. and Ali, M. K. (2004a) Study the Population Transition and Recent Trend of Fertility Decline of Bangladesh. J. of Science, Rajshahi University Studies, Part-B, Vol. 32, pp.141-151.

[6] Islam, M. R. and Ali, M. K. (2004b) Female Stable Population Tends to be Identical-An Evidence from Bangladesh Censuses. J. of Science, Rajshahi University Studies, Part- B, Vol. 32, pp.131-139.

[7] Islam, M. R. (2005). Mathematical Modeling of Age Specific Marital Fertility Rates in Urban Area of Bangladesh. *Pakistan Journal of Statistics, Vol.* 21(3), 289-295.

[8] Islam, M. R. **(**2007a). Construction of Abridged Life Tables and Indirect Estimation of Some mortality measures of Bangladesh in 2005, Journal of Population, Indonesia, V. 11, No. 2, pp. 117-130.

[9] Islam, M. R. (2007b) Predicting Population for Male of Rural Area in Bangladesh. *Journal of Statistical Research of Iran, Vol.* 4(2), 227-238.

[10] Islam, M. R. (2008) Modeling Age Structure for Female Population in Rural Area of Bangladesh. *Journal of Interdisciplinary Mathematics, Vol.* 11(1), 29-37.

[11] Islam, M. R. and Beg, A.B.M. Rabiul Alam (2009). Modeling and Predicting Population of Dhaka District of Bangladesh, International J. of Mathematics and Computation, Vol. 4, No. 9, pp. 69-80.

[12] Islam, M. R. and Beg, A.B.M. Rabiul Alam (2010). Modeling and Predicting Urban Male Population of Bangladesh: Evidence from Census data, International e Journal of Mathematics And Engineering, Vol.. 1, No. 1, pp-86-95.

[13] Islam, M. .R. (2011). Modeling of Diabetic Patients Associated with Age: Polynomial Model Approach, International Journal of Statistics and Applications, V. 1(1), pp. 1-5.

[14] Islam, M. R. (2012a). Male Stable Population Tends to be Identical: Evidence from Bangladesh Population Censuses, American Journal of Mathematics and Statistics, Vol. 2(1), pp. 16-19.

[15] Islam, M. R. (2012b) Mathematical Modeling of Age and of Income Distribution Associated with Female Marriage Migration in Rajshahi, Bangladesh. *Research* Journal of Applied Sciences, Engineering and Technology Vol. 4(17), 3125-3129.

[16] Islam, M. R. (2012c) Modeling and Projecting Population for Muslim of Urban Area in Bangladesh. International Journal of Probability and Statistics, Vol. 1(1), 04-10.

[17] Islam, M. R. & Hossain, M. S. (2013a) Mathematical Modeling of Age Specific Adult Literacy Rates of Rural Area in Bangladesh. *American Open Demography Journal*, Vol. 1(1), 01-12.

[18] Islam, M. R. and Hossain, M. S. (2013b) Mathematical Modeling of Age Specific Participation Rates in Bangladesh. *International Journal of Scientific and Innovative Mathematical Research, Vol.* 1(2), 150-159.

[19] Islam, M. R. (2013) Modeling Age Structure and ASDRs for Human Population of Both Sexes in Bangladesh. *International Journal of Anthropology, Vol.* 28(1), 47-53.

[20] Islam, M. R., Ali, M. K. & Islam, M. N. (2013) Construction of Life Table and Some Mathematical Models for Male Population of Bangladesh. *American Journal of Computational and Applied Mathematics*, Vol.3(6), 269-276.

[21] Islam, M. R. and Hossain, M. S. (2014a) Some Models Associated with Age Specific Adult Literacy Rates of Urban Area in Bangladesh. *International Journal of Ecosystem, Vol.* 4(2), 66-74.

[22] Islam, M. R. and Hossain, M. S. (2014b). Mathematical Modeling of Age Specific Adult Literacy Rates in Bangladesh. *Advances in Life Sciences, Vol.* 4(3), 106-113.

[23] Islam, M.R., Hossain, M.S. and Faroque, O. (2014). U-Shaped Pattern of Employees' Job Satisfaction: Polynomial Model Approach, International Journal of Ecosystem, Vol. 4(4): 170-175.

[24] Islam, M.R. (2014). Modeling of ASFRs and Study the Reproductivity of Women of Urban Area in Bangladesh, Advances in Life Sciences, Vol. 4(5): 227-234.

[25] Islam, M. R. and Hoque, M.N. (2015). Mathematical Modeling and Projecting Population of Bangladesh by Age and Sex from 2002 to 2031. Emerging Techniques in Applied Demography, Applied Demography Series 4, Chapter 5: 53-60.

[26] Islam, M.R. and Hossain, S. (2015). Some Standard Physical Characteristics of Students in Seoul: Modeling Approach,

American Journal of Mathematics and Statistics, 5(5): 230-237.

[27] Ljung. G. and George B. (1978) On a Measure of Lack of Fit in Time Series Models. Biometrica, Vol. 65, pp. 297-303.

[28] Stevens, J. (1996) Applied Multivariate Statistics for the Social Sciences, Third Edition, Lawrence Erlbaum Associates, Inc., Publishers, New Jersey.