Can Algeria be the first African country to outsmart the Malthusian population trap? Insights from the ARIMA approach

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Can Algeria Be The First African Country To Outsmart The Malthusian Population Trap? Insights From The ARIMA Approach

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Abstract

Using annual time series data on total population in Algeria from 1960 to 2017, we model and forecast total population over the next 3 decades using the Box – Jenkins ARIMA technique. Diagnostic tests such as the ADF tests show that Algeria annual total population is I (2). Based on the AIC, the study presents the ARIMA (4, 2, 0) model as the optimal model. The diagnostic tests further show that the presented model is stable and that its residuals are integrated of order zero. The results of the study reveal that total population in Algeria will continue to rise gradually in the next three decades and in 2050 Algeria's total population will be approximately 62 million people. In order to outsmart the Malthusian population trap, 4 policy prescriptions have been suggested for consideration by the government of Algeria.

Key Words: Algeria, Forecasting, Population

JEL Codes: C53, Q56, R23

INTRODUCTION

As the 21st century began, the world's population was estimated to be almost 6.1 billion people (Tartiyus *et al*, 2015). Projections by the United Nations place the figure at more than 9.2 billion by the year 2050 before reaching a maximum of 11 billion by 2200. Over 90% of that population will inhabit the developing world (Todaro & Smith, 2006). The problem of population growth is basically not a problem of numbers but that of human welfare as it affects the provision of welfare and development. The consequences of rapidly growing population manifests heavily on species extinction, deforestation, desertification, climate change and the destruction of natural ecosystems on one hand; and unemployment, pressure on housing, transport traffic congestion, pollution and infrastructure security and stain on amenities (Dominic *et al*, 2016). In Algeria, just like in any other part of the world, population modeling and forecasting is quite vital for policy dialogue. This study endeavors to model and forecast population of Algeria using the Box-Jenkins ARIMA technique.

LITERATURE REVIEW

Theoretical Literature Review: The Malthusian population trap in brief

The Malthusian population trap is a famous theory of the link between population growth and economic development. This theory states that human population grows geometrically while the means of subsistence grows arithmetically being subject to the law of diminishing returns. The popularity of the Malthusian population trap has convinced a plethora of development economists and policy makers that rapid population growth is a threat to economic development. This is mainly attributed to the proposition that rapid population growth results in tightening job markets, generating underemployment and discouraging labour force mobility across sectors. Therefore, the Malthusian population trap argues that rapid population growth is a real problem to any economy (Nyoni & Bonga, 2017).

Empirical Literature Review

In Pakistan, Zakria & Muhammad (2009), forecasted population using Box-Jenkins ARIMA models and relied on a data set ranging from 1951 to 2007; and established that the ARIMA (1, 2, 0) model was the best model. In Bangladesh, Beg & Islam (2016) analyzed population growth of using an autoregressive time trend model based on a data set ranging over 1965 – 2003 and concluded that there is a downward population growth for Bangladesh for the extended period up to 2043. In Ethiopia, Ayele & Zewdie (2017) looked at human population size and its pattern in Ethiopia using Box-Jenkins ARIMA models and employing annual data from 1961 to 2009 and established that the best model for modeling and forecasting population in Ethiopia was the ARIMA (2, 1, 2) model. In the case of Algeria, I will employ the Box-Jenkins ARIMA methodology for the data set ranging from 1960 to 2017.

MATERIALS & METHODS

ARIMA Models

ARIMA models are often considered as delivering more accurate forecasts then econometric techniques (Song *et al*, 2003b). ARIMA models outperform multivariate models in forecasting performance (du Preez & Witt, 2003). Overall performance of ARIMA models is superior to that of the naïve models and smoothing techniques (Goh & Law, 2002). ARIMA models were developed by Box and Jenkins in the 1970s and their approach of identification, estimation and diagnostics is based on the principle of parsimony (Asteriou & Hall, 2007). The general form of the ARIMA (p, d, q) can be represented by a backward shift operator as:

$$\emptyset(B)(1-B)^d POP_t = \theta(B)\mu_t \quad \ldots [1]$$

Where the autoregressive (AR) and moving average (MA) characteristic operators are:

$$\emptyset(B) = \left(1 - \emptyset_1 B - \emptyset_2 B^2 - \cdots - \emptyset_p B^p\right) \quad \ldots [2]$$

$$\theta(B) = \left(1 - \theta_1 B - \theta_2 B^2 - \cdots - \theta_q B^q\right) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [3]$$

and

$$(1 - B)^d POP_t = \Delta^d POP_t \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots [4]$$

Where $\emptyset$ is the parameter estimate of the autoregressive component, θ is the parameter estimate of the moving average component, Δ is the difference operator, d is the difference, B is the backshift operator and μ_t is the disturbance term.

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).

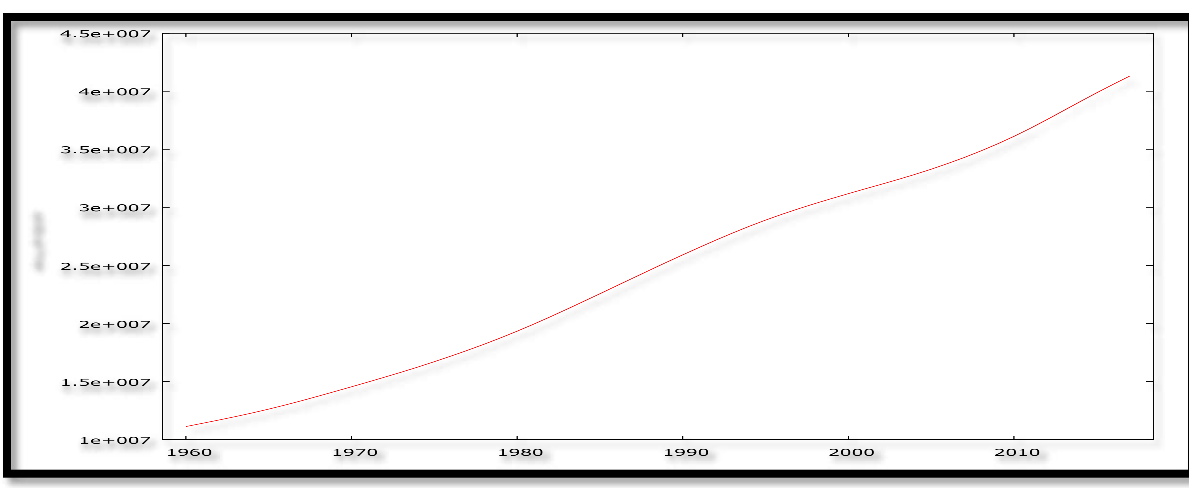
Data Collection

This study is based on 58 observations of annual total population in Algeria (ALPOP or simply POP), i.e. 1960 – 2017. All the data was gathered from the World Bank online database.

Diagnostic Tests & Model Evaluation

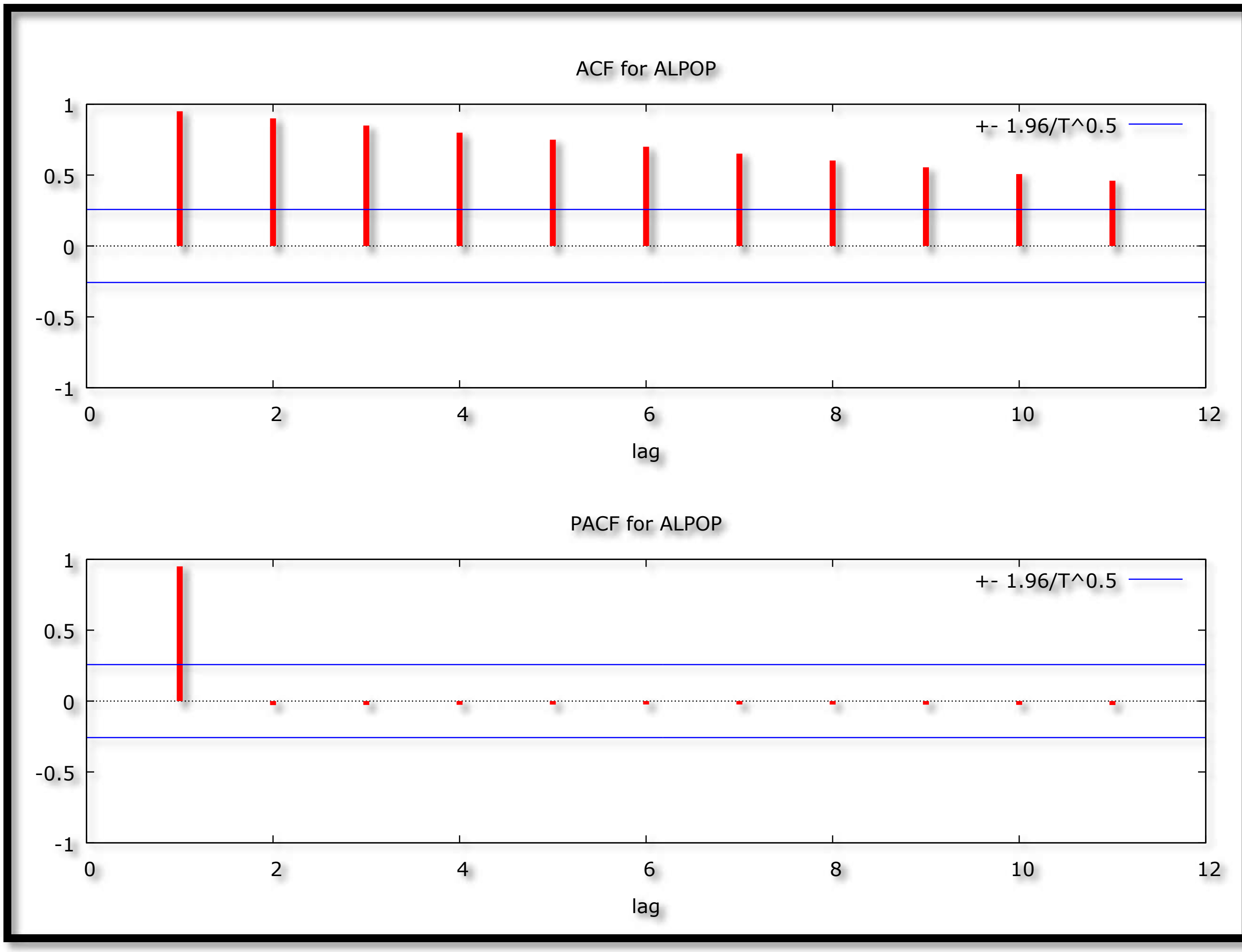
Stationarity Tests: Graphical Analysis

Figure 1



The Correlogram in Levels

Figure 2



The ADF Test

Table 1: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	1.159354	0.9975	-3.562669	@1%	Not stationary
			-2.918778	@5%	Not stationary
			-2.597285	@10%	Not stationary

Table 2: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-4.130006	0.0103	-4.140858	@1%	Not stationary
			-3.496960	@5%	Stationary
			-3.177579	@10%	Stationary

Table 3: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	0.734982	0.8703	-2.610192	@1%	Not stationary
			-1.947248	@5%	Not stationary
			-1.612797	@10%	Not stationary

The Correlogram (at 1st Differences)

Figure 3

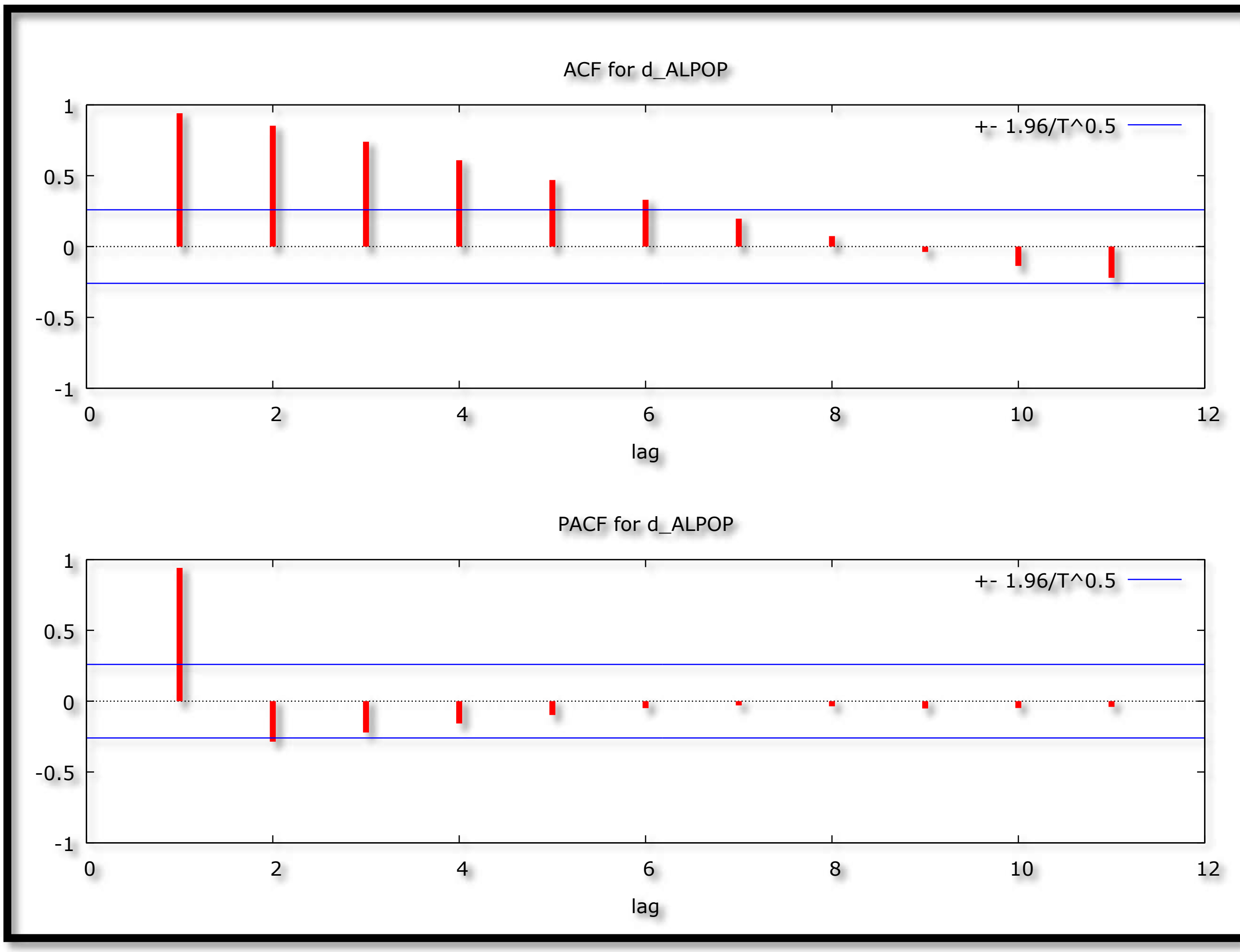


Table 4: 1st Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.077990	0.2541	-3.562669	@1%	Not stationary
			-2.918778	@5%	Not stationary
			-2.597285	@10%	Not stationary

Table 5: 1st Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.441834	0.3547	-4.144584	@1%	Not stationary
			-3.498692	@5%	Not stationary
			-3.178578	@10%	Not stationary

Table 6: 1st Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	0.408291	0.7976	-2.610192	@1%	Not stationary
			-1.947248	@5%	Not stationary
			-1.612797	@10%	Not stationary

Figures 1 – 3 and tables 1 – 6 indicate that the Algeria POP series is neither I (0) nor I (1) and therefore the researcher will go ahead and test for stationarity in second differences.

The Correlogram in (2nd Differences)

Figure 4

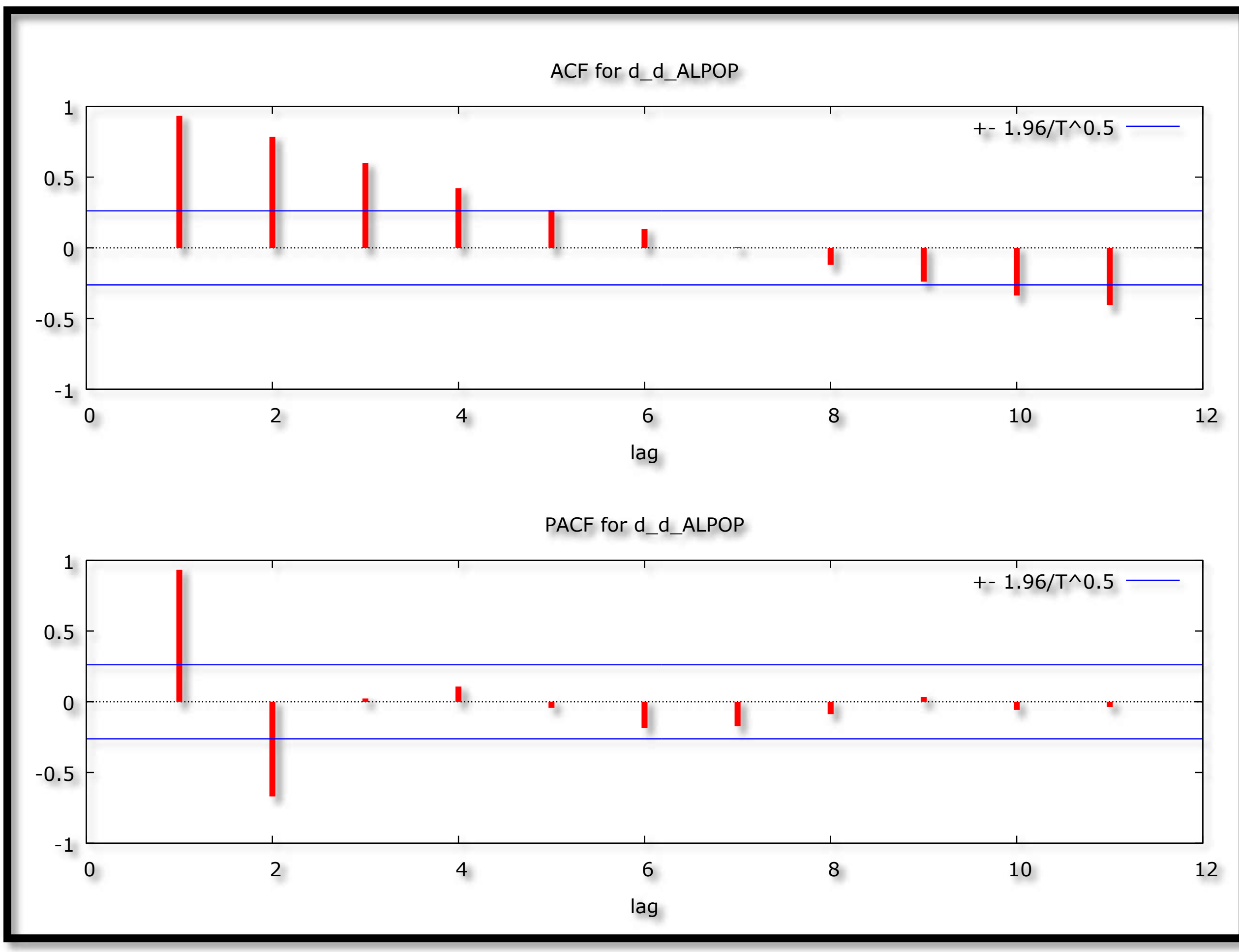


Table 7: 2nd Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.959037	0.0456	-3.562669	@1%	Not stationary
			-2.918778	@5%	Stationary
			-2.597285	@10%	Stationary

Table 8: 2nd Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-4.127695	0.0113	-4.175640	@1%	Not stationary
			-3.513075	@5%	Stationary
			-3.186854	@10%	Stationary

Table 9: 2nd Difference-without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.902125	0.0045	-2.610192	@1%	Stationary
			-1.947248	@5%	Stationary
			-1.612797	@10%	Stationary

Tables 7 – 9 basically show that the Algeria POP series is stationary after taking second differences and is thus an I (2) variable.

Evaluation of ARIMA models (without a constant)

Table 10

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 2, 1)	1098.078	0.00665914	151.77	3177.1	4072.7	0.013146
ARIMA (1, 2, 0)	1153.537	0.010585	10.159	5300.2	6829.6	0.021467
ARIMA (0, 2, 1)	1216.718	0.021286	3983.5	10377	12033	0.043591
ARIMA (2, 2, 1)	1056.371	0.0049321	526.01	2271.5	2810.4	0.0097639
ARIMA (3, 2, 1)	1054.186	0.0047912	409.79	2112.6	2717.5	0.0092609
ARIMA (4, 2, 1)	1053.934	0.0047702	455.23	2136.3	2666.6	0.0093957
ARIMA (5, 2, 1)	1055.647	0.0047783	458.44	2130.4	2660.2	0.0093846
ARIMA (6, 2, 1)	1053.843	0.0047948	526.71	2032.1	2572.7	0.0091306
ARIMA (7, 2, 1)	1055.562	0.0047726	528.72	2027.1	2566	0.0091127
ARIMA (8, 2, 1)	1057.481	0.0047852	534.97	2023.8	2564.1	0.0091154
ARIMA (9, 2, 1)	1058.537	0.0047589	495.37	1989.1	2543.1	0.0089851
ARIMA (2, 2, 0)	1081.393	0.0058036	722.91	2746.2	3534	0.011506
ARIMA (3, 2, 0)	1062.426	0.0049244	407.9	2156	2958.5	0.0091527
ARIMA (4, 2, 0)	**1051.995**	0.0047747	466.24	2134.7	2667.3	0.0094054
ARIMA (5, 2, 0)	1053.993	0.0047738	465.19	2134.5	2667.3	0.0094029
ARIMA (6, 2, 0)	1052.663	0.0047984	496.29	2039.4	2591.7	0.0091079
ARIMA (7, 2, 0)	1053.592	0.0047671	524.77	2027.1	2566.8	0.0091041
ARIMA (8, 2, 0)	1055.512	0.0047828	534.32	2025.7	2564.8	0.0091204
ARIMA (9, 2, 0)	1057.014	0.004773	515.78	2001.2	2554.4	0.0090249

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 consider the minimum AIC in order to choose the best model for forecasting total population in Algeria. Therefore, the ARIMA (4, 2, 0) model is carefully selected.

Residual & Stability Tests

ADF Tests of the Residuals of the ARIMA (4, 2, 0) Model

Table 11: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-7.037589	0.0000	-3.565430	@1%	Stationary
			-2.919952	@5%	Stationary
			-2.597905	@10%	Stationary

Table 12: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-6.972026	0.0000	-4.148465	@1%	Stationary
			-3.500495	@5%	Stationary
			-3.179617	@10%	Stationary

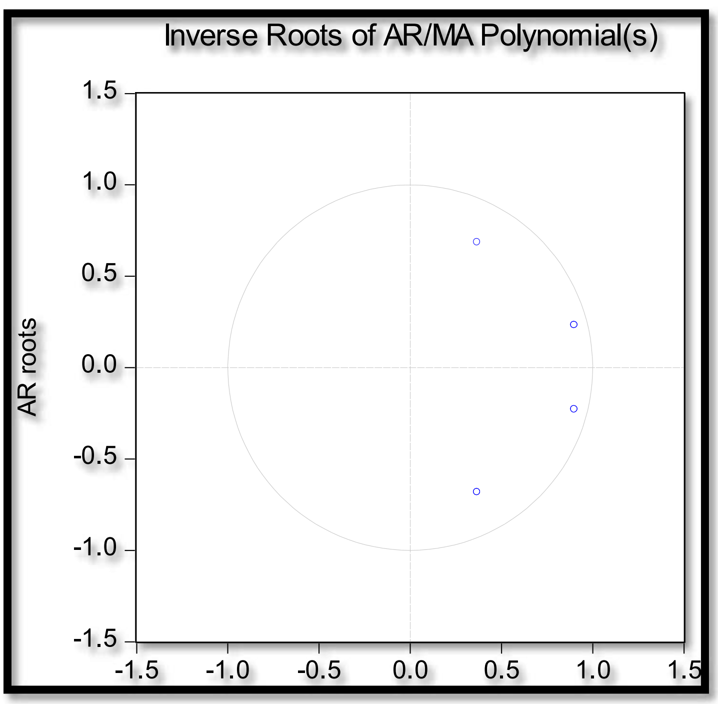
Table 13: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-7.048417	0.0000	-2.611094	@1%	Stationary
			-1.947381	@5%	Stationary
			-1.612725	@10%	Stationary

Tables 11, 12 and 13 indicate that the residuals of the ARIMA (4, 2, 0) model are stationary.

Stability Test of the ARIMA (4, 2, 0) Model

Figure 5



Since the corresponding inverse roots of the characteristic polynomial lie in the unit circle, it graphically proves that the chosen ARIMA (4, 2, 0) model is quite stable.

FINDINGS

Descriptive Statistics

Table 14

Description	Statistic
Mean	24827000
Median	24925000
Minimum	11125000
Maximum	41318000
Standard deviation	9145200
Skewness	0.092401
Excess kurtosis	-1.2683

As shown above, the mean is positive, i.e. 24827000. The wide gap between the minimum (i.e 11125000) and the maximum (i.e. 41318000) is consistent with the observation that the Algeria POP series is constantly trending upwards over the period 1960 – 2017. The skewness is 0.092401 and the most vital characteristic is that it is positive, meaning that the Algeria POP series is positively skewed and non-symmetric. Excess kurtosis is -1.2683; showing that the Algeria POP series is not normally distributed.

Results Presentation[1]

Table 15

ARIMA (4, 2, 0) Model:

$$\Delta^2 POP_{t-1} = 2.51127\Delta^2 POP_{t-1} - 2.73099\Delta^2 POP_{t-2} + 1.65927\Delta^2 - 0.494073\Delta^2 POP_{t-4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots [5]$$

P: (0.0000) (0.0000) (0.0000) (0.0000)

S. E: (0.119804) (0.297013) (0.312995) (0.136098)

Variable	Coefficient	Standard Error	z	p-value
AR (1)	2.51127	0.119804	20.96	0.0000***
AR (2)	-2.73099	0.297013	-9.195	0.0000***
AR (3)	1.65927	0.312995	5.301	0.0000***
AR (4)	-0.494073	0.136098	-3.630	0.0003***

Table 16

Year	Actual	Fitted	Residual
1962	11690153.00	11684830.00	5323.00
1963	11985136.00	11980534.67	4601.33
1964	12295970.00	12292723.73	3246.27

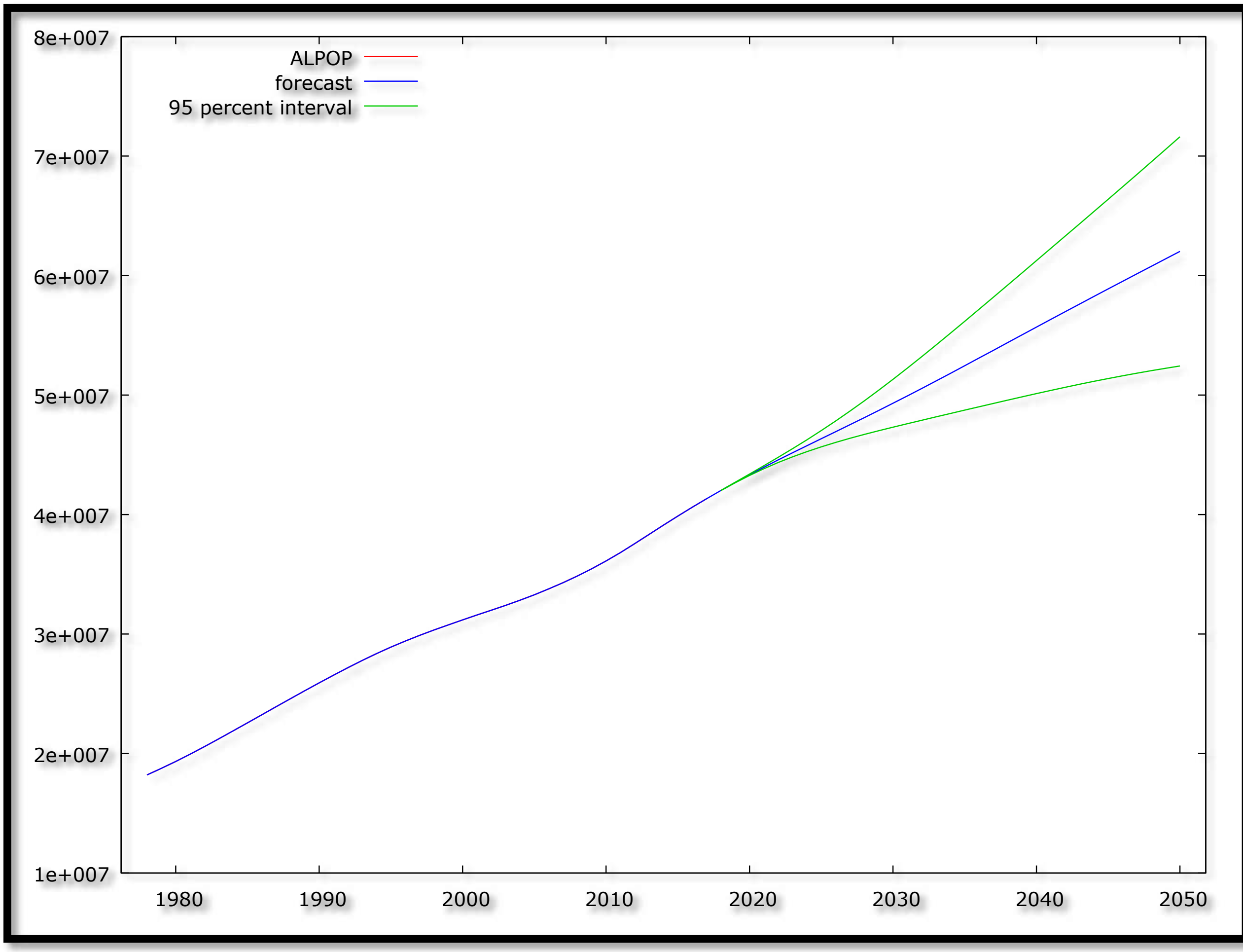
[1] *The *, ** and *** means significant at 10%, 5% and 1% levels of significance; respectively.*

1965	12626952.00	12627510.91	-558.91
1966	12980267.00	12978688.95	1578.05
1967	13354197.00	13356156.33	-1959.33
1968	13744387.00	13744505.16	-118.16
1969	14144438.00	14146212.89	-1774.89
1970	14550034.00	14548018.53	2015.47
1971	14960109.00	14959419.18	689.82
1972	15377093.00	15374617.12	2475.88
1973	15804428.00	15803523.90	904.10
1974	16247113.00	16243581.03	3531.97
1975	16709099.00	16709328.53	-229.53
1976	17190239.00	17191395.96	-1156.96
1977	17690184.00	17687124.76	3059.24
1978	18212326.00	18209485.71	2840.29
1979	18760761.00	18761100.07	-339.07
1980	19337715.00	19336344.27	1370.73
1981	19943664.00	19942021.90	1642.10
1982	20575701.00	20577202.57	-1501.57
1983	21228289.00	21228397.16	-108.16
1984	21893853.00	21895260.24	-1407.24
1985	22565905.00	22564840.16	1064.84
1986	23241272.00	23240023.15	1248.85
1987	23917897.00	23918622.24	-725.24
1988	24591492.00	24592982.22	-1490.22
1989	25257672.00	25256337.20	1334.80
1990	25912367.00	25913955.32	-1588.32
1991	26554329.00	26552821.18	1507.82

1992	27181094.00	27184873.92	-3779.92
1993	27786259.00	27789075.68	-2816.68
1994	28362253.00	28363230.26	-977.26
1995	28904298.00	28905055.10	-757.10
1996	29411415.00	29412421.64	-1006.64
1997	29886839.00	29885801.98	1037.02
1998	30335732.00	30336143.21	-411.21
1999	30765613.00	30763369.89	2243.11
2000	31183660.00	31184875.23	-1215.23
2001	31592153.00	31595546.67	-3393.67
2002	31995046.00	31990533.98	4512.02
2003	32403514.00	32399725.24	3788.76
2004	32831096.00	32831270.07	-174.07
2005	33288437.00	33286881.66	1555.34
2006	33777915.00	33780328.08	-2413.08
2007	34300076.00	34295787.12	4288.88
2008	34860715.00	34856481.69	4233.31
2009	35465760.00	35467346.75	-1586.75
2010	36117637.00	36115589.54	2047.46
2011	36819558.00	36813547.30	6010.70
2012	37565847.00	37573926.15	-8079.15
2013	38338562.00	38342653.73	-4091.73
2014	39113313.00	39116369.53	-3056.53
2015	39871528.00	39869901.02	1626.98
2016	40606052.00	40604583.21	1468.79
2017	41318142.00	41316563.01	1578.99

Forecast Graph

Figure 6



Predicted Total Population

Table 17

Year	Prediction	Std. Error	95% Confidence Interval
2018	42010150.33	2490.213	42005269.61 - 42015031.06
2019	42681855.31	11506.723	42659302.55 - 42704408.08
2020	43331896.82	31089.439	43270962.64 - 43392831.00
2021	43960746.75	64000.852	43835307.39 - 44086186.12
2022	44571774.60	111639.145	44352965.90 - 44790583.30
2023	45170006.04	174601.258	44827793.87 - 45512218.22
2024	45760314.89	253154.102	45264141.97 - 46256487.82
2025	46346573.29	347303.090	45665871.74 - 47027274.84

2026	46931869.11	456623.809	46036902.89 - 47826835.33
2027	47518985.98	580155.468	46381902.15 - 48656069.80
2028	48110498.34	716490.413	46706202.93 - 49514793.74
2029	48708479.75	863986.506	47015097.31 - 50401862.18
2030	49314199.86	1020963.563	47313148.05 - 51315251.67
2031	49928080.64	1185814.128	47603927.66 - 52252233.62
2032	50549883.00	1357048.178	47890117.45 - 53209648.56
2033	51178936.34	1533321.252	48173681.91 - 54184190.77
2034	51814282.38	1713470.961	48455941.01 - 55172623.75
2035	52454740.88	1896553.929	48737563.49 - 56171918.28
2036	53098970.37	2081865.076	49018589.80 - 57179350.94
2037	53745566.52	2268932.153	49298541.22 - 58192591.82
2038	54393181.44	2457492.161	49576585.31 - 59209777.57
2039	55040622.57	2647460.633	49851695.08 - 60229550.06
2040	55686908.80	2838900.422	50122766.22 - 61251051.38
2041	56331290.55	3031991.028	50388697.33 - 62273883.76
2042	56973251.86	3226997.413	50648453.16 - 63298050.57
2043	57612505.55	3424238.490	50901121.44 - 64323889.66
2044	58248980.35	3624057.197	51145958.77 - 65352001.94
2045	58882795.92	3826794.358	51382416.81 - 66383175.04
2046	59514225.72	4032767.538	51610146.58 - 67418304.85
2047	60143653.35	4242254.976	51828986.38 - 68458320.32
2048	60771529.13	4455484.197	52038940.57 - 69504117.69
2049	61398330.85	4672624.989	52240154.16 - 70556507.54
2050	62024530.04	4893786.591	52432884.58 - 71616175.51

Table 16 shows the actual total population of Algeria, the fitted one as well as the residuals. The critical feature of table 16 is the residuals are reasonably small, confirming the accuracy of the selected model, the ARIMA (4, 2, 0) model as already hinted by the forecast evaluation statistics in table 10 above. Figure 6 (with a forecast range from 2018 – 2050) and table 17, clearly show that Algeria's total population is set to continue rising gradually, in the next 3 decades. With a 95% confidence interval of 52432885 to 71616176 and a projected total population of 62024530 by 2050, the chosen ARIMA (4, 2, 0) model is consistent with the population projections by the UN (2015) which forecasted that Algeria's total population will be approximately 56461000 by 2050.

Policy Implications

i. The Algerian government should invest more in infrastructural development in order to cater for the expected increase in total population.
ii. The predicted increase in total population in Algeria justifies the need for more and bigger companies to provide for the anticipated increase in demand for goods and services in Algeria.
iii. The government of Algeria ought to take action so as to improve health service delivery in the country in order to ensure a healthier society, particularly in light of such a likely increase in total population.
iv. The need for political stability cannot be overlooked in Algeria. Without political stability, Algeria's anticipated increase in total population could arguably be a threat to Algeria herself, something which is not desirable.

CONCLUSION

The study shows that the ARIMA (4, 2, 0) model is not only stable but also the most suitable model to forecast total population in Algeria for the next 3 decades. The model predicts that by 2050, Algeria's total population would be approximately, 62 million people. This is a warning signal to the Algerian government, particularly with regards to infrastructural development, e.g schools and hospitals. These findings are vital for the policy makers in Algeria, especially when it comes to long-term planning.

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