Somalia population dynamics versus the Malthusian population trap: What does the ARIMA approach tell us?

NYONI, THABANI

University of Zimbabwe, Department of Economics

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Nyoni, Thabani

Department of Economics

University of Zimbabwe

Harare, Zimbabwe

Email: nyonithabani35@gmail.com

Abstract

Using annual time series data on total population in Somalia 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 Somalia annual total population is basically I (2). Based on the AIC, the study presents the ARIMA (7, 2, 1) model as the most parsimonious model. The diagnostic tests further show that the presented model is really stable and that its residuals are I (0). The results of the study reveal that total population in Somalia will continue to rise sharply in the next three decades and in 2050 Somalia's total population will be approximately 28 million people. In order to circumvent the chances of being a victim of the Malthusian population trap, 4 policy recommendations have been put forward for consideration by the government of Somalia.

Key Words: Forecasting, Population, Somalia

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).

Somalia is emerging from 25 years of political instability and economic difficulty but hard data is lacking for evidence-based planning. The civil war and ongoing conflict that started in 1991 fragmented the country, undermined political institutions, and created widespread vulnerability. The prolonged period of instability created a highly vulnerable population of 12 million people. The region is currently facing a severe and prolonged drought, leaving about half of the population at acute risk of famine, mostly in rural areas and IDP settlements. 1 in 2 Somali people are poor, with almost on third facing conditions of extreme poverty (World Bank, 2016).

In Somalia, just like in any other part of the world, population modeling and forecasting is indeed essential for policy dialogue. This study endeavors to model and forecast total population of Somalia 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

Zakria & Muhammad (2009) analyzed total population using Box-Jenkins ARIMA models in Pakistan, and made use of a data set ranging from 1951 to 2007; and found out that the ARIMA (1, 2, 0) model was the optimal model. Beg & Islam (2016) looked at population growth of Bangladesh using an autoregressive time trend model based on a data set ranging over 1965 – 2003 and illustrated that there is a downward population growth for Bangladesh for the extended period up to 2043. Ayele & Zewdie (2017) carefully scrutinized human population size and its pattern in Ethiopia using Box-Jenkins ARIMA models and employing annual data from 1961 to 2009 and revealed that the optimal model for modeling and forecasting population in Ethiopia was the ARIMA (2, 1, 2) model. In the case of Somalia, the researcher 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:

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

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

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

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

and

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

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).

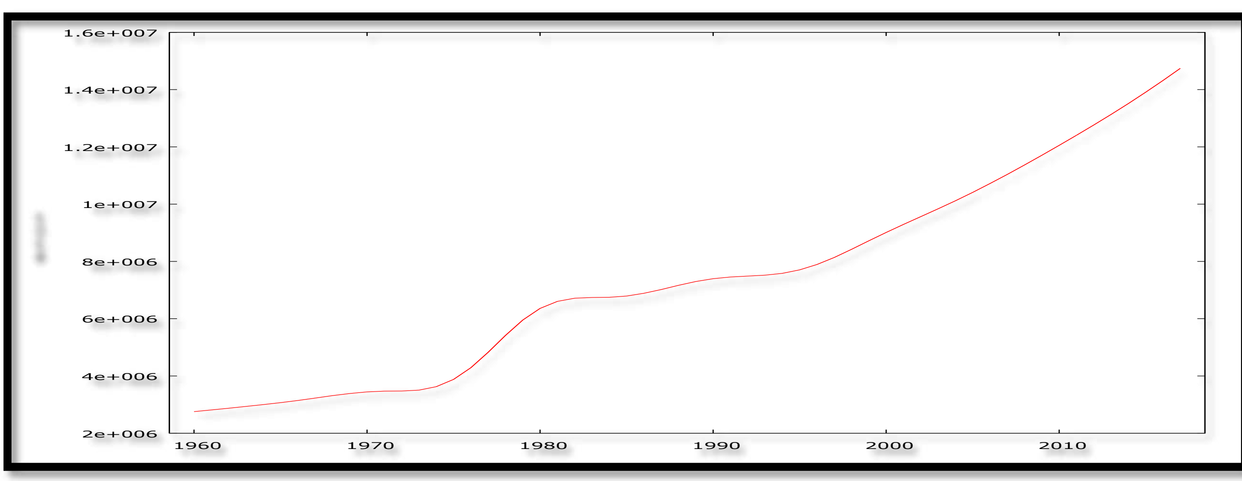
Data Collection

This study is based on 58 observations of annual total population in Somalia; data was taken from the World Bank online database.

Diagnostic Tests & Model Evaluation

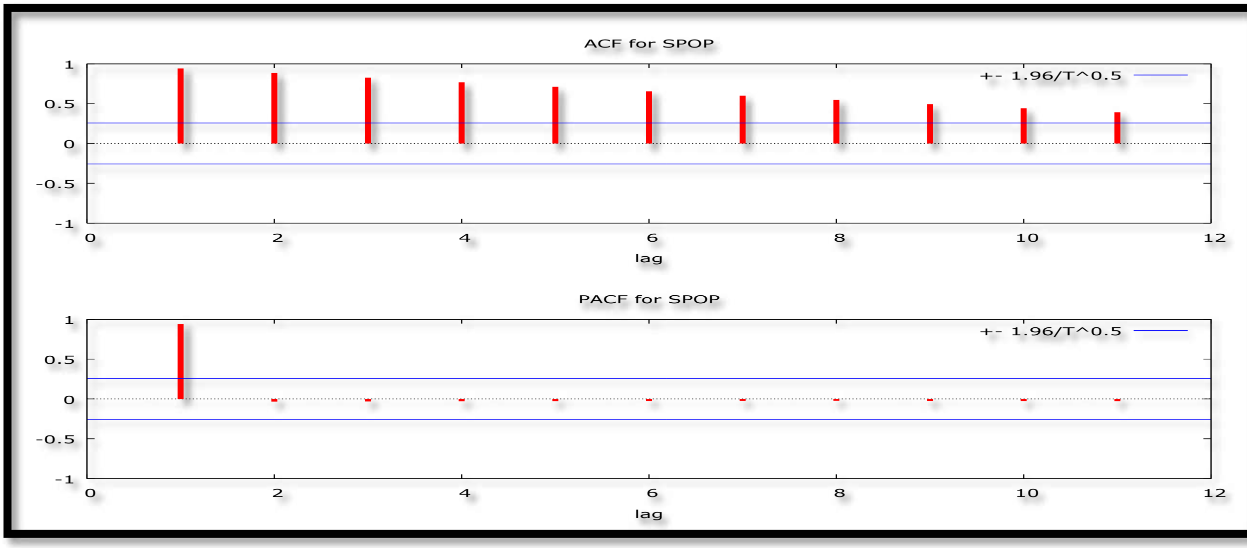
Stationarity Tests: Graphical Analysis

Figure 1



The Correlogram in Levels

Figure 2



The ADF Test

Table 1: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	1.723392	0.9996	-3.574446	@1%	Not stationary
			-2.923780	@5%	Not stationary
			-2.599925	@10%	Not stationary

Table 2: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	0.691175	0.9995	-4.161144	@1%	Not stationary
			-3.506374	@5%	Not stationary
			-3.183002	@10%	Not stationary

Table 3: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	2.455882	0.9961	-2.614029	@1%	Not stationary
			-1.947816	@5%	Not stationary
			-1.612492	@10%	Not stationary

The Correlogram (at 1st Differences)

Figure 3

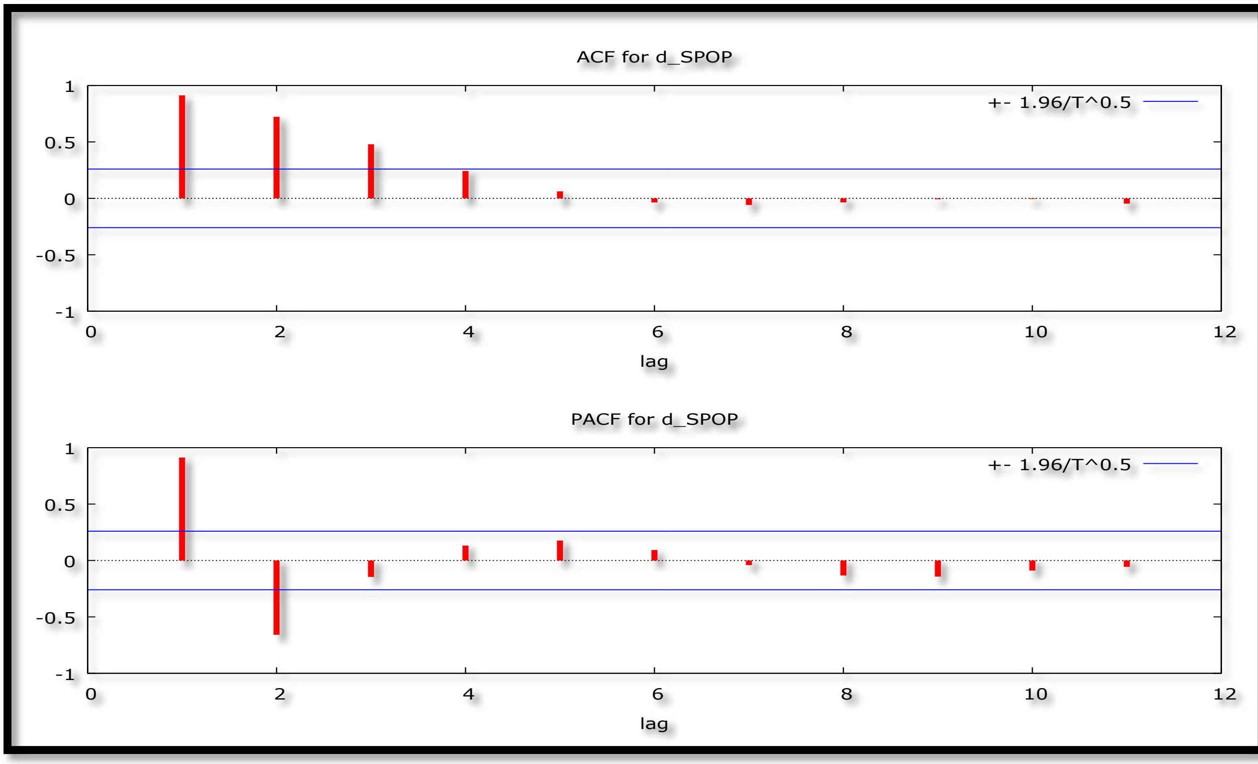


Table 4: 1st Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-1.750451	0.4001	-3.574446	@1%	Not stationary
			-2.923780	@5%	Not stationary
			-2.599925	@10%	Not stationary

Table 5: 1st Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.422159	0.3640	-4.161144	@1%	Not stationary
			-3.506374	@5%	Not stationary
			-3.183002	@10%	Not stationary

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

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	0.235157	0.7502	-2.614029	@1%	Not stationary
			-1.947816	@5%	Not stationary
			-1.612492	@10%	Not stationary

The Correlogram in (2nd Differences)

Figure 4

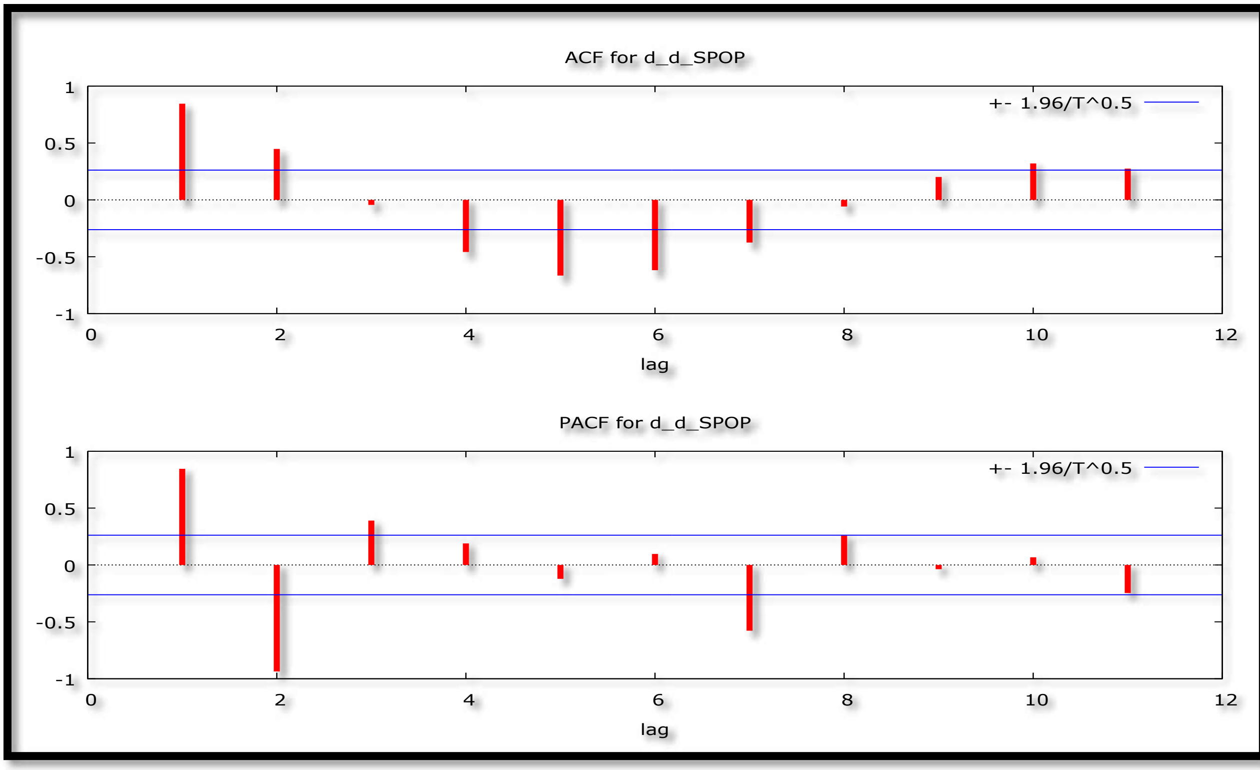


Table 7: 2nd Difference-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.470293	0.1289	-3.574446	@1%	Not stationary
			-2.923780	@5%	Not stationary
			-2.599925	@10%	Not stationary

Table 8: 2nd Difference-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.434424	0.3580	-4.161144	@1%	Not stationary
			-3.506374	@5%	Not stationary
			-3.183002	@10%	Not stationary

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

Variable	ADF Statistic	Probability	Critical Values		Conclusion
POP	-2.259749	0.0244	-2.614029	@1%	Stationary
			-1.947816	@5%	Stationary
			-1.612492	@10%	Stationary

Figures 1 – 4 and tables 1 – 8 indicate that the Somalia POP series is not stationary in levels, first differences and in second differences. However, table 9 shows that the POP series is only stationary after taking second differences, therefore, we regard the Somalia POP series as an I (2) variable. Results in tables 7 and 8 are not new, in fact, they characterize sharply upwards trending series in most instances, a notion which, in this case is confirmed by figure 1 above where we have already seen that the total population in Somalia has been increasing sharply over the past few decades.

Evaluation of ARIMA models (without a constant)

Table 10

Model	AIC	U	ME	MAE	RMSE	MAPE
ARIMA (1, 2, 1)	1271.064	0.097021	886.37	12287	18995	0.22354
ARIMA (1, 2, 0)	1315.24	0.14688	1300.9	18150	29084	0.32454
ARIMA (0, 2, 1)	1323.73	0.16227	3544.7	20242	31340	0.35639
ARIMA (2, 2, 1)	1200.555	0.054792	1522.7	6953.5	9725.2	0.12974
ARIMA (3, 2, 1)	1197.206	0.052497	1013.8	6371.7	9239.9	0.12166
ARIMA (4, 2, 1)	1188.279	0.049107	918.5	5754.2	8331.4	0.11076
ARIMA (5, 2, 1)	1189.04	0.048479	1015.6	5674.3	8221.1	0.10888
ARIMA (6, 2, 1)	1186.886	0.046836	803.94	5396.1	7895.5	0.10513
ARIMA (7, 2, 1)	**1173.201**	0.039837	1055	4764.7	6762.1	0.091595
ARIMA (8, 2, 1)	1174.818	0.039445	977.63	4687.9	6730.5	0.090364
ARIMA (9, 2, 1)	1176.784	0.039396	960.73	4660.3	6728.2	0.089924
ARIMA (10, 2, 1)	1177.844	0.03926	863.37	4581.4	6672	0.088679
ARIMA (2, 2, 0)	1205.069	0.059053	1880.5	7243.7	10346	0.13492
ARIMA (3, 2, 0)	1196.4	0.052642	1152.1	6570.9	9341.3	0.12354
ARIMA (4, 2, 0)	1196.427	0.052552	980.15	6246.4	9172	0.12035
ARIMA (5, 2, 0)	1197.626	0.052433	1062.1	6268.3	9096.1	0.1199
ARIMA (6, 2, 0)	1198.742	0.052432	967.55	6154.2	9021.9	0.1179
ARIMA (7, 2, 0)	1178.722	0.043086	1313.5	5279.2	7284.4	0.10006
ARIMA (8, 2, 0)	1173.824	0.039492	911.03	4616.3	6794.3	0.089137
ARIMA (9, 2, 0)	1175.496	0.039449	960.51	4662.6	6772.8	0.089889
ARIMA (10, 2, 0)	1176.757	0.039361	880.08	4674.9	6727.3	0.090146

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 rely on the minimum AIC in order to choose the best model for forecasting total population in Somalia. Therefore, the ARIMA (7, 2, 1) model is carefully selected.

Residual & Stability Tests

ADF Tests of the Residuals of the ARIMA (7, 2, 1) Model

Table 11: Levels-intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-2.787428	0.0693	-3.610453	@1%	Not stationary
			-2.938987	@5%	Not stationary
			-2.607932	@10%	Stationary

Table 12: Levels-trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-3.732761	0.0317	-4.211868	@1%	Not stationary
			-3.529758	@5%	Stationary

		-3.196411	@10%	Stationary

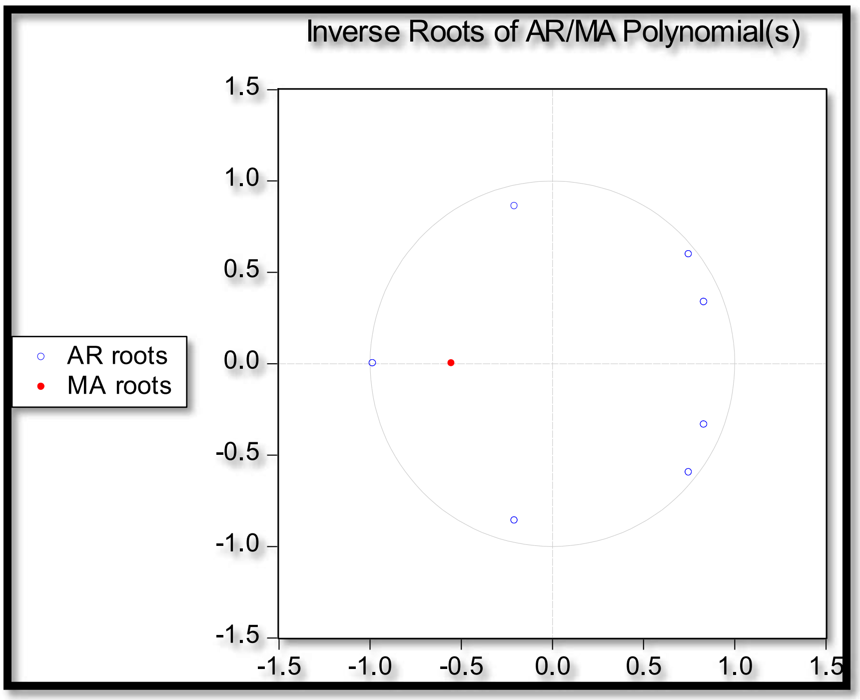
Table 13: without intercept and trend & intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
R_t	-2.462542	0.0151	-2.625606	@1%	Stationary
			-1.949609	@5%	Stationary
			-1.611593	@10%	Stationary

The residuals of the chosen ARIMA (7, 2, 1) model are stationary as clearly shown in tables 11 – 13 above.

Stability Test of the ARIMA (7, 2, 1) Model

Figure 5



Since the corresponding inverse roots of the characteristic polynomial lie in the unit circle, it shows that the chosen optimal model, the ARIMA (7, 2, 1) model is stable.

FINDINGS

Descriptive Statistics

Table 14

Description	Statistic
Mean	7396000
Median	7231900
Minimum	2755900
Maximum	14743000

Standard deviation	3477400
Skewness	0.37656
Excess kurtosis	-0.85153

As shown above, the mean is positive, i.e. 7396000. The wide gap between the minimum (i.e 2755900) and the maximum (i.e. 14743000) is consistent with the observation that the Somalia POP series is gradually trending upwards over the period under study. The skewness is 0.37656 and the most vital feature is that it is positive, meaning that the Somalia POP series is positively skewed and non-symmetric. Excess kurtosis is -0.85153; showing that the Somalia POP series is not normally distributed.

Results Presentation[1]

Table 15

ARIMA (7, 2, 1) Model:

$$\Delta^2 POP_{t-1} = 1.8\Delta^2 POP_{t-1} - \Delta^2 POP_{t-2} - 0.1\Delta^2 POP_{t-3} + 0.5\Delta^2 POP_{t-4} - \Delta^2 POP_{t-5} + 1.1\Delta^2 POP_{t-6} - 0.5\Delta^2 POP_{t-7} + 0.5\Delta^2 \mu_{t-1} \ldots [5]$$

P: (0.000) (0.000) (0.556) (0.009) (0.000) (0.000) (0.000) (0.002)

S. E: (0.151) (0.293) (0.255) (0.188) (0.224) (0.228) (0.119) (0.172)

Variable	Coefficient	Std. Error	z	p-value
AR (1)	1.75411	0.15098	11.62	0.0000***
AR (2)	-0.982829	0.292741	-3.357	0.0008***
AR (3)	-0.149824	0.254514	-0.5887	0.5561
AR (4)	0.488507	0.187553	2.605	0.0092***
AR (5)	-0.984743	0.223593	-4.404	0.0000***
AR (6)	1.14914	0.227834	5.044	0.0000***
AR (7)	-0.523616	0.119137	-4.395	0.0000***
MA (1)	0.53019	0.17209	3.081	0.0021***

Table 16

Year	Actual POP	Fitted	Residual
1962	2874190.00	2872245.00	1945.00
1963	2936443.00	2935944.81	498.19
1964	3001126.00	3000445.43	680.57
1965	3068437.00	3068093.72	343.28
1966	3143836.00	3138122.27	5713.73
1967	3228495.00	3232410.64	-3915.64
1968	3313786.00	3320636.68	-6850.68

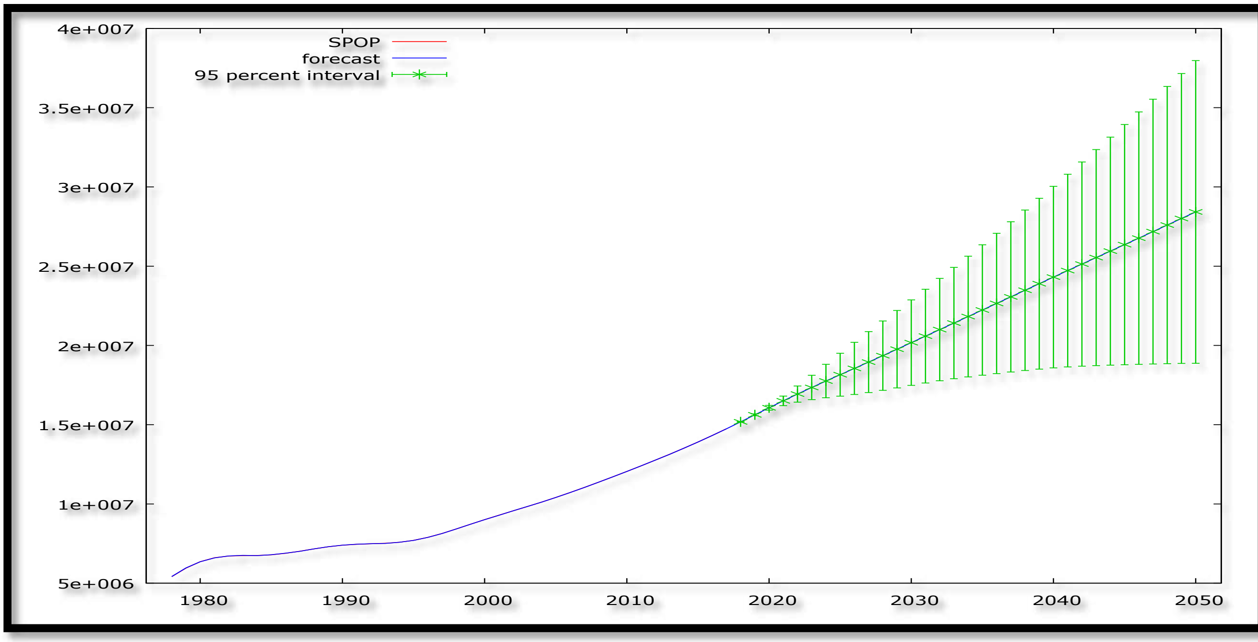
[1] *The *, ** and *** means significant at 10%, 5% and 1% levels of significance; respectively.*

1969	3387632.00	3387966.51	-334.51
1970	3444553.00	3442258.40	2294.60
1971	3470324.00	3482430.55	-12106.55
1972	3475022.00	3452539.98	22482.02
1973	3506008.00	3487994.39	18013.61
1974	3627504.00	3616909.36	10594.64
1975	3880320.00	3878668.59	1651.41
1976	4289469.00	4278391.26	11077.74
1977	4827362.00	4842751.22	-15389.22
1978	5417740.00	5420026.59	-2286.59
1979	5953615.00	5965279.01	-11664.01
1980	6359126.00	6354125.92	5000.08
1981	6604872.00	6596775.49	8096.51
1982	6716448.00	6720702.89	-4254.89
1983	6740220.00	6754749.04	-14529.04
1984	6747932.00	6740961.31	6970.69
1985	6791716.00	6797782.03	-6066.03
1986	6887372.00	6895014.24	-7642.24
1987	7018109.00	7010817.56	7291.44
1988	7165295.00	7165956.57	-661.57
1989	7298417.00	7301524.29	-3107.29
1990	7397347.00	7401137.78	-3790.78
1991	7455936.00	7461566.36	-5630.36
1992	7488544.00	7490699.15	-2155.15
1993	7519811.00	7509290.37	10520.63
1994	7583954.00	7583562.19	391.81
1995	7704894.00	7700372.49	4521.51

1996	7892389.00	7890855.41	1533.59
1997	8137475.00	8133170.31	4304.69
1998	8422372.00	8420590.82	1781.18
1999	8720231.00	8718907.15	1323.85
2000	9011479.00	9008836.24	2642.76
2001	9290823.00	9284474.99	6348.01
2002	9564167.00	9566683.94	-2516.94
2003	9836397.00	9836801.19	-404.19
2004	10116228.00	10113738.16	2489.84
2005	10409925.00	10407450.33	2474.67
2006	10718317.00	10716360.26	1956.74
2007	11038596.00	11033902.95	4693.05
2008	11369276.00	11369842.66	-566.66
2009	11707990.00	11705165.71	2824.29
2010	12053223.00	12053132.68	90.32
2011	12404725.00	12403774.63	950.37
2012	12763776.00	12763118.13	657.87
2013	13132349.00	13128927.18	3421.82
2014	13513125.00	13512081.39	1043.61
2015	13908129.00	13905799.20	2329.80
2016	14317996.00	14316704.57	1291.43
2017	14742523.00	14739815.34	2707.66

Forecast Graph

Figure 6



Predicted Total Population

Table 17

Year	Prediction	Std. Error	95% Confidence Interval
2018	15179438.23	6705.112	15166296.45 - 15192580.01
2019	15623371.70	29498.875	15565554.97 - 15681188.43
2020	16067530.87	76907.545	15916794.86 - 16218266.89
2021	16505817.73	153491.217	16204980.47 - 16806654.99
2022	16933775.60	260047.196	16424092.46 - 17443458.74
2023	17349646.06	391352.862	16582608.54 - 18116683.57
2024	17755103.95	538000.826	16700641.71 - 18809566.20
2025	18154211.75	689761.798	16802303.47 - 19506120.04
2026	18551546.96	838984.644	16907167.27 - 20195926.65
2027	18950974.25	981264.708	17027730.77 - 20874217.74
2028	19354786.63	1116155.977	17167161.12 - 21542412.15
2029	19763170.29	1246237.888	17320588.92 - 22205751.67
2030	20174700.23	1375670.974	17478434.66 - 22870965.79

2031	20587521.89	1508278.884	17631349.59 - 23543694.18
2032	21000202.28	1646780.522	17772571.77 - 24227832.80
2033	21412141.13	1792055.577	17899776.74 - 24924505.52
2034	21823703.59	1943360.161	18014787.67 - 25632619.51
2035	22235845.49	2098961.122	18121957.29 - 26349733.70
2036	22649365.71	2257434.527	18224875.34 - 27073856.08
2037	23064404.33	2418181.225	18324856.22 - 27803952.44
2038	23480372.62	2581711.836	18420310.41 - 28540434.84
2039	23896148.35	2749211.016	18507793.77 - 29284502.93
2040	24310503.57	2922063.233	18583364.88 - 30037642.27
2041	24722664.46	3101035.213	18644747.13 - 30800581.79
2042	25132640.58	3286037.579	18692125.27 - 31573155.88
2043	25541167.43	3476060.784	18728213.49 - 32354121.38
2044	25949397.11	3669674.029	18756968.18 - 33141826.04
2045	26358476.00	3865461.537	18782310.61 - 33934641.40
2046	26769115.79	4062631.400	18806504.56 - 34731727.02
2047	27181369.12	4261117.546	18829732.19 - 35533006.04
2048	27594711.80	4461545.952	18850242.42 - 36339181.18
2049	28008331.72	4664803.893	18865484.10 - 37151179.35
2050	28421469.16	4871738.757	18873036.65 - 37969901.66

Table 16 shows the actual total population of Somalia, the fitted one as well as the residuals. The essential feature of table 16 is that the residuals are quite small, confirming the accuracy of the selected optimal model, the ARIMA (7, 2, 1) 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 Somalia's total population is set to continue rising sharply, in the next 3 decades. With a 95% confidence interval of 188773037 to 37969902 and a projected total population of 28421469 by 2050, the chosen ARIMA (7, 2, 1) model is consistent with the population projections by the UN (2015) which forecasted that Somalia's population will be approximately 27030000 by 2050.

Policy Implications

a. The government of Somalia ought to invest more in infrastructural development in order to cater for the expected increase in total population.
b. The predicted increase in total population in Somalia justifies the need for more and bigger companies to provide for the anticipated increase in demand for goods and services in Somalia. It also justifies the need for more donor organisations to address issues of food security, hunger and starvation.
c. The government of Somalia should 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.
d. The need for political stability cannot be undermined in Somalia. The way the al-Shabab insurgency is being handled leaves a lot to be desired. Without political stability, Somalia's expected increase in total population is a threat not only to her neighboring countries such as Kenya but also to herself.

CONCLUSION

The study shows that the ARIMA (7, 2, 1) model is not only stable but also the most suitable model to forecast total population in Somalia for the next 3 decades. The model predicts that by 2050, Somalia's total population would be approximately, 28 million people. This is a warning signal to policy makers in Somalia, particularly with regards to infrastructural development, e.g schools and hospitals as well as food security. The results of this study are essential for the government of Somalia, especially when it comes to long-term planning.

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