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TOTAL NEW HIV INFECTIONS IN CAMEROON: A BOX-JENKINS ARIMA APPROACH

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Abstract

Using annual time series data on the total number of new HIV infections in Cameroon from 1990 – 2018, the study makes predictions for the period 2019 – 2030. The study applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests confirm that, B, the series under consideration is an I (2) variable. Using the AIC as the model selection criterion, the study presents the ARIMA (1, 2, 0) model as the optimal model. The diagnostic tests further reveal that the presented model is quite stable and its residuals are not serially correlated and are also normally distributed. The results of the study indicate that the total number of new HIV infections in Cameroon will decline sharply over the out-of-sample period. Our model predicts that the country is likely to win the war against HIV by around 2030. In fact, by 2029, the Cameroon is likely to record approximately 1000 total new HIV infections; and by 2030, it will not be surprising to record zero new HIV infections in the country.

1.0INTRODUCTION

HIV/AIDS is a major public health problem in Cameroon and Africa (Nsagha et al., 2012). The first AIDS cases were reported in Cameroon in 1985 and in 1995, 2766 cases had been notified with a cumulative number of 8141 (Mbopi et al., 1998). The national HIV prevalence in Cameroon is approximately 5.5%. HIV transmission is mainly heterosexual (90%) with blood and vertical routes being 5% respectively (Mbanya et al., 2008). In the earlier of the AIDS pandemic, more than 70% of the infected people were aged between 20 and 39 years (Garcia et al., 1992), the work force of the country (Nsagha et al., 2012). Today, youths are still the most infected and those in the 15-24 year age group are hard hit, with infected girls constituting 10-15%, compared to 4-6.5% buys of the same age (Mbanya et al., 2008). The death toll from AIDS continues to rise in Cameroon. The death, especially of many people in their prime working years hampers the economy. Businesses are adversely affected due to the need to recruit and train new staff. Health and social service systems suffer from the loss of health workers, teachers and other skilled workers (NACC, 2010). The strong political will of the government of Cameroon has been instrumental in the fight against the HIV/AIDS pandemic. The health system is decentralized and a multi-sectoral was adopted by the government to fight against the HIV/AIDS pandemic (Nsagha et al., 2012).

The main goal of this study is to predict the number of new HIV infections in Cameroon over the period 2019 – 2030. This paper will go a long way in assessing the possibility of ending the HIV scourge in the country.

2.0 LITERATURE REVIEW

In a review paper, Awuba & Macassa (2007) investigated gender differentials in HIV/AIDS in Cameroon and the extent to which gender was taken into account in the country's policy on HIV/AIDS. The study found out that in Cameroon women were at risk of being infected with HIV/AIDS compared to men and that apart from biological vulnerability, socio-cultural as well as economic factors accounted for those differences. The results of this paper could be the explanation as to why HIV/AIDS is still a major problem in Cameroon. In order to end AIDS in Cameroon gender issues with regards to HIV/AIDS should be addressed at policy level. Mbanya et al. (2008) assessed the effectiveness of HIV control strategies in Cameroon. Their study was descriptive in nature. The authors found out that there have been significantly positive outcomes in various arms of intervention of the Cameroon government. This could be reasons why new HIV infections started decline in Cameroon in around 2000s up to date. In a Zimbabwean study, Nyoni & Nyoni (2020a) examined the trends of new HIV infections in children aged between 0 and 14 years in Zimbabwe, based on annual time series data and employed the generalized ARIMA model. The study indicated that new pediatric HIV infections will continue to decline in the country over the out-of-sample period. No similar study has been conducted in Cameroon. This paper adopts the methodological intuition in Nyoni & Nyoni (2020a).

3.0 METHODODOLOGY

3.1 The Box – Jenkins (1970) 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, 2018c). This approach will be used to analyze, B, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification

If the sequence $\Delta^d B_t$ satisfies an ARMA (p, q) process; then the sequence of B_t also satisfies the ARIMA (p, d, q) process such that:

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

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

3.3 Data Collection

This study is based on annual observations (that is, from 1990 – 2018) on the total number of new HIV infections, that is, adults (ages 15+) and children (ages 0 – 14) [denoted as B] in Cameroon. Out-of-sample forecasts will cover the period 2019 – 2030. All the data was collected from the World Bank online database.

3.4 Diagnostic Tests & Model Evaluation

3.4.1 Stationarity Tests: Graphical Analysis

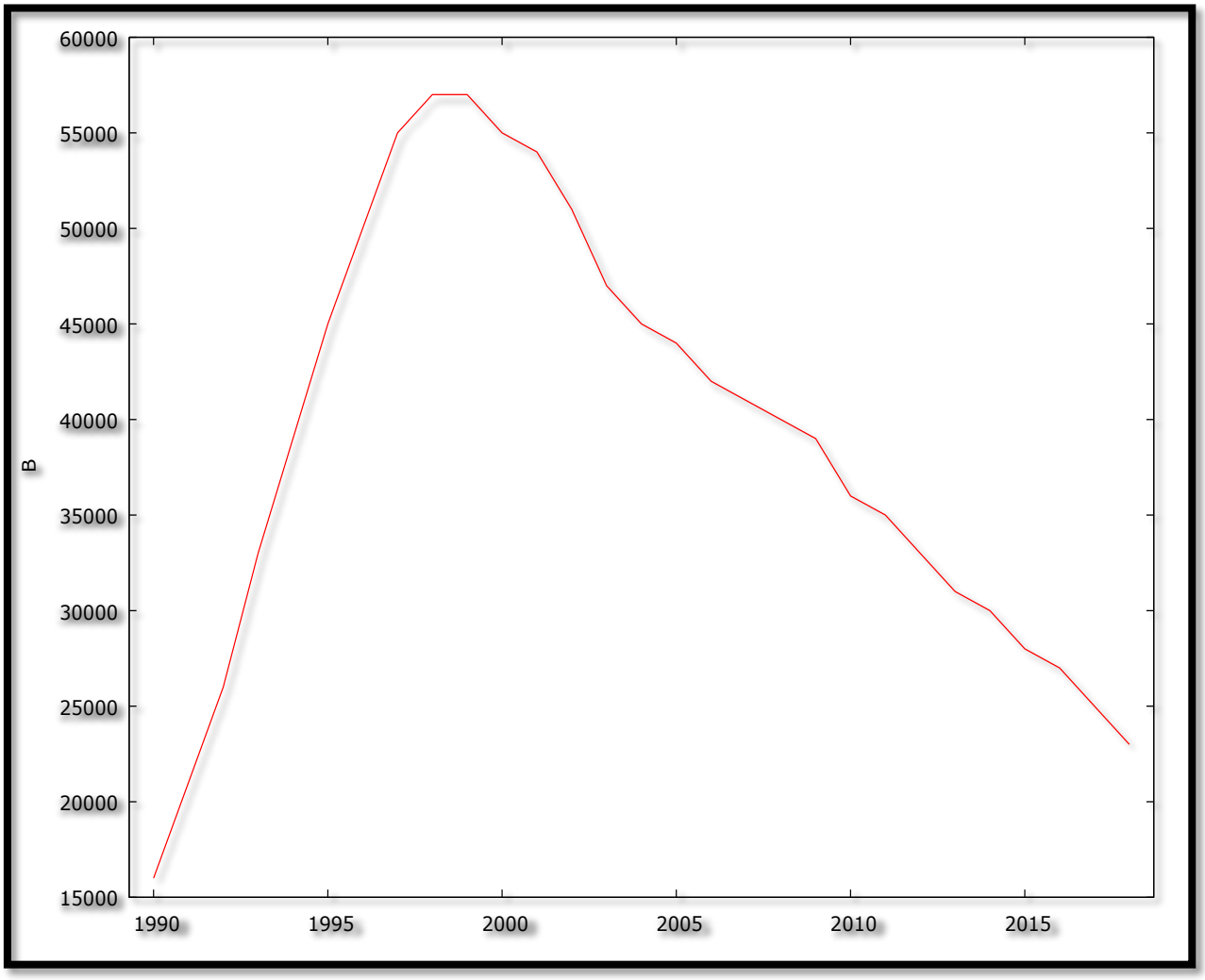

Figure 1

3.4.2 The Correlogram in Levels

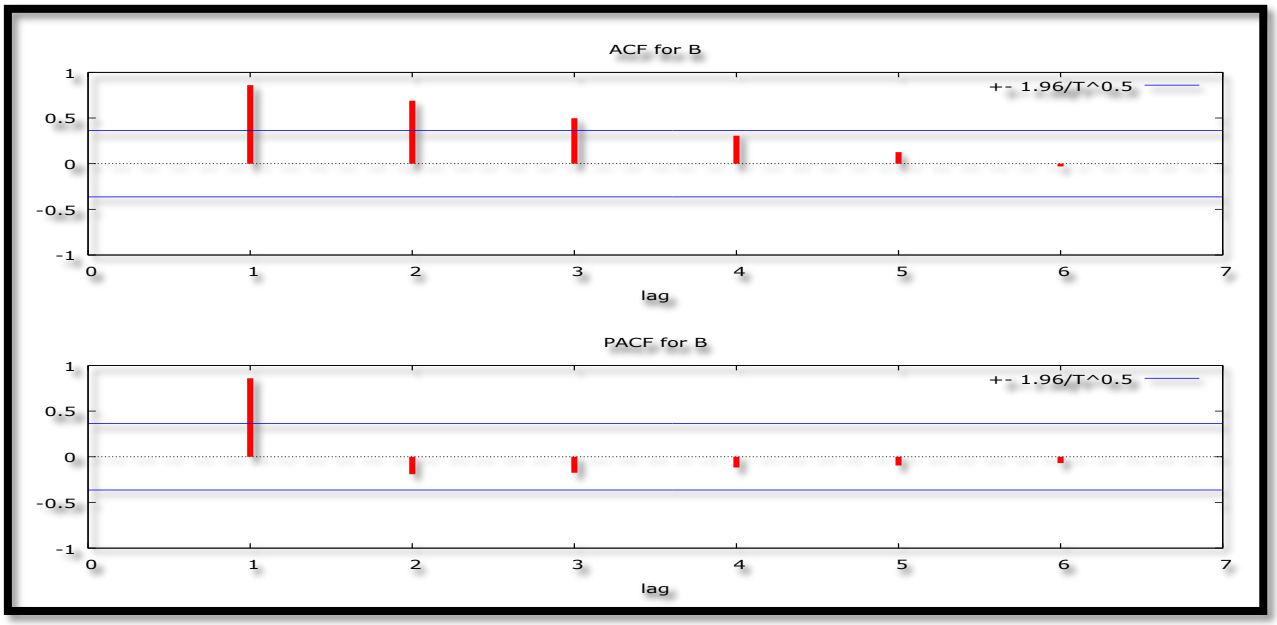

Figure 2: Correlogram in Levels

3.4.3 The ADF Test in Levels

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
B	-2.187707	0.2149	-3.699871	@1%	Non-stationary
			-2.976263	@5%	Non-stationary
			-2.627240	@10%	Non-stationary

Table 1,in line with figure 1 and 2, shows that B is not stationary in levels.

3.4.4 The Correlogram (at First Differences)

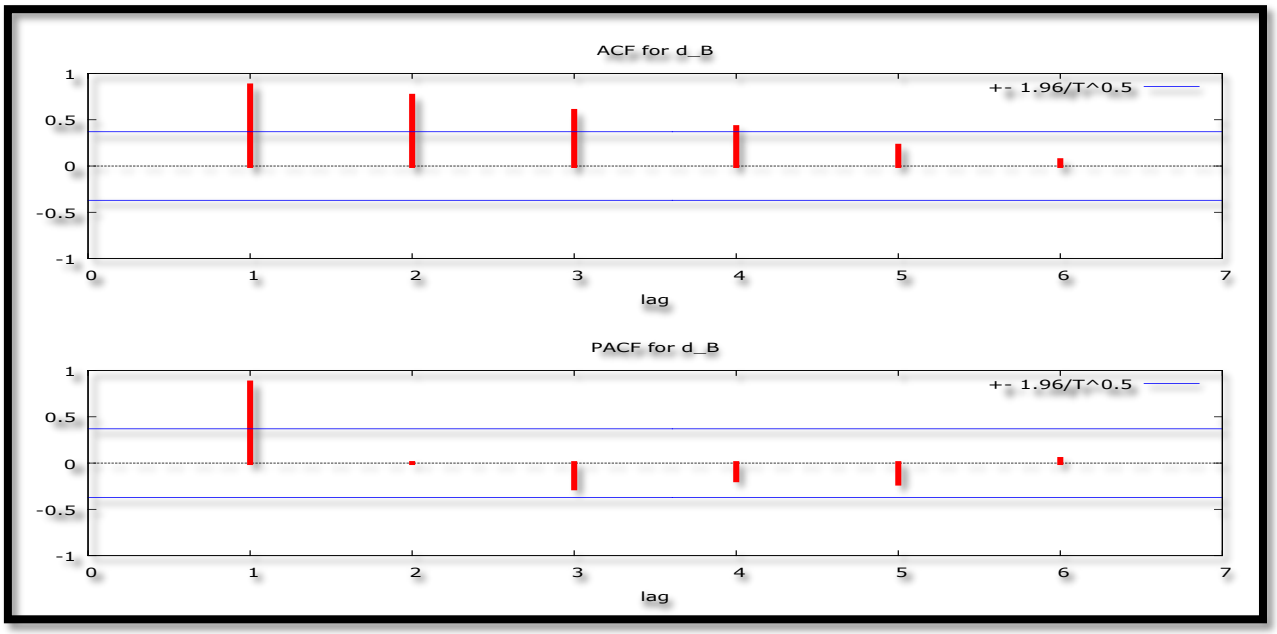

Figure 3: Correlogram (at First Differences)

3.4.5 The ADF Test (at First Differences)

Table 2: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
ΔB	-1.448724	0.5436	-3.699871	@1%	Non-stationary
			-2.976263	@5%	Non-stationary
			-2.627240	@10%	Non-stationary

Figure 3 and table 4 consistently indicate that B is not an I (1) variable.

3.4.6 The Correlogram (at Second Differences)

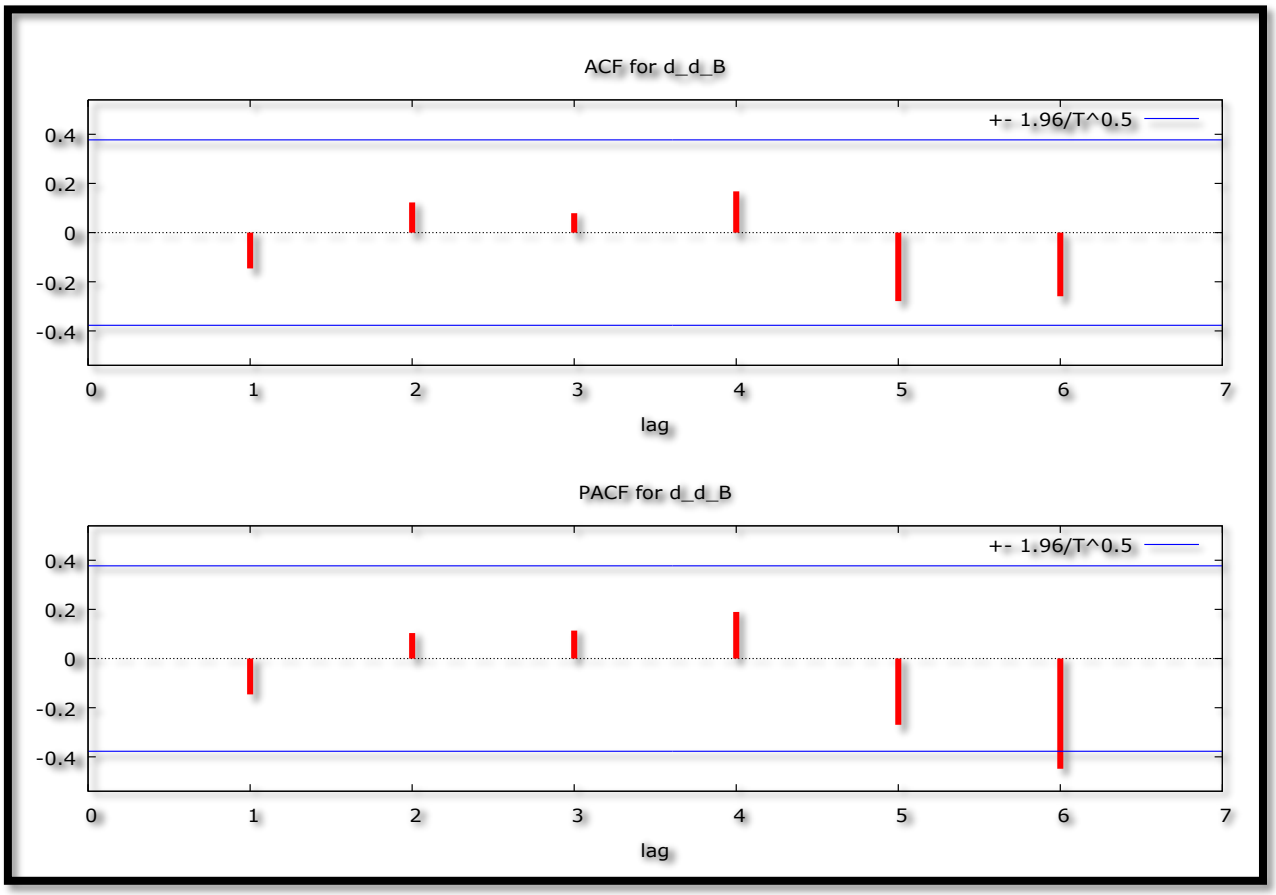

Figure 4: Correlogram (at Second Differences)

3.4.7 The ADF Test (at Second Differences)

Table 3: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
Δ^2B	-5.675761	0.0001	-3.711457	@1%	Stationary
			-2.981038	@5%	Stationary
			-2.629906	@10%	Stationary

Figure 4 and table 3 indicate that B is an I (2) variable.

3.4.8 Evaluation of ARIMA models (with a constant)

Table 4: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 2, 0)	469.4605	0.37298	-284.77	1340.1	2.6106
ARIMA (1, 2, 1)	470.8480	0.38107	-269.06	1325	2.7184
ARIMA (0, 2, 1)	469.5278	0.37582	-279.67	1341.9	2.618
ARIMA (2, 2, 0)	470.7880	0.37188	-245.07	1323.7	2.6847

A model with a lower AIC value is better than the one with a higher AIC value (Nyoni, 2018b) Similarly, the U statistic can be used to find a better model in the sense that it must lie between 0 and 1, of which the closer it is to 0, the better the forecast method (Nyoni, 2018a). In this research paper, only the AIC is used to select the optimal model. Therefore, the ARIMA (1, 2, 0) model is finally chosen.

3.5 Residual & Stability Tests

3.5.1 Correlogram of the Residuals of the ARIMA (1, 2, 0) Model

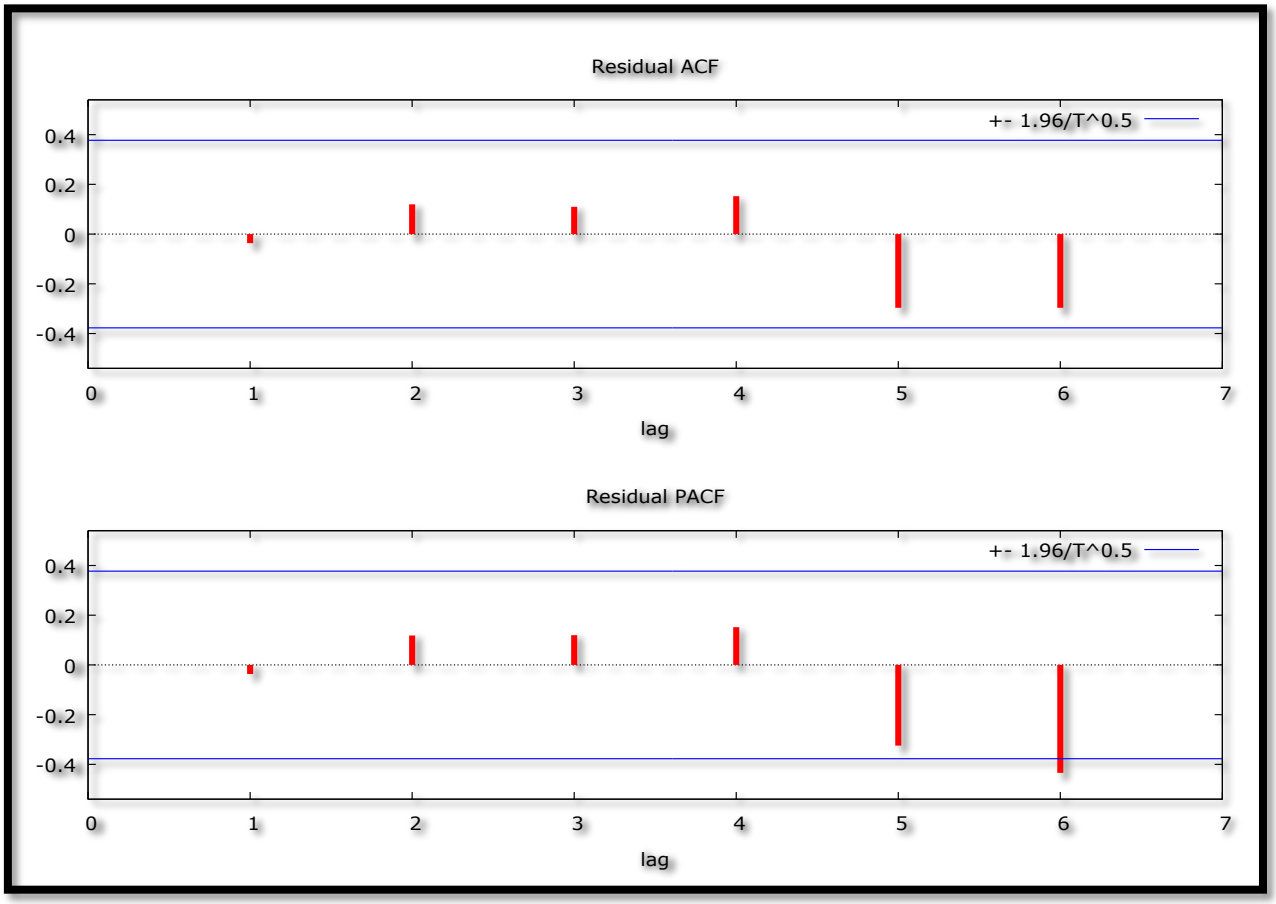

Figure 5: Correlogram of the Residuals

Figure 5 indicates that the estimated ARIMA (1, 2, 0) model is adequate since ACF and PACF lags are quite short and within the bands.

3.5.2 Stability Test of the ARIMA (1, 2, 0) Model

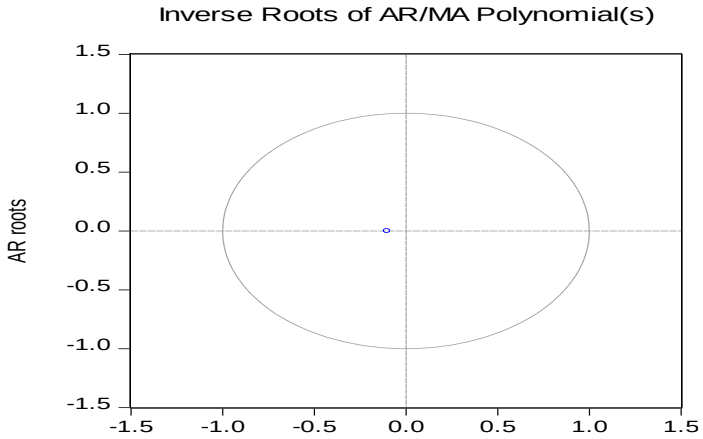

Figure 6: Inverse Roots

Since the AR root lies inside the unit circle, it indicates that the estimated ARIMA process is (covariance) stationary; hence confirming that the ARIMA (1, 2, 0) model is stable.

3.5.3 Normality Test of the Residuals of the ARIMA (1, 2, 0) Model

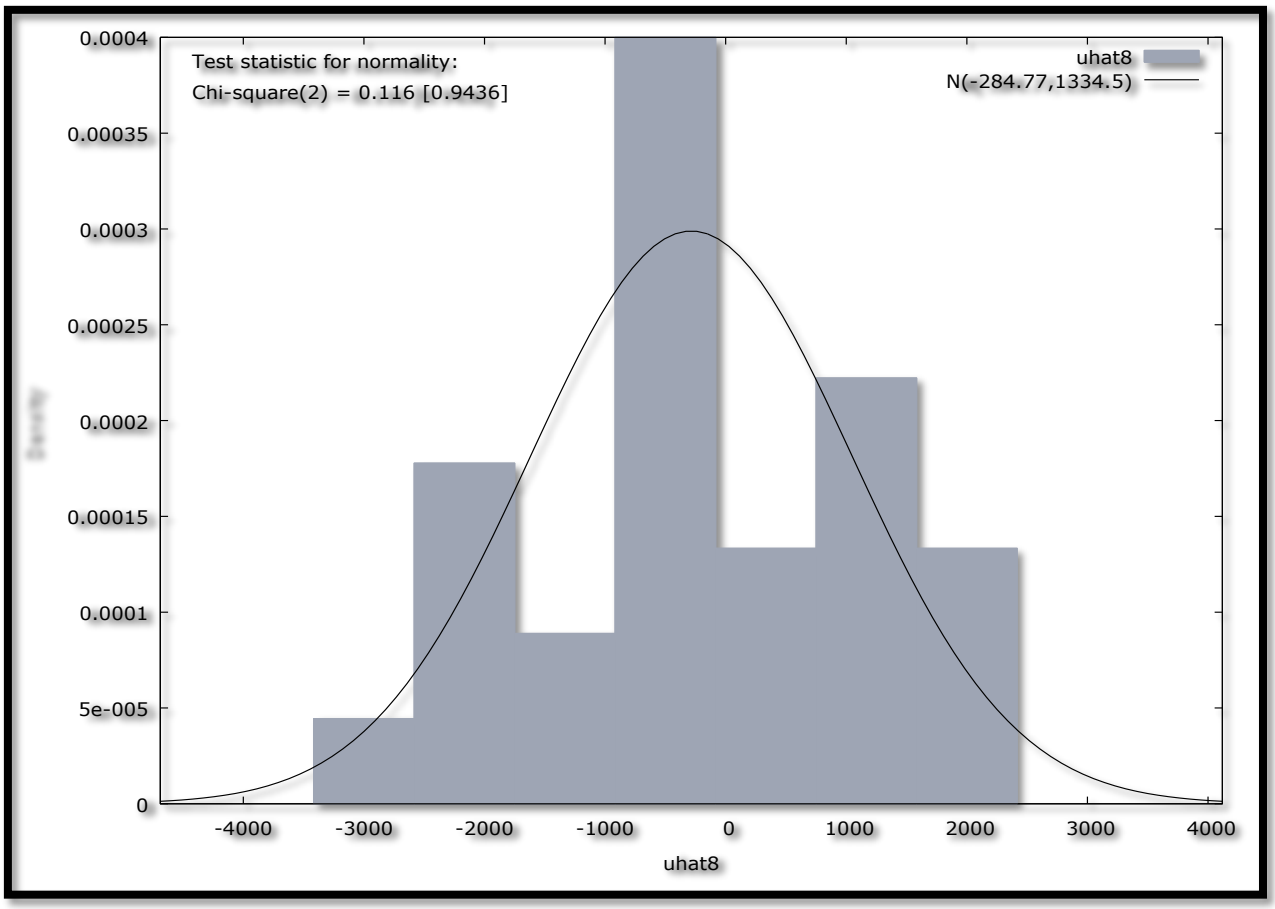

Figure 7: Normality Test

Since the probability value of the chi-square statistic is insignificant, we reject the null hypothesis and conclude that the residuals of the ARIMA (1, 2, 0) model are normally distributed.

4.0 FINDINGS OF THE STUDY

4.1 Results Presentation

Table 5: Main Results

ARIMA (1, 2, 0) Model:				
The selected optimal model, the ARIMA (1, 2, 0) model can be expressed as follows: $\Delta^2 B_t = -0.0983991\Delta^2 B_{t-1} \ldots\ldots\ldots\ldots\ldots [2]$				
Variable	Coefficient	Standard Error	z	p-value
β_1	-0.0983991	0.191447	-0.5140	0.6073

Table 9 shows the main results of the ARIMA (1, 2, 0) model.

Forecast Graph

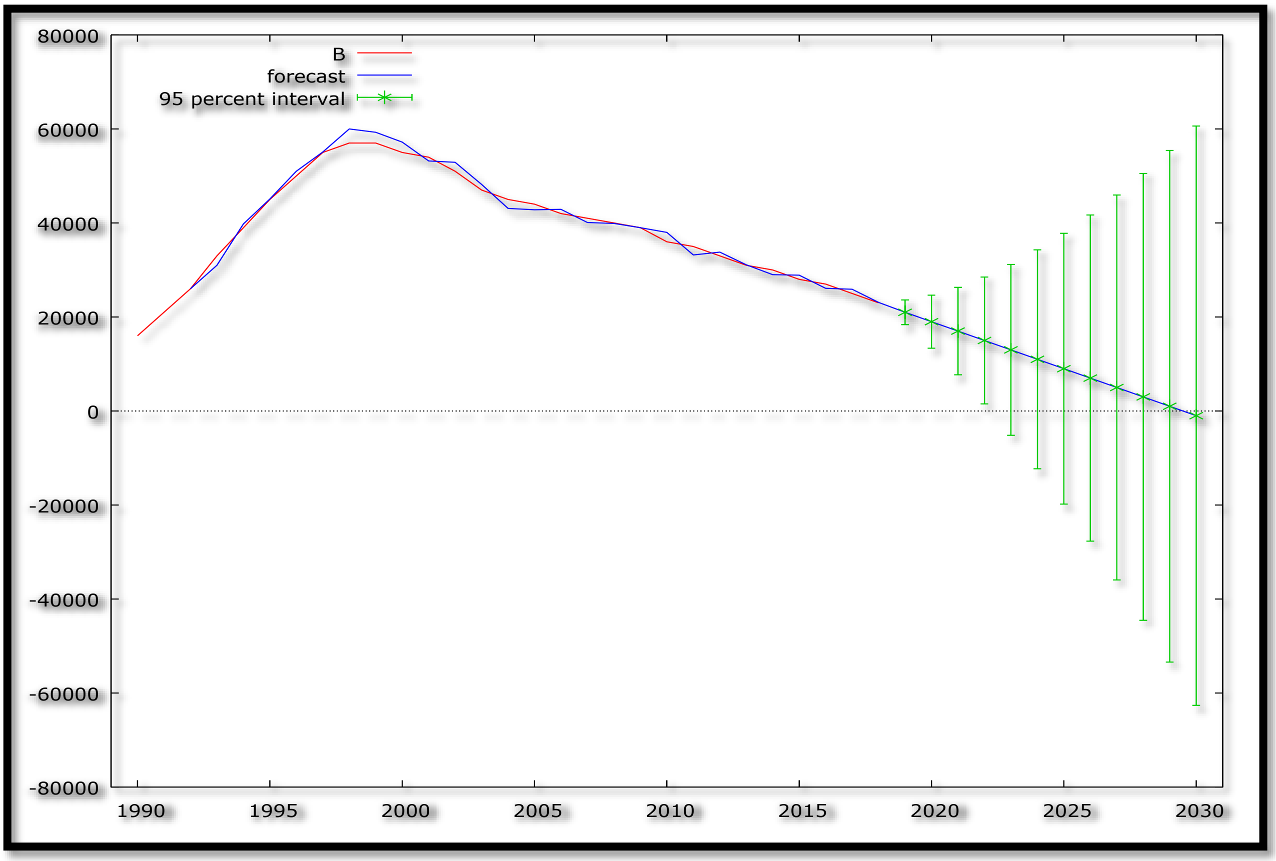

Figure 8: Forecast Graph – In & Out-of-Sample Forecasts

Figure 8 shows the in-and-out-of-sample forecasts of the B series. The out-of-sample forecasts cover the period 2019 – 2030.

Predicted B– Out-of-Sample Forecasts Only

Table 6: Predicted B

Year	Predicted B	Standard Error	95% Confidence Interval
2019	21000.0	1340.13	(18373.4, 23626.6)
2020	19000.0	2879.28	(13356.7, 24643.3)
2021	17000.0	4743.45	(7703.01, 26297.0)
2022	15000.0	6884.49	(1506.64, 28493.4)
2023	13000.0	9271.26	(-5171.33, 31171.3)
2024	11000.0	11881.0	(-12286.3, 34286.3)
2025	9000.00	14696.1	(-19803.9, 37803.9)
2026	7000.00	17702.9	(-27697.0, 41697.0)
2027	5000.00	20889.7	(-35943.0, 45943.0)
2028	3000.00	24247.0	(-44523.2, 50523.2)
2029	1000.00	27766.5	(-53421.4, 55421.4)
2030	-1000.00	31441.2	(-62623.6, 60623.6)

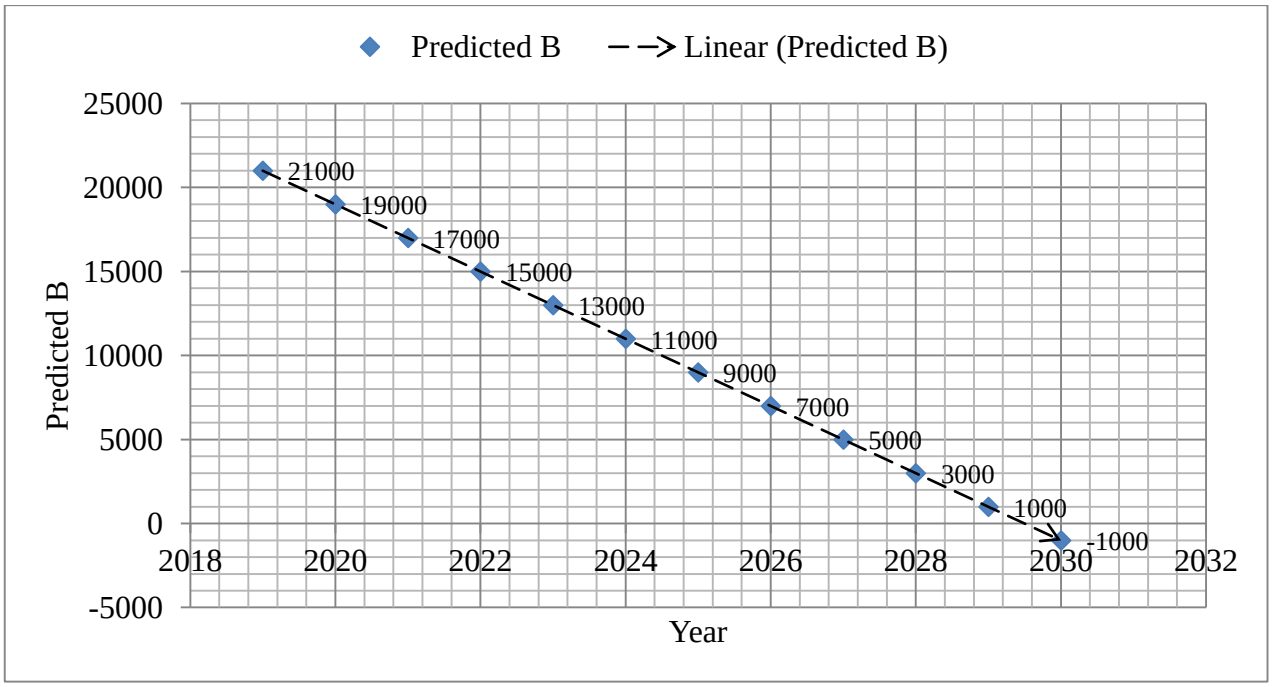

Figure 9: Graphical Analysis of Out-of-Sample Forecasts

Table 6 and figure 9 show the out-of-sample forecasts only. The total number of new HIV infections in Cameroon is projected to decline sharply over the out-of-sample period.

5.0 CONCLUSION

The study shows that the ARIMA (1, 2, 0) model is not only stable but also the most suitable model to forecast the annual total number of new HIV infections in Cameroon over the

period 2019 – 2030. The model predicts a commendable decrease in the annual total number new HIV infections in the country. This study, in line with the argument made by Nsagha et al. (2012); essentially shows that the HIV/AIDS epidemic is under control in Cameroon. However, we still recommend that the Cameroon government should continue strengthening its national AIDS response strategy, with special emphasis mainly directed towards behavior change interventions such as increased condom use as well as reduction of sexual partners.

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