NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 6, ISSUE 11, Nov. -2020

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

DR. SMARTSON. P. NYONI
ZICHIRe Project, University of Zimbabwe, Harare, Zimbabwe

MR. THABANI NYONI
Department of Economics, University of Zimbabwe, Harare, Zimbabwe

ABSTRACT:

Using annual time series data on the total number of new HIV infections in Thailand from 1990 – 2018, the study makes predictions for the period 2019 – 2030. The study applies the Box-Jenkins ARIMA methodology. The diagnostic ADF tests show that, F, the series under consideration is an I (0) variable. Based on the AIC, the study presents the optimal model; the ARIMA (3, 0, 0) model, which is equivalent to an AR (3) process. The residual correlogram further reveals that the presented model is not only adequate but also stable and its residuals are not serially correlated. The results of the study indicate that the total number of new HIV infections in Thailand is likely to continue to decline over the out-of-sample period. However, the country's ambition to end AIDS by 2030 (Thai National AIDS Committee, 2014), will not be achieved; given that the pace of the decline in new HIV infections has also slowed over the years.

INTRODUCTION:

Thailand was one of the most severely affected countries during early stage of the HIV/AIDS pandemic (Saengdidtha et al., 2012). The first HIV/AIDS patient was reported in 1984 (Limsuwan et al., 1986) and epidemic HIV infections were first recognized in 1988, but increased dramatically in the 1990s, mainly as a result of sexual transmission (Weniger et al., 1991). The course of HIV epidemic has been decreased dramatically since its peak in the 1990s. In 1990 alone 140000 new HIV infections were reported. The actual peak was experienced in 1991, when the country recorded 160000 new HIV infections (Nelson et al., 1996). Since then, new HIV infections have followed a downwards trajectory up to as low as 17000 new HIV infections by 2009. The success of Thailand's HIV control has been internationally recognized (Park et al., 2010). The numbers of new HIV infections in the country continue to decline over time (Thai National AIDS Committee, 2014), with the latest data indicating that in 2018, only 6400 new infections were reported. The main goal of this study is to predict the number of new HIV infections in Thailand over the period 2019 – 2030. This paper will go a long way in assessing the possibility of ending the HIV scourge in Thailand by 2030.

LITERATURE REVIEW:

In an Asian study, Khan et al. (2017) explored the association between knowledge about HIV and discriminatory attitudes towards people living with HIV in Pakistan. The authors found a statistically significant inverse relationship between knowledge about HIV and discriminatory attitudes towards people living with HIV. More recently and in an African study, El Fadl et al. (2019) carried out a cross-sectional study to assess the level of HIV-related knowledge among undergraduate dental students at Ain Shams University (ASU) in Cairo, Egypt, and to determine their attitudes toward treating HIV-positive patients. The study found out that within the students' population, almost 94% incorrectly considered dentists to be at high risk of acquiring HIV infection and 47% believed that saliva is a vehicle for its transmission. The research concluded that dental students were not adequately prepared to recognize and manage HIV-positive individuals. Analyzing the uses of epidemiologic and public health approaches for HIV/AIDS control among young men in the Royal Thai Army (RTA) and Thailand, Saengdidtha et al. (2012), in their review article, concluded that factors that contributed to the success of the RTA's operations include the strong organizational infrastructure and management, the relevant strategies and measures, the determination for long-term commitment and total mobilization of resources and multi-sectoral coordination. No similar study has been done in Thailand. Hence, the need for this piece of work.

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, F, the series under consideration.

3.2 The Applied Box – Jenkins ARIMA Model Specification:

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

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

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

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 F] in Thailand. 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 The ADF Test in Levels:

Table 1: with intercept

Variable	ADF Statistic	Probability	Critical Values		Conclusion
F	-4.916514	0.0008	-3.769597	@1%	Stationary
			-3.004861	@5%	Stationary
			-2.642242	@10%	Stationary

Table 1 shows that F is stationary in levels.

3.4.2 Evaluation of ARIMA models (without a constant):

Table 2: Evaluation of ARIMA Models (without a constant)

Model	AIC	U	ME	RMSE	MAPE
ARIMA (1, 0, 0)	623.9787	0.962	463.24	27660	15.238
ARIMA (0, 0, 1)	693.3284	3.8544	25794	40690	51.67
ARIMA (2, 0, 0)	603.0316	0.59517	6221.9	26932	0.59517
ARIMA (3, 0, 0)	**591.5625**	0.54741	5080.9	26861	8.7747
ARIMA (4, 0, 0)	592.8651	0.54426	4987	26830	8.4598

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 (3, 0, 0) model, tantamount to an AR (3) process; is finally chosen.

3.5 Residual & Stability Tests:
3.5.1 Correlogram of the Residuals of the ARIMA (3, 0, 0) Model:

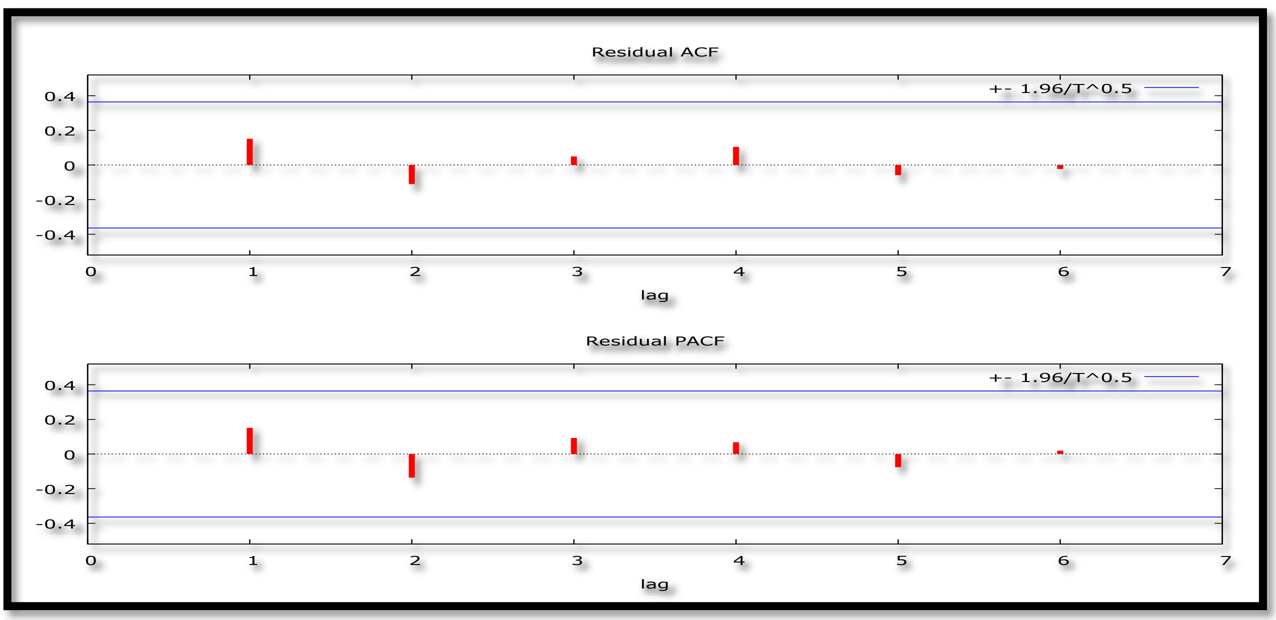

Figure 1: Correlogram of the Residuals

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Figure 1 indicates that the estimated model is adequate and stable since ACF and PACF lags are quite short and within the bands.

FINDINGS OF THE STUDY:

4.1 Results Presentation:

Table 3: Main Results

ARIMA (3, 0, 0) Model:

The chosen optimal model, the ARIMA (3, 0, 0) model can be expressed as follows:

$$F_t = 2.50386F_{t-1} - 2.33071F_{t-2} + 0.812148F_{t-3} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{[2]}$$

Variable	Coefficient	Standard Error	z	p-value
β_1	2.50386	0.209477	11.95	0.0000***
β_2	-2.33071	0.338418	-6.887	0.0000***
β_3	0.812148	0.150660	5.391	0.0000***

Table 9 shows the main results of the ARIMA (3, 0, 0) model.

Forecast Graph

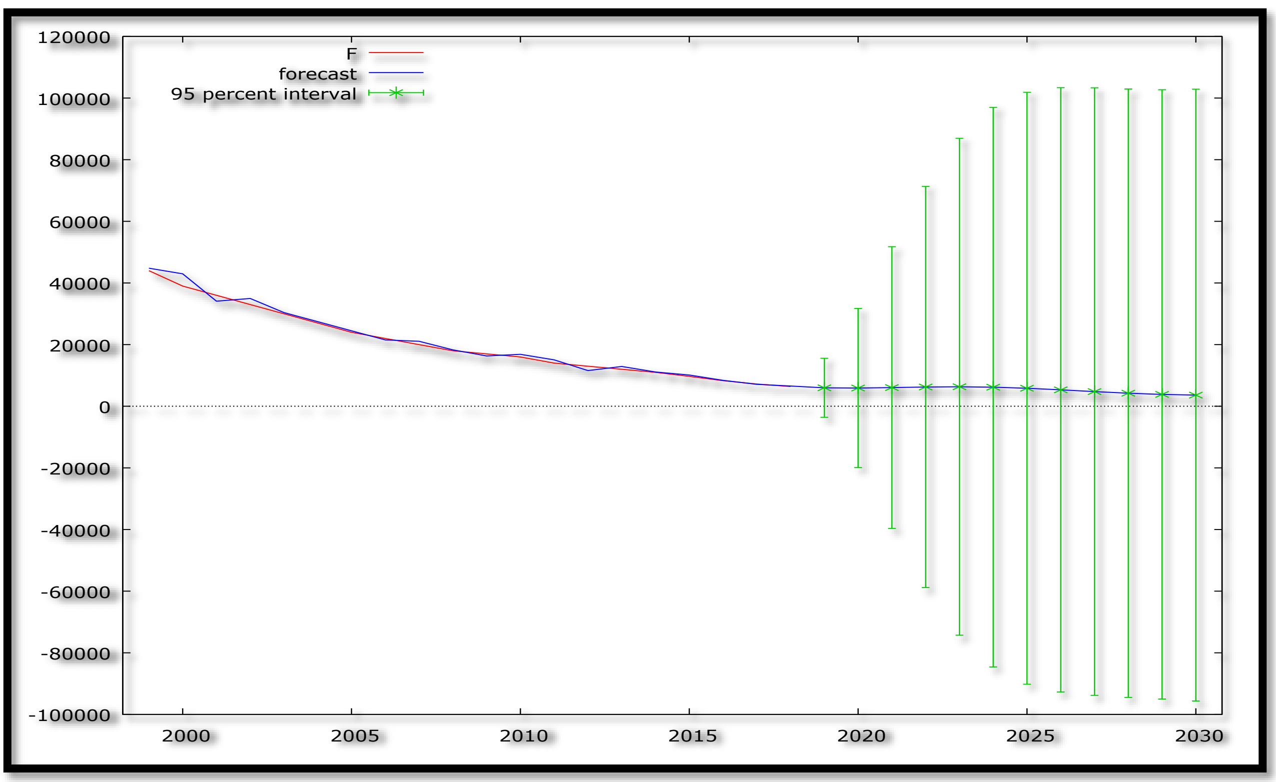

Figure 2: Forecast Graph – In & Out-of-Sample Forecasts

Figure 2 shows the in-and-out-of-sample forecasts of the F series. The out-of-sample forecasts cover the period 2019 – 2030.

Predicted F– Out-of-Sample Forecasts Only

Table 4: Predicted F

Year	Predicted F	Standard Error	95% Confidence Interval
2019	5984.37	4885.64	(-3591.32, 15560.1)
2020	5914.89	13172.5	(-19902.7, 31732.5)
2021	6059.94	23319.3	(-39645.1, 51764.9)
2022	6247.48	33203.8	(-58830.8, 71325.7)
2023	6322.59	41127.9	(-74286.5, 86931.7)
2024	6191.32	46318.2	(-84590.6, 96973.3)
2025	5839.91	48995.4	(-90189.4, 101869.)
2026	5326.98	50016.3	(-92703.1, 103357.)
2027	4755.10	50290.3	(-93812.1, 103322.)
2028	4233.29	50361.2	(-94472.8, 102939.)
2029	3843.07	50429.8	(-94997.5, 102684.)
2030	3617.74	50641.0	(-95636.7, 102872.)

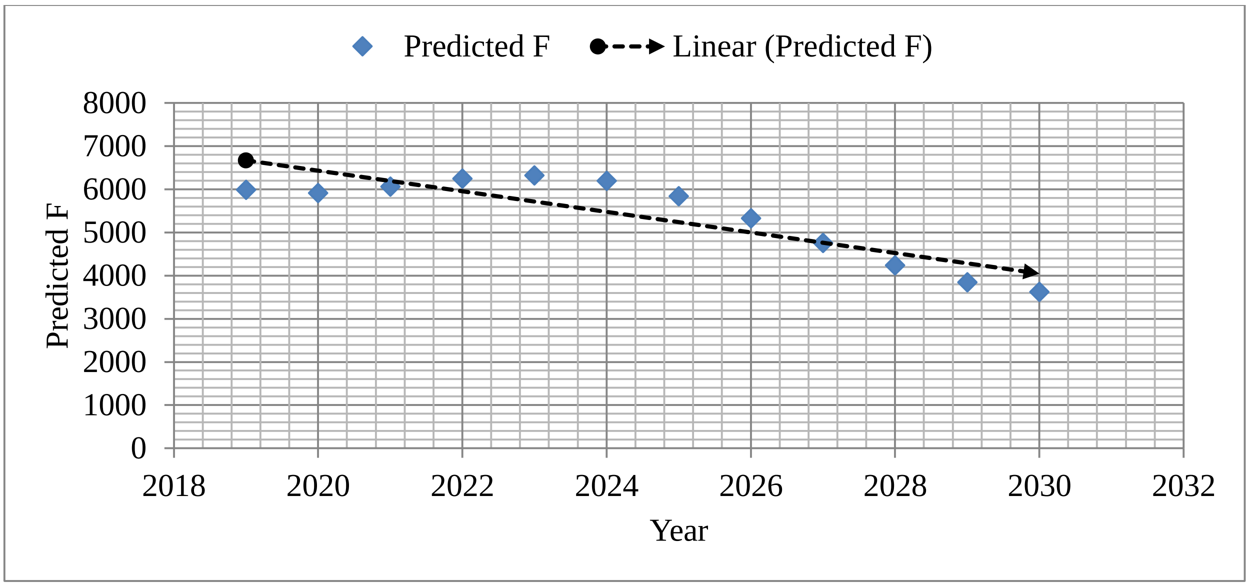

Figure 3: Graphical Analysis of Out-of-Sample Forecasts

Table 4 and figure 3 show the out-of-sample forecasts only. The total number of new HIV infections in Thailand is projected to continue declining from around 5984 new infections in 2019 to almost 3618 new infections by 2030. This is indeed not surprising given the success of the Thai HIV/AIDS control programs (Nelson et al., 1996; Park et al., 2010). The results of the study are in line with the argument made by Saengdidtha et al. (2012) that new HIV infections are bound to go down given the country's multi-sectoral approach that has drawn upon the country's manpower, funds, equipment, knowledge, expertise and national will. However, the results of the study cast a doubt on the country's ambition to end AIDS by 2030 (Thai National AIDS Committee, 2014).

CONCLUSION:

The study shows that the ARIMA (3, 0, 0) model is not only stable but also the most suitable model to forecast the total annual number of new HIV infections in Thailand over the period 2019 – 2030. The model predicts a commendable decrease in the annual number of new HIV infections in the country. This implies that the HIV/AIDS epidemic is under reasonable control in Thailand. However, we still recommend that the Thai government should continue strengthening its national AIDS response strategy. Particular emphasis ought to be directed towards behavior change interventions such as increased condom use as well as reduction of sexual partners. Massive health education must continue indefinitely in the country.

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