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USING ARTIFICIAL NEURAL NETWORKS FOR PREDICTING ABORTION CASES IN CHITUNGWIZA URBAN DISTRICT IN ZIMBABWE

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ABSTRACT
Abortion is an ancient and worldwide practice. Laws on abortion around the globe vary; in some countries, it is available to women upon request, while in others it is completely outlawed. In fact the liberalization of abortion is the subject of not only intense but also sensitive controversy, and once established, it is frequently challenged. Some defend access to abortion as a basic human right, a woman's right, a sexual and reproductive right, and a right to health in light of the consequences of illegal abortions, while on the other side of the same coin; others seriously condemn it in the name of the embryo's right to life. The current study used monthly time series data on abortion caseloads for Chitungwiza urban district from Janaury 2012 to December 2018, to predict abortion cases over the period January 2019 to December 2021. We applied the famous ANN (12, 12, 1) model. Residual analysis of the applied model indicates that the model is stable and acceptable. The results of the study reveal that abortion cases may generally be on an upwards trajectory in Chitungwiza urban district over the out-of-sample period. The study encourages the responsible public health authorities in Chitungwiza urban district to increase access to and improve post-abortion care in order to reduce maternal mortality.

INTRODUCTION
In Zimbabwe, abortion is highly restricted and limited to circumstances of saving the woman's health or in cases of rape, incest or fetal impairment per the 1977 Termination of Pregnancy Act (Parliament of Zimbabwe, 1977). In practice, it is extremely difficult to obtain a legal abortion, most abortions are clandestine and potentially unsafe (UZCHS-CTRC, 2019). Even access to legal abortion under these circumstances is difficult given abortion stigma among both women and providers as well as legal and administrative barriers (Maternowska et al., 2014; Chiweshe et al., 2017). Abortion rates in Zimbabwe stand at 17 abortions per 1000 women of reproductive age. This is basically of the lowest abortion rates in Africa and is largely attributed to high rates of contraceptive use (Sully et al., 2018). Most abortions in the country are indeed deemed unsafe. Among Zimbabwean women experiencing abortion complications, 40% are classified as having moderate to severe complications (Madziyire et al., 2018). Complications from abortion account for at least 5.8% of maternal deaths, making it one of the top five causes (Munjanja et al., 2007). Therefore, it is helpful to model and forecast abortion cases in order to understand abortion dynamics as well as the consequent need for post-abortion care.

OBJECTIVES OF THE STUDY
i. To assess new abortion cases in Chitungwiza urban district over the period January 2012 to December 2018.
ii. To predict abortion cases for Chitungwiza urban district over the period January 2019 to December 2020.
iii. To determine whether abortion cases are increasing or decreasing for Chitungwiza urban district over the out of sample period.

RELATED STUDIES
Sully et al. (2018) estimated the national incidence of induced abortion in Zimbabwe. The study applied the Abortions Incidence Complications Method (AICM) and found out that national incidence of induced was approximately 17.8%. In a Health Facility Survey (HFS), Madziyire et al. (2019) examined the knowledge of abortion laws and attitudes towards abortion in the country and established that amongst health care

providers and experts, 31% and 50% respectively, were misinformed about one or more legal criteria. In a recent paper, Riley et al. (2020) estimated age-specific abortion incidence and unintended pregnancy in Zimbabwe based on a variant of the AICM approach, the indirect estimation methodology. The findings of the study indicated that adolescent women aged 15-19 years had the lowest abortion rate at 5 abortions per 1000 women aged 15-19 years compared with other age groups. Studies on forecasting abortion cases volumes are scanty in the country and therefore, it is this information gap that we seek to fill by predicting abortion cases for Chitungwiza urban district.

METHODOLOGY

The study applies the Artificial Neural Network (ANN) approach in modeling and forecasting monthly abortion cases in Chitungwiza Urban District. Guided by Fischer & Gopal (1994), who averred that no strict rules exist for the determination of the ANN structure; the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function.

Data Issues

This study is based on monthly abortion cases [for women aged 16 – 49] (reffered to as B series in this study) in children under 5 years of age at GDH. The data covers the period January 2012 to December 2018 while the out-of-sample forecast covers the period January 2019 to December 2021. All the data employed in this paper was gathered from the DHIS2 system for Chitungwiza urban district.

FINDINGS OF THE STUDY

DESCRIPTIVE STATISTICS

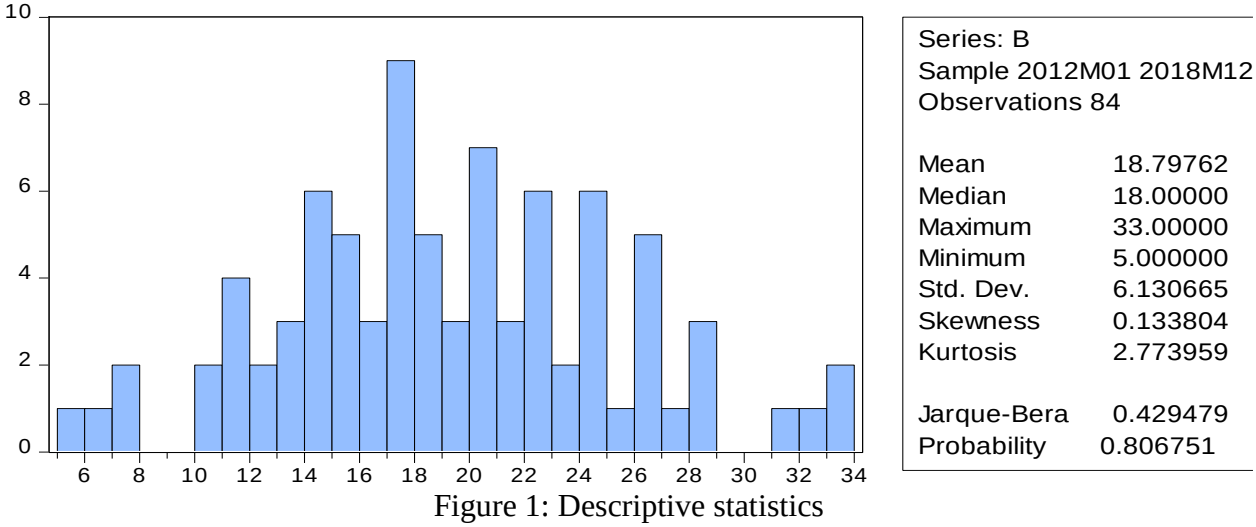

Figure 1: Descriptive statistics

ANN Model Summary

Table 1: ANN model summary

Variable	B
Observations	72 (After Adjusting Endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning:	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.031536
MSE	0.240648
MAE	0.464517

Residual Analysis

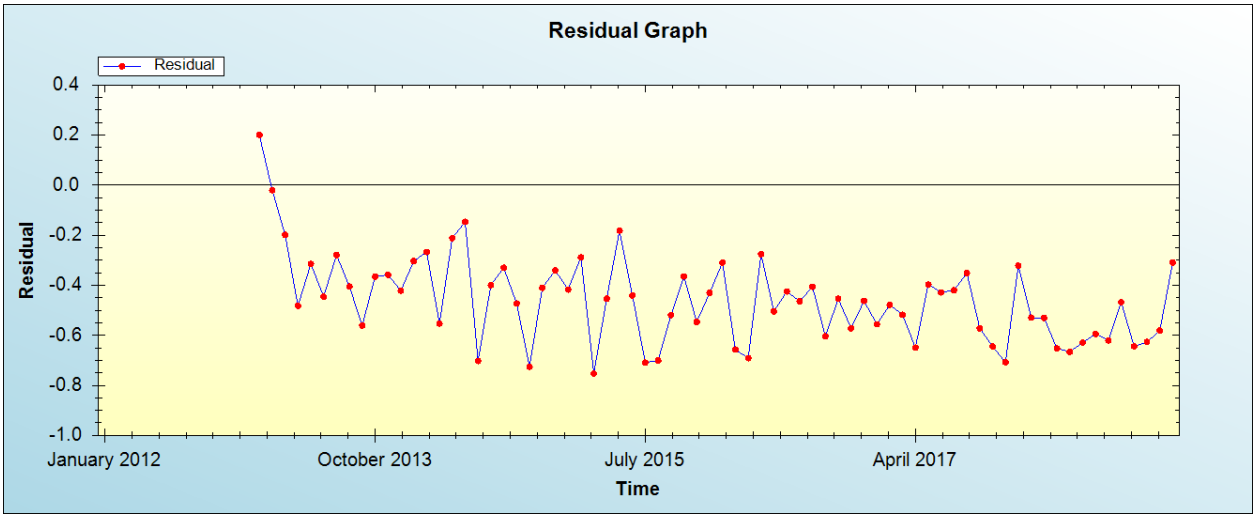

Figure 2: Residual analysis

In-sample Forecast for B

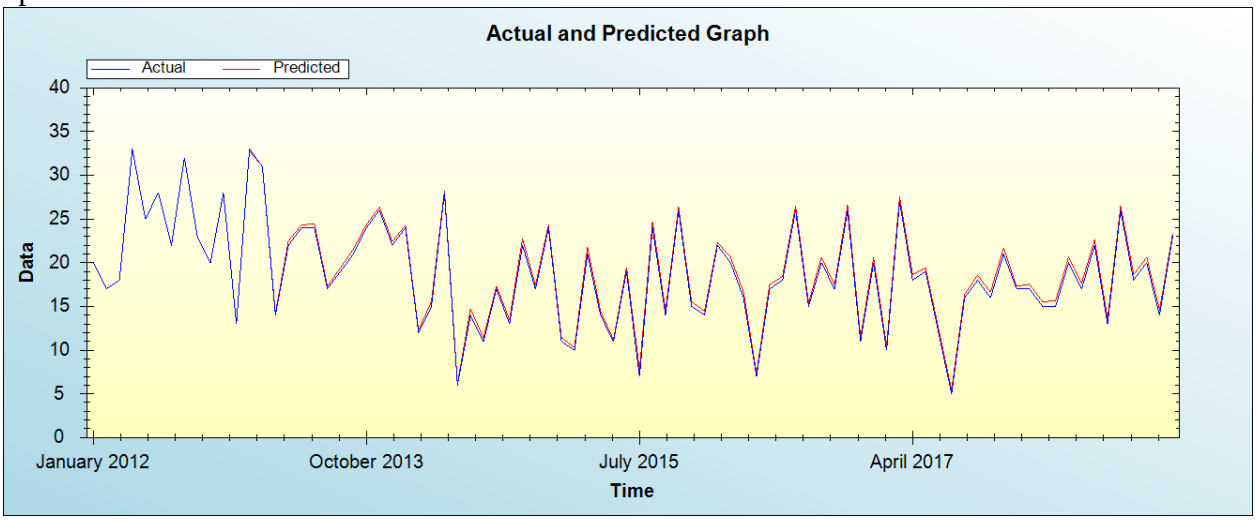

Figure 3: In-sample forecast for the B series

Out-of-Sample Forecast for B: Actual and Forecasted Graph

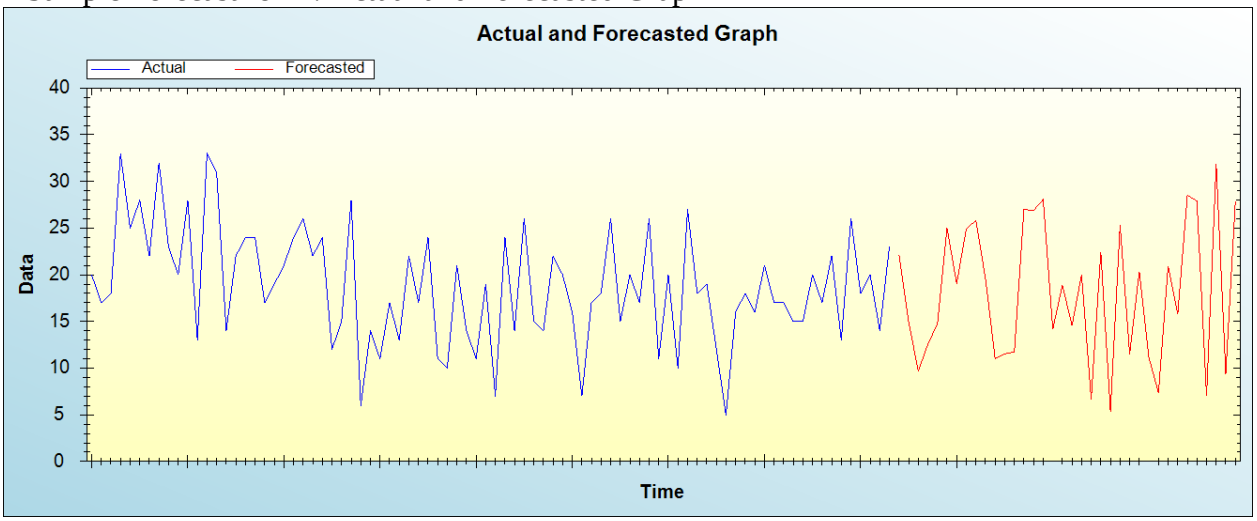

Figure 4: Out-of-sample forecast for B: actual and forecasted graph

Out-of-Sample Forecast for B: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Month-Year	Predicted B
January 2019	22.1505
February 2019	15.0136
March 2019	9.6734
April 2019	12.5401
May 2019	14.7705
June 2019	25.0042
July 2019	19.0571
August 2019	24.9173
September 2019	25.8105
October 2019	19.5596
November 2019	10.9922
December 2019	11.5283
January 2020	11.7354
February 2020	27.0010
March 2020	26.8807
April 2020	28.0690
May 2020	14.1564
June 2020	18.8934
July 2020	14.5599
August 2020	20.0100
September 2020	6.6944
October 2020	22.3916
November 2020	5.3804
December 2020	25.3398
January 2021	11.4977
February 2021	20.3304
March 2021	11.1110
April 2021	7.3412
May 2021	20.9149
June 2021	15.7970
July 2021	28.5115
August 2021	27.8961
September 2021	7.0314
October 2021	31.8971
November 2021	9.3833
December 2021	27.8501

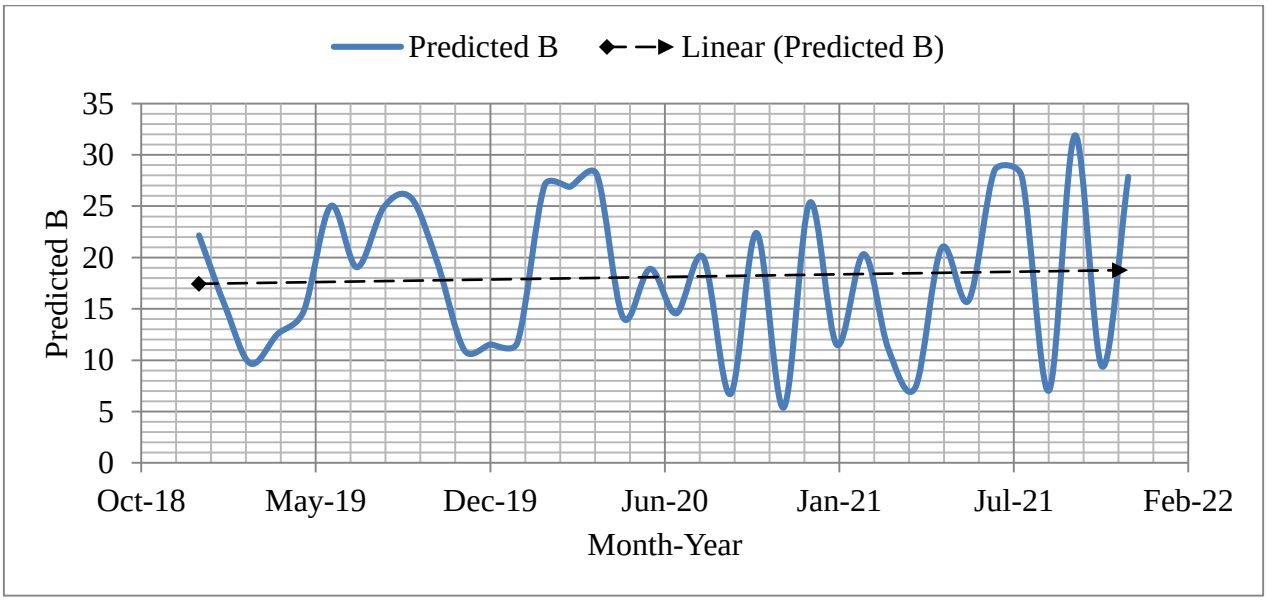

Figure 5: Graphical presentation of out-of-sample forecasts

DISCUSSION OF THE RESULTS

Table 1 is the ANN model summary and shows the ANN (12, 12, 1) neural network model, which has been based on the hyperbolic tangent function as its activation function. Figure 1 shows the descriptive statistics of the series under consideration. Interesting to note is the fact that the series is normally distributed as shown by the kurtosis and JB statistics. We can also see that over the study period, an average of approximately 19 abortion cases per month have been recorded for Chitungwiza urban district. The "criteria" are the evaluation statistics and they all indicate the model is adequate and acceptable. Figure 2 shows the residuals of the model and since the residuals are as close to zero as possible, the model is quite stable and acceptable for generating abortion case volume forecasts for Chitungwiza urban district. Figure 3 shows the in-sample forecast of the model and it can be deduced that the model fits well with data. Figure 4, table 2 and figure 5 are out of sample forecasts. The results of the study indicate that abortion cases are likely to rise (but slightly) over the out-of-sample period.

CONCLUSION & RECOMMENDATIONS

The social and political sensitivity surrounding abortions in Zimbabwe make it very difficult to conduct high-quality research to model and forecast its case volumes. This is very true given that abortion is highly restricted in the country. One of the main difficulties in carrying out research on abortion in Zimbabwe is underreporting largely driven by strong stigma against abortion. In this piece of work, we applied an ANN model to estimate monthly abortion cases as well as forecasting their future trend. Using monthly data over the period Janaury 2012 to December 2018, the study accurately predicted monthly abortion case volumes over the out-of-sample period. The study suggests that the responsible public health authorities in Chitungwiza urban district ought to increase access to and improve post-abortion care in order to reduce maternal mortality.

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