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Analyzing Expected Future Trends of Annual Neonatal Mortality Rate for Mexico Using Forecast Values Produced By the ARIMA Model

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***Abstract* - This study uses annual time series data on neonatal mortality rate (NMR) for Mexico from 1960 to 2019 to predict future trends of NMR over the period 2020 to 2030. Unit root tests have shown that the series under consideration is an I (1) variable. The optimal model based on AIC is the ARIMA (5,1,4) model. The findings of this piece of work showed that neonatal mortality is anticipated to decline from approximately 8 in 2020 to around 5 deaths per 1000 live births by the end of 2030. Hence, the Mexican government should draft and implement locally designed policies that will help tackle various causes of neonatal mortality in the country.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

Neonatal mortality rate is defined as the probability of dying before 28days of age per 1000 live births (Binns *et al.* 2015; WHO, 2013). Deaths of newborns during the first month life remains a global challenge especially in Low and middle income countries (Nakimuli *et al*. 2015). Worldwide approximately 2.4 million neonates died in 2019 with a daily death toll of 6700 (UNICEF, 2020). It is important to highlight that the majority of neonatal deaths are preventable. Therefore effective interventions can be implemented during antenatal care, delivery and postnatal periods (Hug *et al*. 2019). The objective of this study is to model and project future trends of neonatal mortality rate (NMR) for Mexico using the popular Box-Jenkins ARIMA model. The linear time series nature of the data set being used calls for the use of statistical models such as the ARIMA (p, d, q) model for the data analysis (Nyoni, 2018; Box & Jenkins, 1970). We expect that forecast results are going to assist in tracking abnormal trends of NMR and facilitate implementation of neonatal strategies that are effective in controlling mortality in neonates.

II. LITERATURE REVIEW

Baroni *et al.* (2021) outlined an integrated dataset containing monthly data in a historical series from 1996 to 2017 with information on all births, neonatal deaths, and NMR (total, early and late components) enriched with information related to the municipality. It is a dataset of historical data with information on the number of births, the number of neonatal deaths, the neonatal mortality rate (including early and late), and geographic information for each month (between January 1996 and December 2017) and Brazilian municipality. Schuurmans *et al.* (2021)conducted a retrospective cohort study in Haiti to determine the prevalence of maternal death, stillbirth and low birth weight in women with (pre-) eclampsia and complicated pregnancies or deliveries in Centre de Références des Urgences Obstétricales, an obstetric emergency hospital in Port-au-Prince, Haiti, and identified the main risk factors for these adverse pregnancy outcomes. The study included pregnant women admitted to Centre de Référence des Urgences Obstétricales between 2013 and 2018 using hospital records. Risk factors investigated were age group, type of pregnancy (singleton, multiple), type of delivery and use of antenatal care services. The findings showed that of all admissions, 10 991 (34.9%) were women with (pre-) eclampsia and the main predictors of adverse pregnancy outcomes were not attending antenatal care, low birth weight and caesarian section in patients with complicated pregnancy. Raymondville *et al.* (2020) conducted a convergent, mixed methods study to assess barriers and facilitators to facility based childbirth at Hôpital Universitaire de Mirebalais (HUM) in Mirebalais, Haiti. A secondary analyses of a prospective cohort of pregnant women seeking antenatal care at HUM was performed and quantitatively assessed predictors of not having a facility-based childbirth at HUM. The study also prospectively enrolled 30 pregnant women and interviewed them about their experiences delivering at home or at HUM. It was found that living further from the hospital, poverty and household hunger were associated with not having a facility-based childbirth. Primigravid women were more likely to have a facility-based childbirth.The probit model was applied by a Lambon-Quayefio & Owoo (2018) to investigate the factors that affect neonatal deaths as well as examine the effect of the Ghana Health

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Insurance on neonatal deaths in Ghana using the most recent round of the Ghana Demographic and Health Survey. The study findings suggested significant regional differences in neonatal deaths and that the national health insurance may have the potential to substantially improve the health outcomes of neonates and have policy implications for increasing coverage to more mothers and their neonates, as well as coverage in critical neonatal services and drugs.

III. METHODOLOGY

The Box – Jenkins Approach

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). The Box – Jenkins technique was proposed by Box & Jenkins (1970) and is widely used in many forecasting contexts.

Data Issues

This study is based on annual NMR in Mexico for the period 1960 to 2019. The out-of-sample forecast covers the period 2020 to 2030. All the data employed in this research paper was gathered from the World Bank online database.

Evaluation of ARIMA Models

Criteria Table

Table 2: Criteria Table

Model Selection Criteria Table
Dependent Variable: DLOG(M)
Date: 01/23/22 Time: 18:02
Sample: 1960 2019
Included observations: 59

Model	LogL	AIC*	BIC	HQ
(5,4)(0,0)	216.559339	-6.968113	-6.580776	-6.816912
(5,5)(0,0)	216.608576	-6.935884	-6.513334	-6.770938
(4,3)(0,0)	213.360519	-6.927475	-6.610563	-6.803765
(5,3)(0,0)	214.073871	-6.917758	-6.565633	-6.780303
(4,4)(0,0)	213.878332	-6.911130	-6.559005	-6.773675
(4,0)(0,0)	209.330025	-6.892543	-6.681268	-6.810070
(3,1)(0,0)	209.157321	-6.886689	-6.675414	-6.804216
(4,5)(0,0)	214.153314	-6.886553	-6.499216	-6.735352
(3,3)(0,0)	210.981317	-6.880723	-6.599023	-6.770758
(3,5)(0,0)	212.626595	-6.868698	-6.516573	-6.731243
(4,1)(0,0)	209.543504	-6.865881	-6.619394	-6.769663
(5,0)(0,0)	209.520406	-6.865098	-6.618611	-6.768880
(3,2)(0,0)	209.324227	-6.858448	-6.611961	-6.762230
(4,2)(0,0)	210.318199	-6.858244	-6.576544	-6.748280
(2,4)(0,0)	210.055996	-6.849356	-6.567656	-6.739392
(2,2)(0,0)	207.694321	-6.837096	-6.625821	-6.754622
(5,2)(0,0)	210.668824	-6.836231	-6.519319	-6.712522

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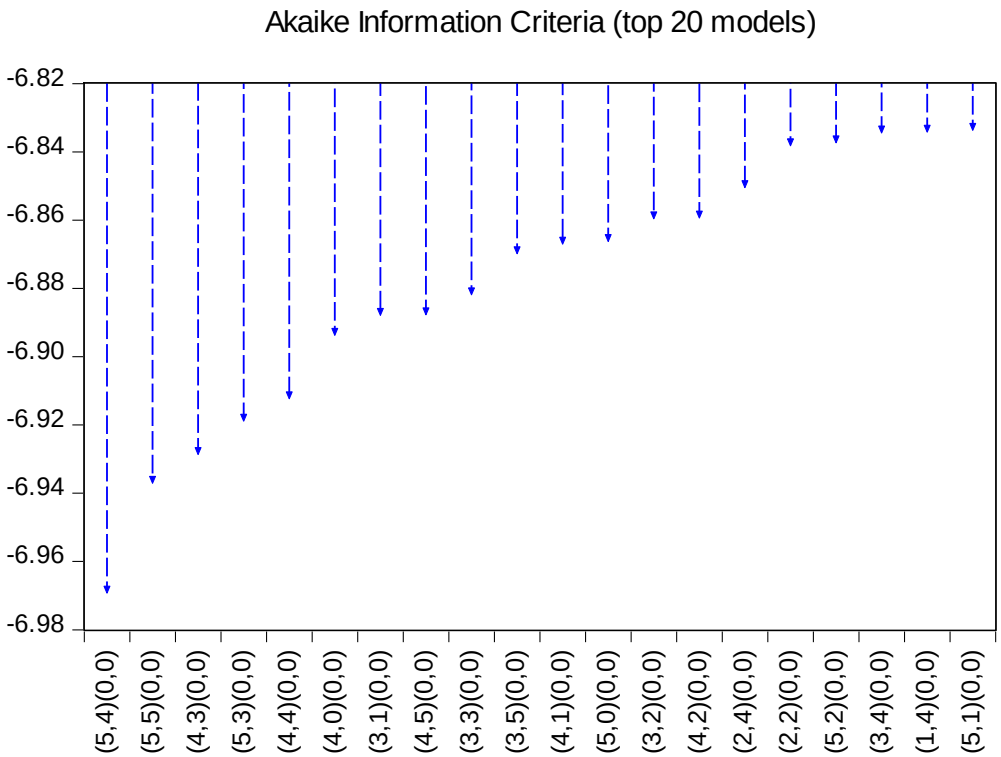
(3,4)(0,0)	210.582689	-6.833311	-6.516399	-6.709602
(1,4)(0,0)	208.575641	-6.833073	-6.586585	-6.736854
(5,1)(0,0)	209.559458	-6.832524	-6.550824	-6.722560

Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

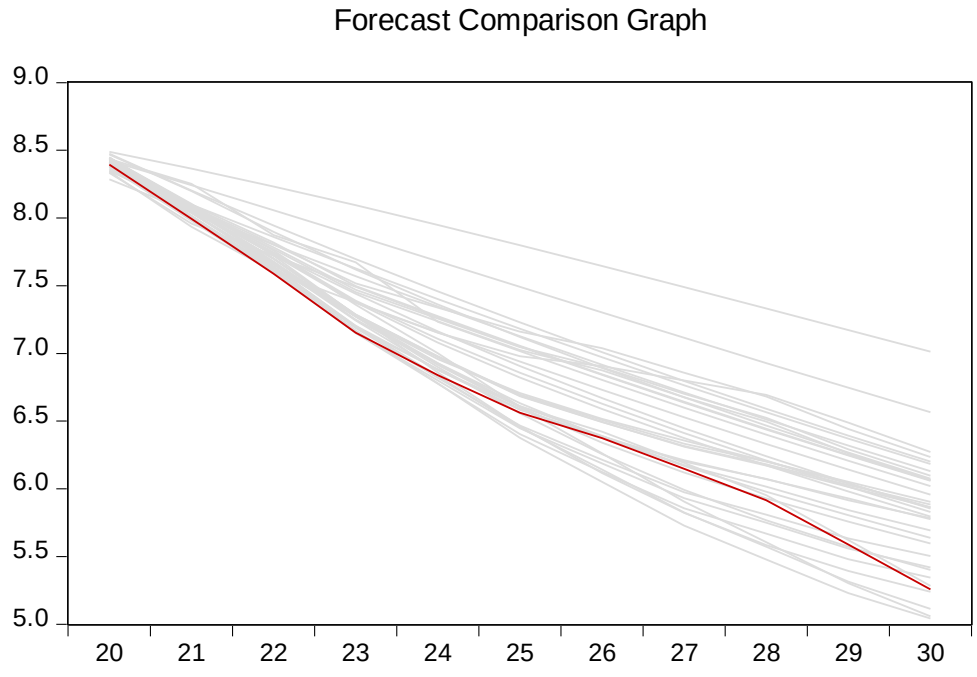


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Table 2 and Figure 1 indicate that the optimal model is the ARIMA (5,1,4) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (5,1,4) model.

IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 5: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	8.393460796483508
2021	7.994479341091866
2022	7.587361279932676
2023	7.153512021239818
2024	6.839120434465915
2025	6.562154421577314
2026	6.375100919633949
2027	6.148304734674735
2028	5.914847521745806
2029	5.58821227780179
2030	5.256322960868679

Table 2 clearly indicates that neonatal mortality is anticipated to decline from approximately 8 in 2020 to around 5 deaths per 1000 live births by the end of 2030.

V. POLICY IMPLICATION & CONCLUSION

Child mortality is a global health problem particularly in low and middle income countries. The decrease of neonatal mortality has been slower than that of under five deaths therefore special attention must be given to attending to factors that strongly influence neonatal deaths in this country. In this study we apply the ARIMA model to model and project NMR for Mexico and the findings indicate that neonatal mortality is anticipated to decline from approximately 8 in 2020 to around 5 deaths per 1000 live births by the end of 2030. Hence the Mexican government should draft and implement locally designed policies that will help tackle local causes of neonatal mortality.

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