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Neonatal Health Policy-Making in Denmark through Utilization of a Time Series Forecasting Technique

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***Abstract* - This study uses annual time series data on neonatal mortality rate (NMR) for Denmark 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 (2) variable. The optimal model based on AIC is the ARIMA (1,2,3) model. The ARIMA model predictions revealed that neonatal mortality will continue to decline and remain low throughout the forecast period. Hence, we implore policy makers in Denmark to craft neonatal policies which are suitable for their setting to address local factors that contribute to neonatal mortality.**

Keywords: ARIMA, Forecasting, NMR.

I. INTRODUCTION

The death of a newborn between the time of birth and 28 days of life is known as a neonatal death (Ezeh *et al*.2014; Rajaratnam*et al*. 2010). Neonatal mortality is a huge public health problem with low and middle income countries having the highest burden (Lawn *et al*. 2005). There is a noticeable significant improvement in perinatal birth outcomes in the developed world with most European countries reporting around 3 deaths per 1000 live births (European perinatal health report, 2013; Eurostat, 2011). Neonatal mortality remains a health problem in Europe although there is significant progress in the reduction of neonatal deaths in the region including Denmark. In this paper we proposed the Box-Jenkins ARIMA model to model and forecast neonatal mortality rate for Denmark. The statistical/econometric model has been found to be useful in modelling linear data (Nyoni, 2018; Box & Jenkins, 1970). Forecast results are expected to detect abnormal future trends of NMRso as to inform policy, decision making and resource mobilization to effectively control neonatal mortality in Denmark.

II. LITERATURE REVIEW

In a 2021 study, Rasmussen *et al* investigated the recent figures and explored if potential differences could be explained by the well-known educational and income inequalities in stillbirth and infant death using a novel approach. Stillbirth and infant mortality varied considerably according to country of origin, with only immigrants from China, Norway, and Poland having an overall lower risk than Danish women. Women of Pakistani, Turkish, and Somali origin had a particularly high risk of both outcomes. Regression analysis was employed by Jawad *et al*. (2021) to assess the association between conflict and maternal and child health globally. Data for 181 countries (2000–2019) from the Uppsala Conflict Data Program and World Bank were analyzed using panel regression models. The study findings showed that armed conflict is associated with substantial and persistent excess maternal and child deaths globally. Wallace *et al*. (2020)investigated infant mortality among native-born children of immigrants in France for the period 2008–17. A nationally representative socio-demographic panel consisting of 296 400 births and 980 infant deaths for the period 2008–17 was used. Children of immigrants were defined as being born to at least one parent born abroad and their infant mortality was compared with that of children born to two parents born in France. Data was analyzed using multilevel logit models and the study results showed that there was a substantial amount of excess infant mortality among those children born to at least one parent from Eastern Europe, Northern Africa, Western Africa, Other Sub-Saharan Africa and the Americas, with variation among specific origin countries belonging to these groups. Zeitlin *et al*. (2020) examined the patterns of stillbirth and neonatal mortality rates in Europe between 2004 and 2010. Data about live births, stillbirths and neonatal deaths by gestational age (GA) were collected using a common protocol by the Euro-Peristat project in 2004 and 2010. The study concluded that stillbirths and neonatal deaths declined at all gestational ages in countries with both high and low levels of mortality in 2004.

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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 Denmark 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 1: Criteria Table

Model Selection Criteria Table			
Dependent Variable: DLOG(D01, 2)			
Date: 01/22/22 Time: 13:29			
Sample: 1960 2019			
Included observations: 58			
Model	LogL	AIC*	BIC
(1,3)(0,0)	156.617795	-5.193717	-4.980568
(1,4)(0,0)	156.671683	-5.161093	-4.912418
(2,3)(0,0)	156.643926	-5.160135	-4.911461
(0,3)(0,0)	154.617995	-5.159241	-4.981617
(0,4)(0,0)	155.496701	-5.155059	-4.941909
(0,5)(0,0)	156.133422	-5.142532	-4.893858
(3,3)(0,0)	156.953170	-5.136316	-4.852117
(2,4)(0,0)	156.687660	-5.127161	-4.842962
(3,2)(0,0)	155.538054	-5.122002	-4.873328
(2,2)(0,0)	154.401613	-5.117297	-4.904148
(4,3)(0,0)	157.135871	-5.108133	-4.788410
(1,2)(0,0)	152.872782	-5.099061	-4.921437
(3,5)(0,0)	157.854753	-5.098440	-4.743191
(1,5)(0,0)	155.794473	-5.096361	-4.812162
(2,5)(0,0)	156.698966	-5.093068	-4.773344
(3,4)(0,0)	156.691168	-5.092799	-4.773075
(4,2)(0,0)	155.570119	-5.088625	-4.804426
(4,4)(0,0)	157.318767	-5.079957	-4.724709
(0,2)(0,0)	150.712952	-5.059067	-4.916968
(5,2)(0,0)	155.578390	-5.054427	-4.734703

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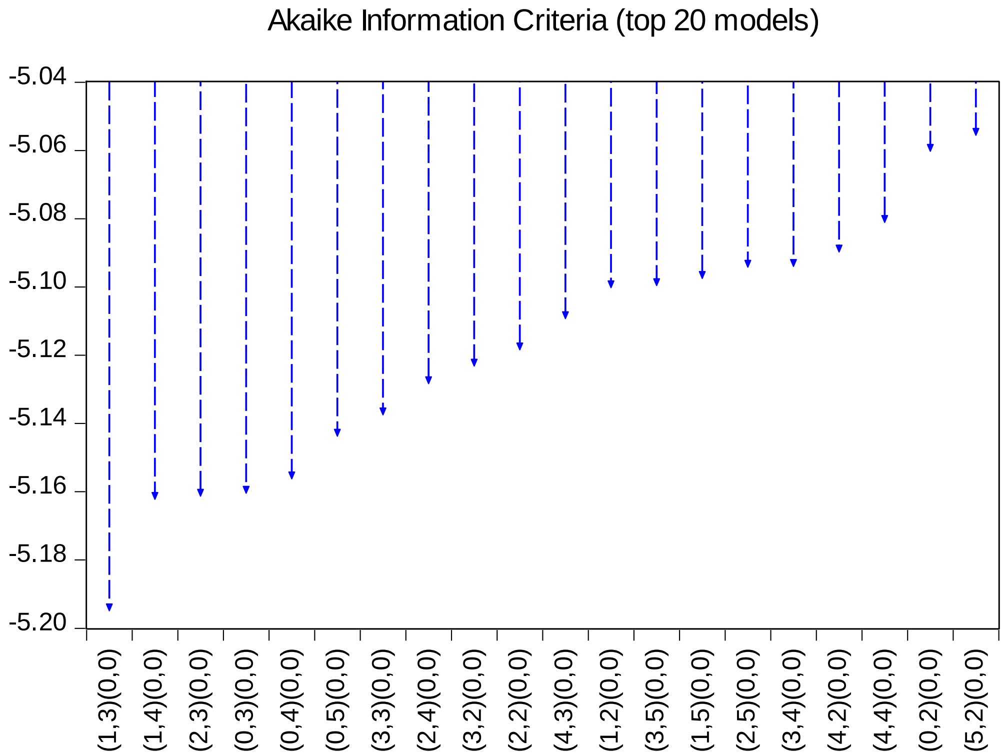
Criteria Graph

Figure 1: Criteria Graph



Forecast Comparison Graph

Figure 2: Forecast Comparison Graph

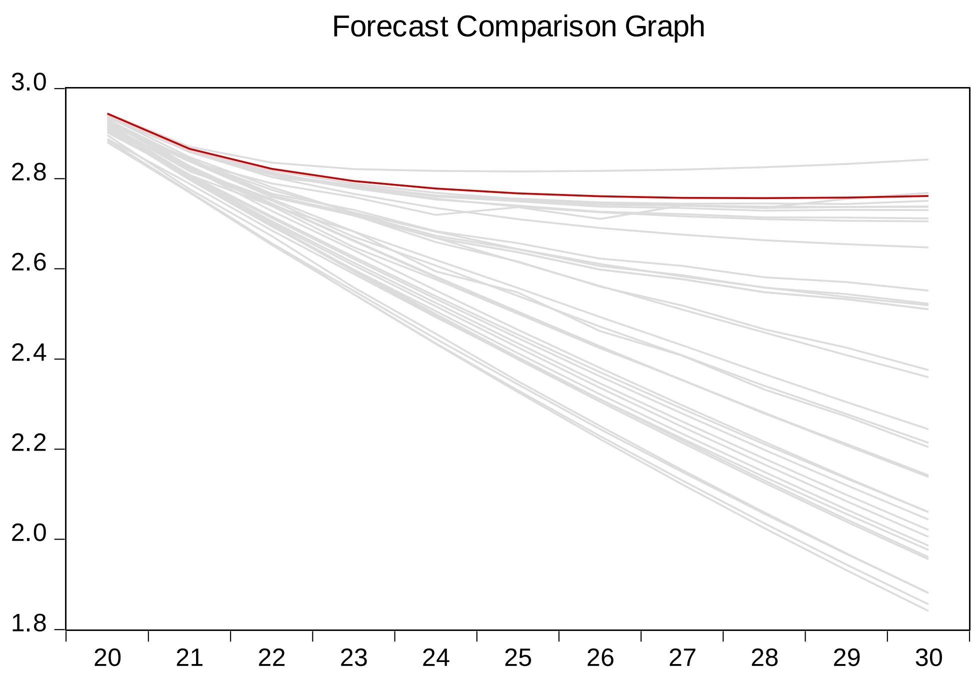


Table 1 and Figure 1 indicate that the optimal model is the ARIMA (1,2,3) model. Figure 2 is a combined forecast comparison graph showing the out-of-sample forecasts of the top 25 models evaluated based on the AIC criterion. The red line shows the forecast line graph of the optimal model, the ARIMA (1,2,3) model.

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IV. RESULTS

ARIMA () Model Forecast

Tabulated Out of Sample Forecasts

Table 2: Tabulated Out of Sample Forecasts

Year	Forecasts
2020	2.944064398708544
2021	2.865944492553257
2022	2.821508962414584
2023	2.79485900863019
2024	2.778177146947172
2025	2.767546913280128
2026	2.760985709396622
2027	2.757484337451787
2028	2.756528414955313
2029	2.757857242632318
2030	2.761341569564967

Table 5 and Figure 3 clearly indicate that neonatal mortality will continue to decline and remain low throughout the forecast period.

V. POLICY IMPLICATION & CONCLUSION

Although child mortality rates have significantly declined across Europe including Denmark, this problem remains a public health challenge. In this study we applied the ARIMA model to forecast future trends of NMR for Denmark and the findings suggest that neonatal mortality will continue to decline and remain low throughout the forecast period. Hence, we implore policy makers in Denmark to craft neonatal policies which are suitable for their setting so as to address major drivers of neonatal deaths in the country.

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