Projection of Total Fertility Rate (TFR) in Brazil

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Abstract - **In this research article, the ANN approach was applied to analyze TFR in Brazil. The employed annual data covers the period 1960-2018 and the out-of-sample period ranges over the period 2019-2030. The residuals and forecast evaluation criteria (Error, MSE and MAE) of the applied model indicate that the model is stable in forecasting TFR in Brazil. The results of the study indicate that annual total fertility rates in Brazil are likely to be 1.9 births per woman throughout the out-of-sample period. Therefore, the Brazilian government is encouraged to promote child bearing by providing pro-fertility incentives to couples and lowering the cost of raising children.**

Keywords: ANN, Forecasting, Total fertility rate (TFR).

I. INTRODUCTION

The total fertility rate is an important fertility indicator in population projections, historical and international comparisons (Castanheira & Kohler, 2015). It is the average number of children born to a woman throughout her life if she passes through her child bearing age (15-49years) and experiences the exact current age specific fertility rates (Demena, 2005). TFR is the recognized standard measure of fertility of a population and determines its growth and composition. Brazil was the first Latin American country to witness low fertility levels which are below replacement level fertility (Batyra et al, 2021). Brazil's total fertility dropped from 6.1 births per woman in 1955 to 1.7 births per woman in 2020 (Worldometer, 2020).The country's period fertility rates which are below replacement levels are of major concern for the country's age structure and for the sustainability of its intergenerational relations (Castanheira & Kohler, 2016; Goldani, 2002).In this paper we shall mention a few studies that have focused on fertility. Batyra et al (2021) used four Brazilian censuses to forecast the CTFR for the total population and by educational level using rates reconstructed with indirect techniques. The results of four forecasting methods indicated that the CTFR is likely to decline to 2.1 for the 1980 cohort, and to 1.9 for the 1984 cohort. Educational differences in the CTFR are likely to remain stark – at between 0.7 and 0.9 depending on the cohort and the method. Coutinho & Golgher (2018) modelled the proximate determinants of fertility for Brazil using a framework proposed by Bongaarts (2001), which is useful to explore and compare factors behind total fertility rates. The study concluded that women in recent periods are having, in aggregate, fewer children than their ideal family sizes. However, unwanted pregnancies still explain why certain social groups have more children than desired and also found that women with higher levels of education tend to desire more children than women with lower educational levels. Castanheira & Kohler (2015) demonstrated that the use of the P/F Brass methods in Brazil to adjust for a presumed underreporting of births has the potential to overestimate the country's 2010 TFR by about 8% and concluded that further use of the P/F method in Latin American countries should be carefully evaluated. Amaral et al (2015) analyzed the 1970, 1980, 1991, 2000, and 2010 Brazilian Demographic Censuses, in order to investigate the associated factors with a woman having had a live birth during the year prior to each census. Authors estimated logistic regression models for women aged 10–49 years. The study found out that the probability a woman had a child is higher in the North and Northeast regions, as well as in households without electricity. Women that have a greater chance of having had a child are black/brown, Catholic, married, non-labor market participants, short-term migrants, experienced a stillbirth, between 20–29 years of age, have less education, and have higher parity.

The aim of this study is to project total fertility rate in Brazil using a machine learning technique. The findings of this paper will highlight the likely fertility trends in the out of sample period. This is important for policy making and will trigger an early response to the future health, education and employment needs of the Brazilian population.

II. METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modeling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines 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. This paper applies the Artificial Neural Network (ANN) approach in predicting annual total fertility rates in Brazil.

Data Issues

This study is based on annual total fertility rate (births per woman) in Brazil for the period 1960 – 2018. The out-of-sample forecast covers the period 2019 – 2030. All the data employed in this research paper was gathered from the World Bank online database.

III. FINDINGS OF THE STUDY

ANN Model Summary

Table 1: ANN model summary

Variable	L
Observations	47 (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	0.104219
MSE	0.028546
MAE	0.139790

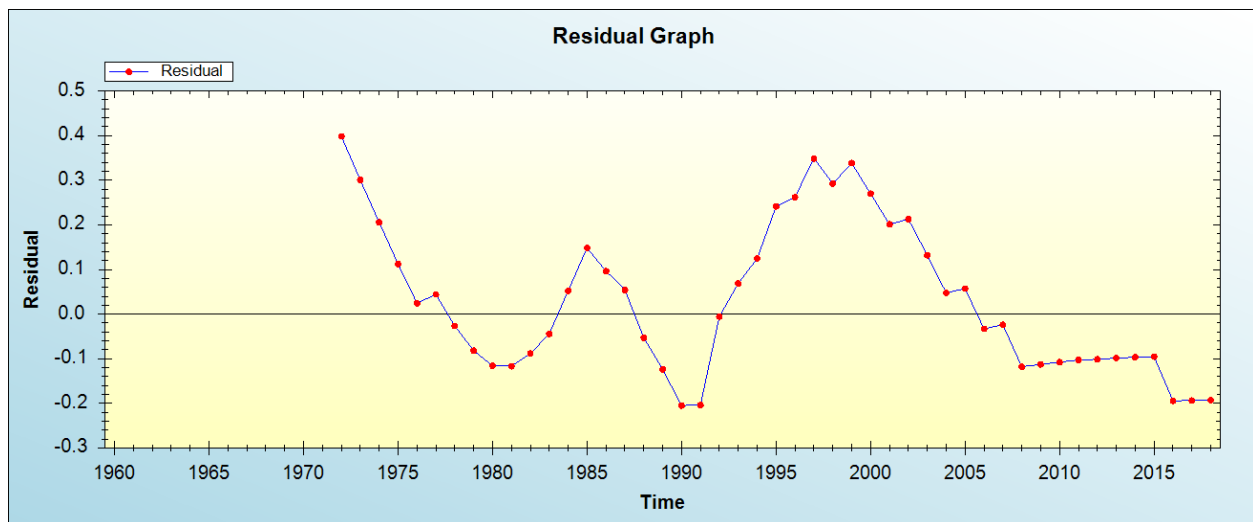*Residual Analysis for the Applied Model*

Figure 1: Residual analysis
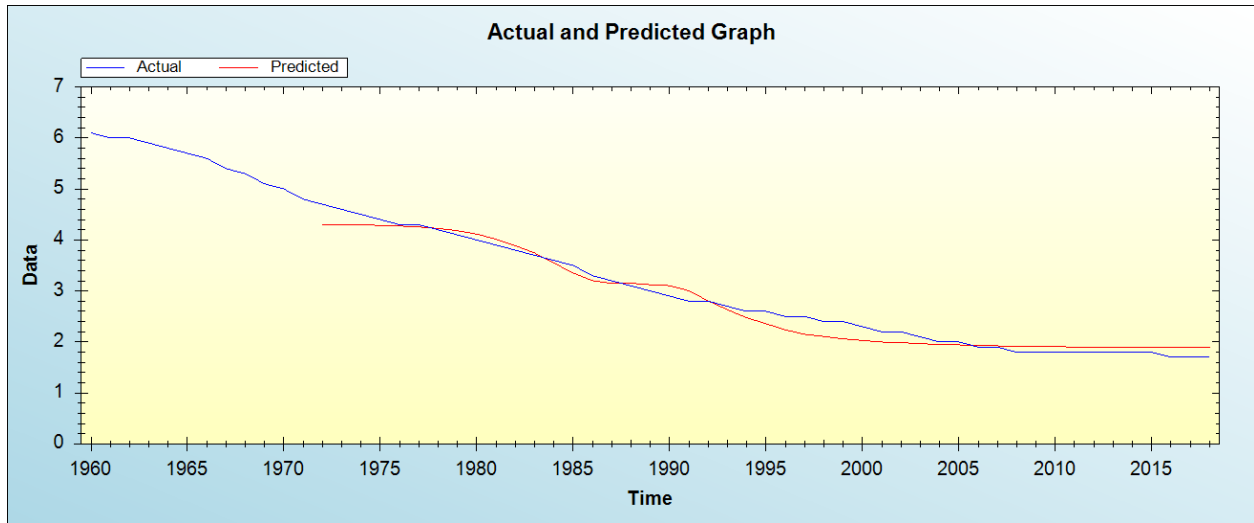
In-sample Forecast for L

Figure 2: In-sample forecast for the L series

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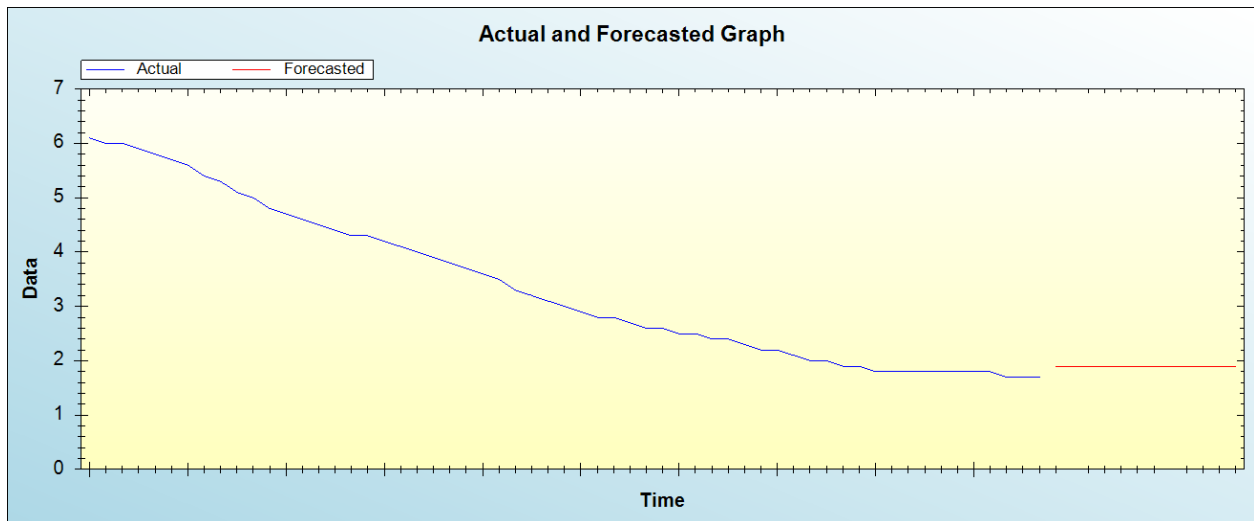

Figure 3: Out-of-sample forecast for L: actual and forecasted graph

Out-of-Sample Forecast for L: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted TFR values
2019	1.8920
2020	1.8924
2021	1.8921
2022	1.8928
2023	1.8924
2024	1.8929
2025	1.8935
2026	1.8938
2027	1.8936
2028	1.8937
2029	1.8953
2030	1.8959

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that annual total fertility rates in Brazil are likely to be 1.9 births per woman throughout the out-of-sample period.

IV. CONCLUSION & RECOMMENDATIONS

Total fertility rates below replacement level are of major concern in Brazil as this has serious implications on future labor force and health care expenditure. In this study we predicted TFR for Brazil using a machine learning approach. The results of the study indicate that annual total fertility rates in Brazil are likely to be 1.9 births per woman throughout the out-of-sample period. Therefore the Brazilian government is encouraged to promote child bearing by providing pro-fertility incentives to couples and lowering the cost of raising children.

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