Historic Total Fertility Rates of Sri Lanka (1960 – 2021) and Future Trends

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Abstract

Fertility is one of the key components that determine the population change in Sri Lanka. Total Fertility Rates (TFR) are the average number of children a woman would have by the end of her childbearing years (15-49) if she bore children at the current age-specific fertility rates. The average has been declining over the past decade in Sri Lanka. It is essential to understand the trends and patterns of TFR in that aspect to enhance the quality of predetermined long-term economic, health and educational plans as well the policy implements in the country. The main objective of the study is to identify the trends and patterns of historic Total Fertility Rates of Sri Lanka (1960 – 2021) and future trends. The study carries out based on the secondary data on TFR extracted from World Bank data (1960-2021). Initially, the univariate time series analysis was utilized to identify the pattern of TFR using the R Statistical software. This study revealed that there is a decreasing future trend in TFR using ARIMA (1, 2, 1) model which was fitted as the best model to forecast the future behavior TFR. The fitted model was. The forecasted TFR values for the period from 2022 to 2026 were 1.9577, 1.9372, 1.9167, 1.8963 and 1.8758 respectively. It is suggested to have a comparative study on fertility trends and patterns with consideration of socioeconomic and cultural factors in Sri Lanka since TFR varies due to socioeconomic and cultural diversity.

Keywords: *Age Specific Fertility Rate, ARIMA model, Total Fertility Rate, Univariate time series analysis*

1. Introduction

Background of the study

Fertility is one of major component which determines the population change in any population. Fertility is the ability of an individual or couple to reproduce through normal sexual activity, fertile women are able to conceive within one year if the women have intercourse regularly without contraception (Demographic and Health Survey, 2016). With the evidences provided through out of the Demographic and Health survey in Sri Lanka and World Bank reports, It can be revealed that Total Fertility Rates (TFR) have been declining over past decades. TFR has been declining from 5.465 in 1960 to 1.99 in 2021 (World Bank Open Data, 2023). Although during the period 1995 to 2000 Sri Lanka experienced fertility rates even below the replacement level identified by a TFR of 1.9, survey data from the Sri Lanka Demographic and Health Survey 2006 indicate a TFR of 2.3, which demonstrates an increase in fertility, well above the replacement level (De Silva, et al., 2011).

Over the last decades of Sri Lankan history, it remarkably shows the unstable nature of fertility level. Even though the maternal mortality rate and infant mortality rate was declining over the last few decades due to women's education, development of science and medical facilities, that indirectly increased the contraceptive usage and totally

changed the attitude towards the fertility and the fertility preference of Sri Lankan women. In addition to that, the opening of the economy was one of the effective strategies introduced in Sri Lanka for the development of Sri Lankan economy. Generally speaking, that enforced in the country for training better employees with a proper education and skill which were expanded the employment opportunities from local to foreign with the attention of equal access to productive employment for both male and females and provided better income opportunities for both. Those were impacted to the conventional socio-cultural setting in Sri Lanka opening equal opportunities for specially women and minor categories whose contribution was basically employed to the family and agricultural sector. This makes reasons for the unstable nature of fertility level in Sri Lanka in the last few decades.

Further, financial inducements were introduced in 1980 s in Sri Lanka when the TFR is at a higher level in order to reduced fertility to replacement level as the increased fertility was seriously affected with the socioeconomic development of the country. (De Silva, et al., 2011). When the fertility was declined with the influence of women's education, better employment opportunities due to open economy in the country, the Sri Lankan government attempted to improve the reproductive health policy making the priority on family friendly social culture where work life and family life are compatible.

Anyhow, as a multicultural population, this might be resulted due to the regional and other social differentials of Sri Lanka. The study mainly focuses on trends and patterns of historic Total Fertility Rates of Sri Lanka (1960 – 2021) and future trends.

Research Problem

Of the three principal components of demography, which determine the elements of population which are the population size, structure, composition and distribution, Fertility is directly impacted in change of population and its growth. Since the population growth policies are formulated based on the existing trends of fertility, it is an essential requirement of identifying the patterns in fertility due to the sociocultural and economic diversity related to different regions, ethnic groups and other important demographic variables.

Objectives

TFR is an important measure which can illustrate the true behavior of fertility compared to the previous time period and compared to another population. Therefore, Fertility behaviour is evaluated based on TFR corresponding to the trend and the pattern performed. The main objective of the study is to identify the trends and patterns of historic Total Fertility Rates of Sri Lanka (1960 – 2021). In addition, it is generated the specific objectives as identifying the trend and pattern of fertility forecasting future behavior for a short period of future years.

2. Literature Review

The recent fertility decline in the world has been received the attention of the most of researchers to an overview of the issue in different perspectives such as policy implements, contraceptive usages, fertility preference, nuptiality patterns, fertility trends. World Total Fertility Rate has been decreased from 5 in 1960 to 2.4 in 2020. (World Bank Open Data, 2023). Further this decline shows over several decades even in Sri Lankan

context. Total Fertility Rate has been declining from 5.5 to 2.2 from 1960 to 2020 in Sri Lanka (World Bank Open Data, 2023). Hence, a number of studies have been performed by several researchers in national and international levels to understand the decline through out of examine the trends and the patterns of fertility all over the world.

McNicoll (1992) carried out a study in fertility patterns and policies selecting countries of the third world. The researcher has been identified the changing trends in five major third world regions confirming the value of analyzing fertility change considering the marriages, conception and fetal mortality. The collected data from the world fertility survey in 1972 and other relevant surveys were utilized in the study. The study has shown the statistical evidences on the secular fertility decline in industrialized countries from 4-7 children to 3 children per woman. The established regional trends in fertility in Latin America has been falling by 40 % while West Asia and North Africa shows a higher fertility rate remaining TFR value is 8. More prominently, the researcher has suggested to pay balanced comparable attention on fertility policy implements even though the fertility decline could be faster or slower.

In addition to that, World fertility trends were studied by Skirbekk (2008) with special reference to the social status. The researcher performed a statistical analysis with the use of 879 samples which were extracted from 129 secondary data sources covering Asia, Africa, Latin America, Middle East, Europe and North America. The study revealed the association between social status and fertility over the time and across the world regions and it was used different types of measures of social status for the analysis. The study depicted that high status was associated with relatively high fertility in the period before the fertility decline in the world. The results were significantly switched to the opposite direction showing a negative or neutral fertility effect with high status after the period fertility decline started. In addition to that, the study revealed that Asia, Africa, Latin-America and Middle East countries confirmed the result than Europe and North America. Generally, the results illustrated that in the period of world fertility rate had declined, individuals were more trend to have a smaller number of births when the social status was higher. Furthermore, the study made statistical evidence to prove that education was increasingly significant determinant of social status during the 20th century and the analysis confirmed that there was a negative association between education and fertility. Moreover, the study revealed that when the social status become higher, individuals were more trend to have lesser number of children and education was a major factor to increase the social status and when the education level was higher, individuals were more trend to having lesser number of children likewise when the social status were higher, the individuals were trend to having a smaller number of children remarkably.

Fernando (1975) has performed a study based on the data in the1963 census of population by Registrar General's Department regarding the fertility differentials in Sri Lankan context. The analysis indicates the traditional pattern of lower urban fertility rates than the rural regions in both 1963 and 1970. The analysis was further developed dividing the regions on an agro-climatic basis and considering the age-specific fertility rates, age specific marital fertility, average size of family over rural and urban sectors. The study statistically confirmed that there was an inverse association between average age at marriage for females and the fertility levels in 1963. Furthermore, the researcher argued that The National Family Planning Programme inaugurated in 1965 had been given a strong impact on the level of fertility rates in all the regions in Sri Lanka. Further, the researcher suggests a proper systematic analysis confirming essentiality of the

paucity of data for considering the other variables which are impacted other than the explained impacts such as abortion, lactation, and contraceptive activity.

The fertility decline in Sri Lankan context has been studied by (B. Caldwell, 1996) in another perspective of family and demographic change. According to the researcher, Sri Lanka has almost completed the demographic transition with low mortality rate and fertility rate and being rising up the marriage age of female from six years distinctively contributed in the decline in fertility in the country. While the birth rates are approaching or the below replacement, the low fertility shows more complicated variations within the country due to marriage patterns, family planning and health services use of non-contraception methods. From the respondents from Loluwagoda, Welisara and Rahatungoda, the study revealed that the higher proportion of wives made the decision regarding family planning without the reference of the husbands while the higher educated respondents made a joint decision as a couple and higher educated female had less influence of family health workers, family planning programs, relatives were being a stringer marriage partners in the family. In addition to that, the study was shown that the Sri Lankan fertility decline is influenced from the pressure from relatives, costs of bearing children, increasing need of education, increasing women employment as it was reduced the time for child bearing and comparative benefits could be obtained financially.

De Silva, et al. (2011) were carried out a study on increased fertility and determinants in Sri Lankan context utilizing the data obtained from Sri Lanka Demographic and Health Surveys (SLDHS), 1987, 1993, 2000 and 2006-2007 under the multistage data collecting from ever-married women aged 15-49 years. According to the researchers, SLDHS in 2006-2007 indicates an unexpected fertility increased the TFR value from 1.9 to 2.3. Further, the study has been recognized the rise in women in the early twenties and peak age group is 25-29 years age. In addition to that, female marriage age has been declining with age 23.6. When it compares the patterns in contraceptive use, it was shown a remarkable decline in use of non-reversible methods. The findings confirm that very small proportion of abortion of abortion seekers did not use none of the contraception while two thirds of them used traditional methods to avoid conception while abortion services are active at reasonable price in Sri Lankan context even though induced abortion is illegal.

Finally, it can be recognized a remarkable research gap through out of the literature review. The majority of the researches were brought out the studies related to fertility decline considering the 19th century in Sri Lankan context as well as in the world context. Likewise, McNicoll (1992) has carried out the study in changing trend of fertility in third world regions focusing the study on the factors such as marriages, fetal mortality and conception using data related to world fertility survey in 1972. In addition to that, (Skirbekk, 2008) had studied the fertility trend directly but with special reference to the social status of individuals and confirmed the significant associations among fertility, social status and education comparing periods across the different regions in the world. Even though these studies enriched by adding the relevant factors to the consideration the results are outdated and not valid for the current situation. The gap has remained the same even in Sri Lankan context. Fernando (1975) revealed the fertility pattern in traditional aspect considering the rural and urban regions in Sri Lanka based on the census of the population in 1963. De Silva, et al. (2011) has also used data in Sri Lanka Demographic and Health Survey only up to 2007. But the real view on the fertility patterns, the trends and behavior might be entirely opposite in the present situation as all these studies were based on the outdated data. When it is considered, the fertility

declined in Sri Lanka, the results might be impacted due to the various factors associated with Covid 19 pandemic and the existing economic crisis in the Sri Lankan context in the period of 2019-2023. Hence, this study is expected to fulfill the research gap with the use of more current secondary data to identify the fertility trends and patterns in Sri Lanka using TFR as the main considered variable.

Significance of the study

Fertility is directly impacted in change of population and its growth. Since the population growth policies are formulated based on the existing trends of fertility, it is an essential requirement of identifying the trends and patterns in fertility in any of the country. The forecasted values related to fertility measure facilitates to ensure the state capability in providing the basic infrastructure, medical facilities and health facilities for the citizens in the country. In addition to that, the results of the study and the fitted model can be utilized to implement the existing policies with special reference to the behavior of the fertility in the future. This may support for preplanning designed programs and projects which are compatible with the existing trend of fertility and to evaluate the quality avoiding the mismatch the provided facilities and the actual requirements of individuals.

Limitation of the study

As Sri Lanka is a multi-cultural country, TFR might be impacted from the sociocultural diversities. The study carries out without considering those factors such as different regions, ethnic groups and other important demographic variables and considered whole country as one unit. In additional to that the measure used to evaluate the trends and patterns of fertility is considered only the live births which can be happened to a woman within the reproductive age 15-49. Therefore, it is not considered the live births of a woman after the reproductive age limit and before the reproductive age limit in this analysis.

3. Materials and Methods

The TFR data related to Sri Lanka from 1960 to 2021 were extracted from the World Bank Development Indicator as the secondary data source. As the analyzing techniques, time series analysis was employed under the quantitative aspect using R statistical software. Under statistical analysis Stationary Test was utilized in order to use the probabilistic approach in time series analysis, as the Stationary test Zivot & Andew unit root test was utilized to determine whether the time series is stationary or not. The specified time series model used in the analysis was ARMA model: ARMA processes are a combination of Autoregressive (AR) and Moving Average (MA) processes. ARMA model of order p and q process respectively is given by:

$$Y_t = \delta + \varphi_1 Y_{t-1} + \varphi_2 Y_{t-2} + \ldots + \varphi_p Y_{t-p} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \qquad (1)$$

Autoregressive Integrated Moving Average (ARIMA) model: The ARMA models can be used for stationary time series data. If the series is non-stationary, it can be converted to a stationary series using differencing as appropriate, and in addition the term “integrated” should be used. The ARIMA (p, d, q) model can be written as:

$$Y_t^{'} = c + \varphi_1 Y_{t-1}^{'} + \varphi_2 Y_{t-2}^{'} + \ldots + \varphi_p Y_{t-p}^{'} + \theta_1 \varepsilon_{t-1} + \theta_2 \varepsilon_{t-2} + \ldots + \theta_q \varepsilon_{t-q} + \varepsilon_t \qquad (2)$$

where, p and q are order of AR and MA components respectively, d is the number of differencing, c is constant term and is the differenced time series value of at time t and is the error term used in the model.

Lag length selection was done using Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF): ACF and PACF plots were used to determine the optimal lags of MA (q) and AR (p) respectively.

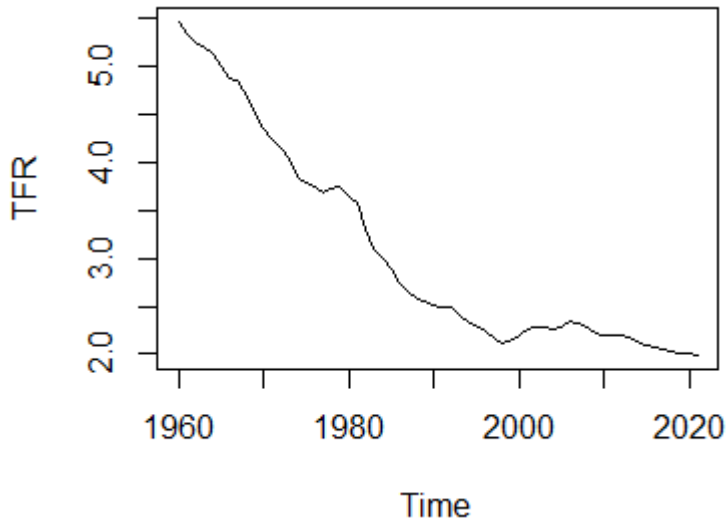
Akaike Information Criterion (AIC) was carried out to choose the best model through out of the tentative models fitted as the Model selection criterion.

4. Result and Discussion

Preliminary Analysis

The TFR in Sri Lanka from 1960 to 2021 is illustrated in Figure 1. The series shows a decreasing trend. It is shown small increment 1999 to 2012 compared to 1998, but after 2012 it shows the same decreasing trend of the series.

Figure 1: Total Fertility Rate in Sri Lanka from 1960 to 2021



Source: Compiled by authors, 2024

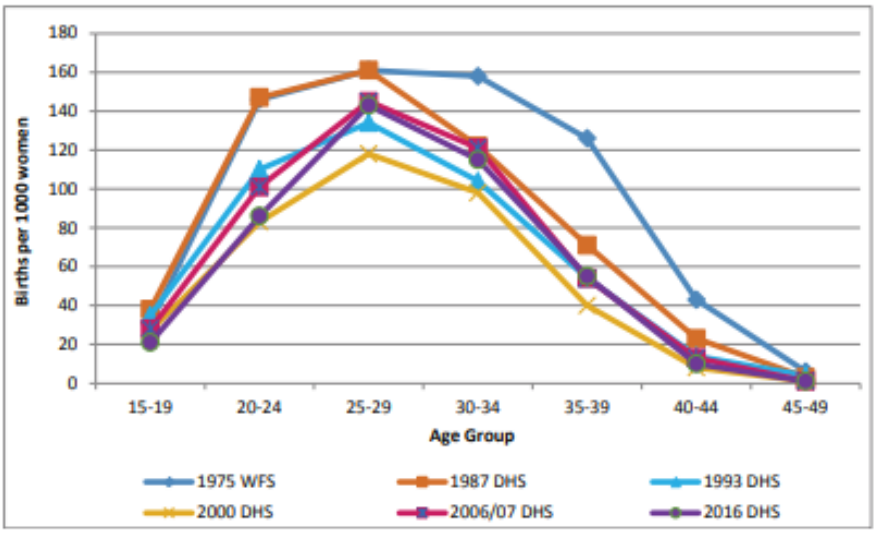
Figure 2 illustrated that the fertility patterns show that the young adult age groups of 15-19, 22-24, and 25-29 are having greater fertility declines during the last 35 years. There is a slight increase in the ASFRs of these same age groups in 2016 (Demographic and Health Survey, 2016).

Stationary test

Zivot & Andew unit root test revealed the original series is not stationary. The series were converted into stationary series by taking the second differencing. Hence, the test statistics of intercept, trend and both intercept and trend are greater than the critical value, the null hypothesis is rejected (Series is not stationary). The results were shown in

Table 1.

Figure 2: Age Specific Fertility Rates (ASFR) in Sri Lanka from 1975 to 2016



Source: Demographic and Health Survey 2016, Sri Lanka, 2024

Table 1: Results of Zivot & Andew unit root test for 2nd differenced TFR series

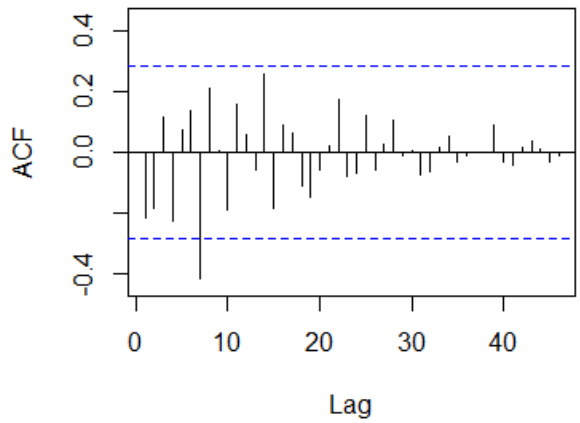
Category	Test Statistics	Critical value $\alpha = 0.01$	Critical value $\alpha = 0.05$	Critical value $\alpha = 0.10$
Intercept	-6.0269	-5.34	-4.80	-4.58
Trend	-6.0269	-4.93	-4.42	-4.11
Intercept and trend	-6.9447	-5.57	-5.08	-4.82

Source: Compiled by authors, 2024

Model identification

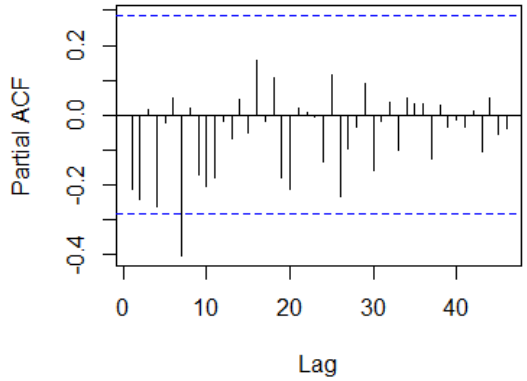
The orders of ARIMA model parameters can be chosen using ACF plot and PACF plot. As the bars of ACF plot passed out of the confidence limits at only 1, order of MA term is 1. Similarly significant bar at 1 in PCAF plot indicates that the order of AR term is also 1. (Figure 3 & Figure 4).

Figure 3: ACF for 2nd differenced TFR series



Source: Compiled by authors, 2024

Figure 4: PACF for 2nd differenced TFR series



Source: Compiled by authors, 2024

It was used AIC criteria to select the best model throughout of 9 tentative models fitted. Hence ARIMA (1, 2, 1) was selected as the best model. The results were given in Table 2.

Table 2: Results Tentative models for TFR

Model	AIC
ARIMA(2,2,2)	-124.8933
ARIMA(0,2,0)	-123.6395
ARIMA(1,2,0)	-123.856
ARIMA(0,2,1)	-125.6521
ARIMA(1,2,1)	-128.2549
ARIMA(2,2,1)	-126.3077
ARIMA(1,2,2)	-126.3462
ARIMA(0,2,2)	-128.1503
ARIMA(2,2,0)	-124.9358

Source: Compiled by authors, 2024

Parameter Estimation

The estimated parameters for the fitted model ARIMA (1,2,1) are given Table 3.

Table 3: The estimated parameters for ARIMA (1,2, 1)

Component	Coefficient	Standard error
AR(1)	0.4935	0.1667
MA(1)	-0.8941	0.0825

Source: Compiled by authors, 2024

Using the coefficients, the fitted model can be illustrated as follows;

$$Y_t = 0.4935Y_{t-1} - 0.8941\varepsilon_{t-1}$$

With 0.1667 and 0.0825 standard error of the AR (1) and MA(1) estimated parameters respectively.

Model diagnostics

Under model diagnostics, it was diagnosed three main requirements for the confirmation

the fitted model as the best model to forecast the future TFR in Sri Lanka. The first requirement is the residuals of the series should be independently distributed. The second requirement is the variance of the residuals should be constant around the mean value which is zero. The third requirement is the residuals should be normally distributed. Randomness of the residuals: It was used Box-Pierce Test to check whether the residuals are independently and identically distributed or not. The test made statistical evidences for satisfying the requirement. Hence, the p value is not less than significant level 0.05, was not rejected (Residuals are independently distributed). That indicates the residuals are random. The first requirement is satisfied. Table 4 is shown the results.

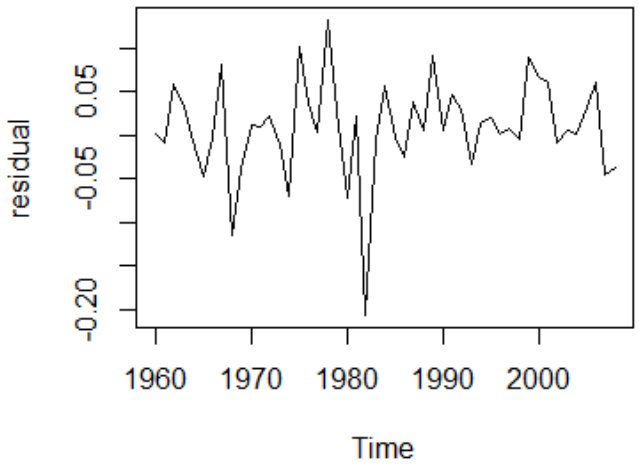
Table 4: Box-Pierce Test

Test	p value
Box-Pierce Test	0.1186

Source: Compiled by authors, 2024

Variance of residuals and mean of residuals: The residuals plot of the time series is varying within a constant band which indicates that the variance of the residuals is constant at mean value of zero. Therefore, the second requirement of constant variance of residuals around the mean values zero is also satisfied. (Figure 4)

Figure 5: Residuals plot of the time series



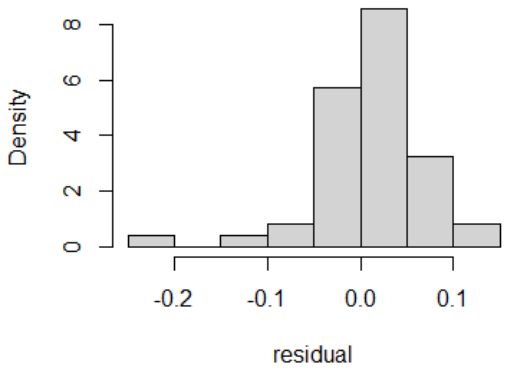
Source: Compiled by Researchers using Data Analysis, 2024

Normality of residuals: Shapiro-Wilk normality test and histogram of the residuals were used to determine whether the residuals are normally distributed or not. The residuals are not normally distributed hence P value (P value =0.0044) is less than significant level (Residuals are normally distributed). (Figure 5)

Forecasting TFR using ARIMA (1, 2, 1) model

The Series of TFR of Sri Lanka from 1960 to 2008 were used to fit the model. And Series of TFR of Sri Lanka from 2009 to 2021 were used to test the accuracy of the estimated TFR values corresponding to the real TFR values in Sri Lankan context. Further, it was used 2022 to 2026 as the forecasting period. (Figure 7) (Table 5)

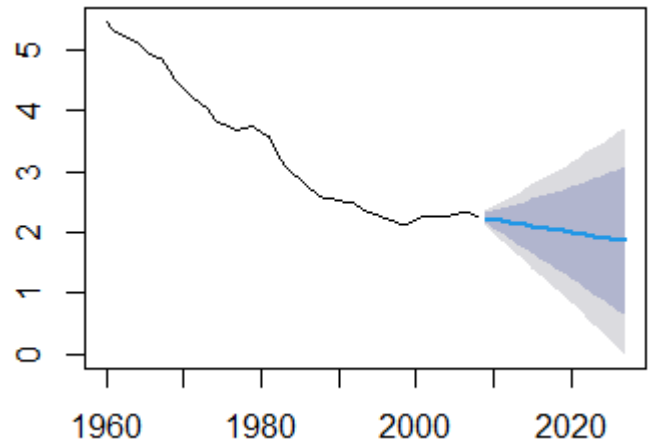
Figure 6: Histogram of residuals



Source: Compiled by Researchers using Data Analysis, 2024

Figure 7 illustrates that the decreasing trend of TFR remains further.

Figure 7: Forecast of TFR for 2022-2026 using ARIMA



Source: Compiled by Researchers, 2024

Table 5: Estimated TFR from 2022 to 2026

Year	Estimated TFR	95%Confidence Interval
2022	1.9577	(0.61394,3.30144)
2023	1.9372	(0.4927,3.817)
2024	1.9167	(0.3698,3.4637
2025	1.8963	(0.2451,3.5474)
2026	1.8758	(0.1187,3.6329)

Source: Compiled by Researchers, 2024

5. Conclusion

Preliminary Analysis depicts that TFR in Sri Lanka from 1960 to 2021 shows the decreasing trend over the period of time and time series forecast confirmed that the pattern continues even in the period of 6 years from 2021. Even though the original series were not stationary based on Zivot & Andew unit root test, second differentiated series

utilized to fit ARIMA (1, 2, 1) which were chosen over 9 tentative ARIMA models under AIC criteria as the best fitted model to forecast future TFR values from 2022 to 2026 with the statistical confirmation of stationary series. The fitted model was $Y_t = 0.4935Y_{t-1} - 0.8941\varepsilon_{t-1}$. Then the forecasted TFR values for the period were 1.9577, 1.9372, 1.9167, 1.8963 and 1.8758.

In addition to that, it is suggested to proceed a statistical analysis on fertility rate in Sri Lankan context with consideration of socioeconomic and cultural factors which may impacted with the fertility pattern due to sociocultural and economic diversity in Sri Lanka. Comparative study on fertility trends and patterns illustrating the different fertility trends and patterns associated with different regions and ethnic groups in Sri Lankan context may provide the information relevant to the trends and patterns of fertility behavior in detail. Further, it will provide more benefit if it can be utilized a measure to reflect the fertility behavior which captures the live births before the lower reproductive age limit and after the higher reproductive age limit of women in Sri Lanka.

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