

Fertility Transition in Bangladesh: Why and How?

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Bangladesh, a South Asian country with a population of approximately 175.7 million, is undergoing a critical phase of fertility transition. This study examines this phenomenon by analysing the relationship between the total fertility rate and several key determinants, including women's enrolment in secondary education, their labor force participation, household income, the infant mortality rate, and the use of modern contraceptive methods. Using an Autoregressive Distributed Lag (ARDL) regression applied with Error Correction model on time-series data from 1980 to 2024, the analysis shows that women's education, women's participation in labor force and usage of modern techniques in family planning significantly and negatively influence total fertility rate in long run, while improvement in childhood mortality significantly and positively influences the total fertility rate in long run. In the short run, women's education and usage of modern techniques in family planning show delayed positive influence on total fertility rate, while improvement in childhood mortality shows volatility and women's participation in labor force does not show any influence. These findings provide important insights for policymakers and stakeholders, underscoring the need to expand daycare facilities, promote birth spacing, and strengthen the effectiveness of population policies.

JEL Classification: J11, O15

Keywords: Fertility Rate, Women Education, Women Labour Force, ARDL

1. INTRODUCTION

Bangladesh is a country located in South Asia. In terms of population, Bangladesh is the eighth-most populous country in the world, with approximately 175.7 million people living in an area of 148,460 square kilometers (57,320 sq. mi) (World Bank, 2025). In fact, population had been a big concern for Bangladesh since its independence. However, in recent years, the country is passing through a critical stage of fertility transition. Fertility transition occurs when a substantial portion of population adopts contraceptive measures on a parity-specific basis, which is influenced by combinations of conditions either brought about by government or by modernization (Mason, 1997).

Bangladesh provides a notable example of this demographic transition. Fertility decline began in the mid-1970s (Islam & Nesa, 2009), with the Total Fertility Rate (TFR) falling rapidly from 6.3 births per woman in 1975 to 3.4 in 1994. The TFR continued around 3.4 until 2004, then declined further to 3.3. At the same period, the contraceptive prevalence rate (CPR) increased to 58 percent, highlighting the popularity of family planning methods (Islam & Nesa, 2009).

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Female education appears as an important determinant of fertility control in literature. Higher educational attainment motivates delay marriage and labour force participation, and influences reproductive decisions (Gani, 2016). The opportunity cost of childbearing increases with employment opportunities, making larger families less attractive. Educated women are likely to focus on the health and education and prefer to ensure child quality over quantity. Education also enhances women's decision-making autonomy, enabling them to exercise greater control over their reproductive choices. Declining infant mortality also contributes to lower fertility levels by reducing the perceived need for replacement births (Gani, 2016).

Sustained government policies and collaboration with non-governmental organisations have played important role in fertility transition in Bangladesh through expanding family planning services (Rizvi, 2014). Public health initiatives, including tetanus immunisation, safe delivery services, and improved maternal and child healthcare, contributed to substantial reductions in maternal and infant mortality between 2001 and 2010 (Rizvi, 2014). At the same time, the Education Policy of 1978–1981 expanded free and equitable access to schooling, particularly for girls, leading to higher female enrolment and strengthening women's socioeconomic empowerment (Dove, 1983). Together, these investments in health, education, and family planning have played a central role in Bangladesh's successful fertility transition.

The Classic Demographic Transition Theory states that the changes from high fertility and mortality of agriculture-based community to lower fertility in urban industrial societies is an outcome of small family size concept brought by socioeconomic modernization and the changes in cost-benefits of having children (Kirk, D., & Pillet, 1998). However, economists have challenged this theory in recent decades when analyzing the rate of fertility decline in Europe and in developing countries. They claim that in Europe, fertility declines due to industrialization whereas in Asia and Latin America, this was due to urbanization and modernization (Mason, 1997). Therefore, the context of the contemporary fertility transitions differs among regions or among countries.

This study aims to examine the determinants of fertility transition in Bangladesh considering the theories related to demographic transition. The study investigates how the rate of total fertility is influenced by different socio-economic factors such as household income, women's schooling, women's participation in labor force, usage of modern techniques for family planning as well as the mortality rate. Existing literature examines these factors in separate studies on Bangladesh. Instead, this study inspects these variables in a combined framework.

By applying the ARDL technique with Error Correction model on time series data from 1980 to 2024, the study finds that levels of women's education, women's participation in labor force and usage of modern techniques in family planning significantly and negatively influence total fertility rate in long run, while improvement in childhood mortality significantly and positively influences the total fertility rate in long run. In the short run, women's education and usage of modern techniques in family planning show delayed positive influence on total fertility rate, while improvement in childhood mortality shows volatility and women's participation in labor force does not show any influence. The results have important implications in future policy design for fertility control.

The remainder of the paper is organised as follows. Section 2 reviews literature and develops theory. Section 3 explains the model, followed by results and discussion in Section 4. The last section concludes the paper.

2. THEORISATION AND REVIEW OF LITERATURE

The classic demographic transition theory describes the shift from high fertility and mortality in agrarian societies to lower fertility in urban-industrial setup as an outcome of socioeconomic modernization (Mason, 1997). This transition popularized smaller family size, influenced by the cost-benefit perception of having children. However, the declining fertility trends in both Europe and developing countries motivate the economists in recent decades to question the generalization of this theory. Europe underwent extensive socioeconomic transformations that gradually influenced neighbouring regions. From the 1950s to the 1970s, several countries in Asia and Latin America also began experiencing rapid fertility declines. This led to a growing debate: while Europe's fertility decline was primarily attributed to industrialization, the declines in Asia and Latin America were linked more closely to urbanization and modernization.

Contemporary fertility transitions differ from the European experience in several significant ways. These include higher initial fertility levels, rapid and unprecedented reductions in mortality, swift population growth, the active involvement of governments and NGOs in promoting family planning, and the availability of modern contraceptive methods. These factors played a critical role in accelerating fertility decline in developing nations (Kirk, 1998).

In addition to the Classic Demographic Transition theory, theories such as the Proximate Determinants Model (Bongaarts, 1978; Bongaarts, Frank & Lesthaeghe, 1984) and the Microeconomic Models of Fertility (Cochrane, 1975; Turchi, 1975; Arroyo & Zhang, 1997; Robinson, 1997) also explain the fertility transition. According to the Bongaarts' Proximate Determinants Model, four proximate factors such as women's marriage and sexual activities, use and effectiveness of contraceptive, infecundity following childbirth and induced abortion directly affect fertility, while factors such as education and income indirectly affect fertility. In a later study, however, Bongaarts relaxed the rigidity of the model by including the option for further fine-tune based on diversified national conditions (Bongaarts, 2015). Laelago, Habtu and Yohannes (2019) and Ahmed (2020) also support this model diversification while studying the fertility decline in Ethiopia. In contrast to the Bongaarts' Proximate Determinants Model, the Microeconomic Models of Fertility relies on consumer choice and utility maximization to explain fertility. This theory considers childbirth as a rational and household-level decision based on family income, expenditure, price level, work-life balance and many other relevant macroeconomic factors (Cochrane, 1975; Turchi, 1975; Arroyo & Zhang, 1997; Robinson, 1997).

Mason (2005) elaborates on the concept of fertility transition, explaining that such transitions occur when a combination of institutional, cultural, and environmental factors motivates or enables a substantial portion of the population to adopt birth-prevention measures targeted at limiting family size. The first country in each region to undergo a fertility transition often does so due to internal changes—cultural, structural, or environmental—that support fertility limitation. However, other countries in the same region may follow suit, influenced more by the example or impact of the pioneering country than by parallel internal changes.

The diffusion of fertility-reducing behavior is shaped by several factors, including the reach and effectiveness of communication and transportation networks, the presence of a shared language, the configuration of informal social networks, the influence of local and national leaders, and whether state policies support contraception. A decline in mortality is typically necessary—but not always sufficient—for a fertility decline. In

pretransition societies, families often aim to maintain a specific number of surviving children. When child survival rates increase, families may respond by adopting child-limiting behaviours. Initially, these may be postnatal controls (such as infanticide, neglect, or child spacing through prolonged breastfeeding), especially in the absence of modern family planning resources.

However, when traditional postnatal controls are no longer viable—due to changing social norms, policies, or external circumstances - parents may shift toward prenatal controls (such as contraception or abortion). This shift is more obvious when supported by state programs or policy interventions. For example, European populations in the late 19th and early 20th centuries suffered from declining foreign migration opportunities, which indirectly motivated fertility control for adapting to the change in economic and demographic situation (Mason, 2005).

2.1. Household Income

Repetto (1978) and Flegg (1980) argue that national income distribution is associated with fertility levels. Similarly, modern attitudes and values influence fertility. Modern life engages various consumption and investments in self and children. Consequently, changing living standard inversely relate to fertility rates (Repetto, 1978; Flegg, 1980). Individuals with higher incomes and integrated modern socioeconomic systems also contribute to fertility decline.

Interestingly, Repetto (1978) claims income distribution within a population not directly correlated with fertility rates, rather a linear relationship between changes in household earnings and fertility behaviour. The phenomena are common across all income ranges, suggesting that income distribution would influence fertility only under exceptional circumstances. For instance, a \$1,000 increase in annual income may cause lifestyle changes, but the magnitude of this change varies across socioeconomic groups. It is therefore misleading to assume that fertility decisions simply rise with income. Households with lower incomes typically have higher fertility rates than those with higher incomes, so an income increase among low-income households would produce a stronger fertility response.

In a recent study, van Wijk (2024) argues that income effects are primarily driven by first birth, while higher-order births attenuate this relationship. Consequently, high income appears to be an important prerequisite for the transition to parenthood, and individuals with lower income may find it more challenging to realize their fertility intentions. Similar suggestion also comes from Doepke, et al. (2023) that income-fertility relation in high-income countries have flattened or reversed. In addition, Imrie, et al. (2023) emphasizes that assisted conception is more common among mothers with higher socioeconomic status than natural conception.

2.2. Women's Enrolment in School

Education is an investment in human capital. For girls, however, this investment often ends with marriage or motherhood (Gani, 2016). Consequently, years of schooling can be viewed as a determinant of lower fertility rates: the more years of education a woman attains, the fewer children she is likely to have. According to the economic theory of fertility, higher education increases the opportunity cost of childbearing, as having children may lead to forgone income (Gani, 2016). Moreover, the household bargaining model suggests that women's decision-making autonomy rises with their education level, in turn influencing fertility choices (Gani, 2016).

Consistent with Gani (2016), Kim (2023) and Zhang & Zhao (2023), identify a negative relationship between women's education and fertility. According to Zhang and Zhao (2023), each additional year of education reduces childbirth by 0.9 units and delays the first childbirth by 0.7 years. Consequently, despite having better health and greater physical capacity, educated women tend to prioritize child quality and quality of life over larger family size (Kim, 2023). Interestingly, however, Chen (2022) presents a contrasting view, showing that each additional year of women's education in China increases childbirth by 0.14 units. This finding can be justified twofold: education does not influence the mean age of marriage, and it increases the demand for children. Overall, these findings suggest that the relationship between women's education and fertility varies across regions.

Beyond schooling, employment diversity plays an important role in controlling fertility in Bangladesh (Islam & Nesa, 2009). Regardless of education level, both the total fertility rate (TFR) and total marital fertility rate (TMFR) are higher among women engaged in agricultural sector compared to urban women. For example, the TFR among uneducated women in the Sylhet and Chittagong Divisions exceed 5 births, which is substantially above the national benchmark, while the rate in the Khulna and Rajshahi Divisions is 4.1. In contrast, TFR is low among wealthy women with at least a secondary education, while women with higher secondary qualifications from affluent, urban households have TFRs close to replacement level (Islam & Nesa, 2009).

2.3. Women's Participation in the Labour Force

Educated women's participation in economic activities is a significant factor in reducing fertility rates (Brinker & Amonker, 2013). The working status and related bargaining power give them better control over fertility by making independent choices. Their earning capacity enhances self-confidence and independence, giving greater autonomy in decision-making. In addition, working women are more open to television, radio, and other sources of information, enabling them to learn about family planning methods and services (Brinker & Amonker, 2013).

For instance, in mid-twentieth-century India, women working in agriculture had limited control over their status within the family and society. They worked out of economic necessity rather than personal preference, which give them little ability to take fertility decisions. With the benefit of industrialisation and the IT sector, opportunities in high-skilled and well-paid jobs expanded for women. This shift enabled women to active participation in family planning decisions (Brinker & Amonker, 2013). Thus, high literacy and education levels influence delayed marriage and lower fertility rates.

Doepke, et al. (2023) challenges the traditional theory that women's labor force participation is negatively related to fertility. Instead, they argue for a positive relationship between the two across countries, supported by factors such as family-friendly policies, supportive fathers, favorable social norms, and flexible labour markets. This perspective is further reinforced by Del Rey, Kyriacou & Silva (2021), who highlight a positive association between maternity leave and women's labor force participation.

2.4. Child Mortality

Reduction in the number of infants and child mortality has a compelling outcome in lowering fertility (Bradshaw, et al., 2023). When the rate of child mortality and number of infants decreases, parents' willingness to compensate for dead children with a new one also decreases (Brinker & Amonker, 2013). Similarly, behavioral as well as physiological

components are affected by mortality of children (Kirk & Pillet, 1998). In the sub-Saharan regions of Africa, infant deaths reduce the contraceptive effect of breast-feeding as well as the period of postpartum abstinence, thus reinforcing already high fertility. Behavioral changes act as a channel to involve and replace effects against dead infants. The insurance effect shapes the risk of mortality from the societal prevailing perception, whereas the replacement effect assimilates with the families' reaction to the death of a child. However, it is very difficult to support an empirical link between the level of child mortality and fertility (Kirk & Pillet, 1998). Firstly, fertility and child mortality respond to the same determinants (education, rural-urban residence, income), thus having positive coincidental relations. Secondly, high mortality results from smaller birth spacing and high fertility as in higher chances of conceiving because of climate, age, etc. Thirdly, a time lag is expected between the reduction of child mortality and parents' perception of it. In addition, Kirk and Pillet (1998) stated that the fertility transition effects are brought about through a reduction in the length of breastfeeding and postpartum abstinence which promoted the idea for smaller families, increasing use of contraceptives, and later age at first birth.

Educated women have the motivation and some knowledge of how to regulate their fertility more efficiently. The young, educated women of sub-Saharan Africa are frequently unmarried. They have the tendency to adopt efficient methods of family planning in the short run and continue to use contraceptives throughout their childbearing years. Incorporating them more formally into the design of family planning activities would seem to be appropriate, particularly for the countries in West Africa, where the progress of the fertility transition has been slow to date (Kirk, 1998). In a recent study, Bradshaw, et al. (2023) combines child mortality, household size and access to contraception to explain fertility control.

2.5. Perception on Use of Modern Contraceptive Methods

Women's ability to express their views and participate in household decisions without seeking their partner's approval is often defined as decision-making autonomy. In a study on Mexico, Cosío-Zavala (2009) finds that the use of birth control methods is strongly associated with women's emancipation. However, the decision to use contraceptives depends not only on women's own preferences but also on their husbands' acceptance, as well as on women's knowledge of available contraceptive methods (Cosío-Zavala, 2009).

Bongaarts (2002) argues that fertility has declined sharply, particularly in the developing world. He notes that couples do not base their family-size decisions on the theoretical notion of replacement fertility. Many developed countries have already reached very low fertility levels and are likely to fall further below replacement. A key factor driving this decline is delayed childbearing. According to Bongaarts (2002), the "postponement effect" - whereby younger women extend the spacing between births - began in the 1970s and continues in many developed societies. Once this wave of postponement subsides, period fertility is expected to recover somewhat. In other words, the tempo effect will eventually fade, and a modest upward trend in fertility may emerge. However, significant upward pressure on period fertility could challenge women's ability to determine their preferred family size, particularly in contexts where contemporary norms favour having two children, but childbearing increasingly begins at older ages (Bongaarts, 2002).

Recent studies such as Dasgupta, et al. (2022) highlight variation across regions in terms of fertility transition and contraceptive use. For example, African regions experience a slower transition compared with Asia, Latin America, and the Caribbean. From a different perspective, Götmark & Andersson (2023) suggest that fertility transition is primarily driven by access to modern contraceptives and family planning services rather than by broader macroeconomic conditions. In contrast, Ahinkorah, et al. (2021) report a low incidence of modern contraceptive use even among women with no intention to have children. They suggest that demographic and socioeconomic factors such as age, literacy, mass media exposure, surrounding environment and community context play important role in deciding modern contraceptive use.

2.6. Summary

The literature discovers several socioeconomic and demographic factors that drive fertility transition. In line with this evidence, the present study examines the roles of women's education, female labour force participation, national income, infant mortality, and contraceptive use in explaining fertility transition in Bangladesh. Although these determinants have been tested individually in previous studies, the existing literature has not examined them within a comprehensive empirical framework for Bangladesh. This study addresses that gap by developing and estimating an integrated model that captures the combined effects of these key determinants on fertility transition.

Among the determinants highlighted in the literature, abortion is legally restricted in Bangladesh, while reliable data on women's marriage patterns, sexual behavior, and postpartum infecundity are not readily available. Consequently, these variables could not be included in the empirical analysis.

3. METHODOLOGY

The objective of the study is to identify the factors that influence total fertility rate. Hence, total fertility rate is taken as the dependent variable, while women's schooling (Kim, 2023; Zhang & Zhao, 2023; Chen, 2022), participation in labour force (Brinker & Amonker, 2013; Doepke, et al., 2023; Del Rey, Kyriacou & Silva, 2021), national income level (van Wijk, 2024; Doepke, et al., 2023), infant mortality rate (Bradshaw, et al. 2023; Brinker & Amonker, 2013) and demand for modern family planning techniques (Dasgupta, et al. 2022; Götmark & Andersson, 2023; Ahinkorah, et al., 2021) are included as the explanatory variables. As such, the model designed for the study stands as follows:

$$TFR = \alpha + \beta_1 WSCH + \beta_2 WL + \beta_3 HI + \beta_4 IMR + \beta_5 DMFP + \mu_t \quad (1)$$

Here:

TFR is the total fertility rate taken as birth per women in logarithm, WSCH is the women's schooling enrolled at secondary level taken as percentage of gross, WL is the women's participation in labour force taken as percentage of total labour force, HI is the household income level take as natural log of gross national income (GNI) per capita, IMR is the infant mortality rate per thousand live birth taken in natural log, DMFP is the demand for family planning which takes contraceptive prevalence in any method (as percentage of married women ages 15-49) as a proxy, and μ_t is the error term

3.1. Construction and Description of Variables

Data has been collected from World Bank database (WDI – World Development Indicator). Data period covers from 1980 to 2024, which is consistent with data availability and source reliability. Model has been estimated using the ARDL approach, applied with ECM. Conventional approaches have been followed for time series analysis, such as, overviewing data summary, checking data stationarity using Augmented Dickey-Fuller (ADF) unit-root test, checking lag length criteria using AIC, SC and HQ approach, and finally doing ARDL estimation applied with ECM.

ARDL-ECM offers several advantages over other time-series econometric methods such as handling variables with a mixture of I (0) and I (1) (provided none are I(2)), performs well with relatively small sample sizes, and simultaneously estimates both long-run equilibrium relationships and short-run dynamics within a single framework. Unlike traditional cointegration techniques such as Engle–Granger and Johansen, it handles variables with different order of integration and provides a straightforward bounds testing approach for cointegration. Additionally, the error correction term measures the speed at which short-run deviations adjust toward long-run equilibrium, while the flexible lag structure allows different variables to have different lag lengths, improving model specification. These features make ARDL-ECM a reliable approach for analysing dynamic relationships and suggesting policy decisions in economics and related fields.

Results are presented and discussed in the next section.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

Table 1 presents the descriptive statistics for the variables included in the analysis. All variables include 45 observations, thus making a balanced dataset for the empirical investigation.

Table 1
Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
TFR	45	1.175591	0.3595318	0.7603384	1.844668
WSCH	45	42.18444	21.70371	6.40982	75.08965
WL	45	25.98164	5.703007	18.708	36.941
HI	45	25.35633	0.7115246	24.26658	26.60382
IMR	45	4.001533	0.5731289	3.194583	4.888091
DMFP	45	49.60444	17.65651	12.1	84.8

Note: Std. Dev. represents Standard Deviation and Obs. denotes Number of Observations.

Overall, the summary statistics indicate substantial variation across the explanatory variables. Women’s years of schooling (WSCH) and the demand for modern family planning (DMFP) exhibit relatively large variation, suggesting diversity in educational attainment and use of family planning services across the sample. Such variations may contribute to differences in fertility behaviour,

since higher education level and greater access to modern family planning generally associate with lower fertility rates.

In contrast, the household income (HI) and infant mortality rate (IMR) show relatively low variability, indicating that these indicators are comparatively stable across the observations. The low diversity in these variables suggests that their effects on fertility are likely to arise from gradual differences rather than large fluctuations.

The total fertility rate (TFR) shows moderate variation across the sample, reflecting differences in fertility outcomes among the observed units. This variation provides sufficient scope to examine how socioeconomic and demographic factors influence fertility behaviour. Likewise, women labour force participation (WL) exhibits moderate variation, indicating differences in level of education may influence reproductive choices and family size.

Overall, the descriptive statistics suggest that the dataset captures meaningful heterogeneity in the key explanatory variables, making it suitable for investigating the determinants of fertility. The observed variation in education, family planning, health, and demographic indicators provides a useful basis for the subsequent econometric analysis of total fertility rates.

4.2. Unit Root Test for Time Series

The Dickey-Fuller unit root test is used for confirming stationarity of data. The null hypothesis of ADF test states that the time series is non-stationary. If the P-value is ≤ 0.05 (at 5 percent significance level), the null hypothesis is rejected confirming stationarity of data. If the P-value is > 0.05 , the null hypothesis cannot be rejected indicating non-stationarity of data. Results for unit root test are presented in Table 2.¹

Table 2

Results for ADF Unit Root Test

Variables	Probability		
	Level	First Diff.	Second Diff.
TFR	0.0001	0.0503	0.0420
WSCH	0.4419	0.0035	0.217
WL	0.5653	0.0347	0.0505
HI	0.7926	0.4351	0.7482
IMR	0.5605	0.0008	0.0271
DMFP	0.0019	0.1104	0.0311

For total fertility rate, the p value < 0.05 at level. Therefore, we reject null hypothesis at level. Hence, the time series for total fertility rate is stationary at level. For women's schooling, the p value < 0.05 at first difference. Therefore, we reject null hypothesis at first difference. Hence, the time series for women's schooling is stationary at first difference.

For women labour participation, the p value < 0.05 at first difference. Therefore, we reject null hypothesis at first difference. Hence, the time series for women labour participation is stationary at first difference. For infant mortality rate, the p value < 0.05

¹ The Augmented Dickey-Fuller (ADF) test explicitly accounts for serial correlation by including lagged difference terms, resulting in more reliable estimates when residuals are autocorrelated. It also allows optimal lag selection using information criteria, performs relatively well in small samples, and provides a straightforward parametric framework for unit root testing. In contrast, the PP test corrects serial correlation and heteroskedasticity using non-parametric adjustments, which can be more sensitive to bandwidth selection and may be less efficient in small samples.

at first difference. Therefore, we reject null hypothesis at first difference. Hence, the time series for infant mortality rate is stationary at first difference. For demand for family planning, the p value < 0.05 at level. Therefore, we reject null hypothesis at level. Hence, the time series for demand for family planning is stationary at level.

For household income, the p value > 0.05 even at second difference. Therefore, we cannot reject null hypothesis even at second difference. Hence, the time series for household income is non-stationary even at second difference. This may happen due to data quality, which is out of scope to control in this study. Since data is collected from World Bank database, which is most reliable source in this case, we prefer to drop the variable from the model.

Hence, except for household income, remaining variables fit for ARDL analysis.

4.3. Model Fitness

Table 3
Model Fitness

R^2	0.9562
Adjusted R^2	0.9165
Root MSE	0.0048
Log Likelihood	174.6078

The model fitness is very high. The R-square value suggests that the ARDL specification explains approximately more than 90 percent of the variation in total fertility rate.

4.4. Regression Results

Regression of Equation 1 is estimated with Autoregressive Distributed Lag (ARDL) technique applied with error correction model. According to different lag-selection criteria, the maximum preferred lag-length was 4 (The lag-selection table is presented in Appendix). Accordingly, the optimal lag-length of four was specified for the ARDL model. Stata evaluated all possible lag combinations up to this limit using AIC criteria. The short-run ECM incorporates up to three lags, which were selected within the estimation process. Estimated results for long-term coefficients are presented in Table 4 and short-run dynamics are presented in Table 5.

The results for long-term coefficients can be interpreted as follows. In Table 4, the first variable represents the error-correction term (ECT). That is, the coefficient of the lagged dependent variable in the ECM output. As expected, the error-correction term is negative and significant, indicating the speed of adjustment back to the long-run equilibrium. The coefficient value of ECM is 0.66, referring that 66 percent deviation of total fertility rate from the long-run (LR) equilibrium is corrected each period. Among the independent variables, women's schooling, women labor participation and demand for family planning show negative and significant long-term effect on total fertility rate, while infant mortality rate shows positive and significant long-term effect on total fertility rate. Coefficients for all four independent variables are significant at 1 percent level. The long-term coefficient for women's schooling is -0.0679, indicating that 1 percent increase in women's schooling decreases total fertility rate by 0.068 percent in long-run. The long-term coefficient for women labor participation is -0.2781, indicating that 1 percent increase in women labour participation decreases total fertility rate by 0.278 percent in long-run. The long-term coefficient for infant

mortality rate is 0.4252, indicating that 1 percent increase in infant mortality rate increases total fertility rate by 0.425 percent in long-run. The long-term coefficient for demand for family planning is -0.0956, indicating that 1 percent increase in demand for family planning decreases total fertility rate by 0.096 percent in long-run. The result is consistent with Gani (2016), Kim (2023), Zhang and Zhao (2023), Brinker & Amonker (2013), Bradshaw, et al. (2023), Cosío-Zavala (2009) & Götmark & Andersson (2023); while contrasts with Doepke, et al. (2023) and Del Rey, Kyriacou & Silva (2021).

Table 4
Results of the ARDL Estimation Long-run Coefficients

Variable	Coefficient	Interpretation
TFR (Error-correction term)	-0.6606*** (0.0874)	Approximately 66 percent deviation from long-run (LR) equilibrium is corrected each period
WSCH	-0.0679*** (0.0192)	1 percent increase in WSCH decreases TFR by 0.068 percent in LR
WL	-0.2781*** (0.0515)	1 percent increase in WL decreases TFR by 0.278 percent in LR
IMR	0.4252*** (0.0197)	1 percent increase in IMR increases TFR by 0.425 percent in LR
DMFP	-0.0956*** (0.0272)	1 percent increase in DMFP decreases TFR by 0.096 percent in LR

Note: Values in parentheses are standard errors. ***, ** and * indicate statistical significance at 1 percent, 5 percent, and 10 percent level, respectively.

4.4.1. Results of the ARDL Estimation: Short-Run Dynamics

Table 5 presents the estimated short-run dynamics from the ARDL model. The results indicate that the effects of the explanatory variables on total fertility rate (TFR) differ across lag structures, suggesting that short-run adjustments are not immediate.

Table 5
Results of the ARDL Estimation Short-Run Dynamics

Variable	Lag 0	Lag 1	Lag 2	Lag 3
TFR	—	0.6289*** (0.1112)	0.4953*** (.1371)	1.1657*** (0.1871)
WSCH	-0.0135 (0.0133)	-0.0231 (.0146)	0.0232 (0.0145)	0.0670*** (0.0133)
WL	—	—	—	—
IMR	2.1443*** (0.4421)	0.8282** (0.3878)	-2.3411*** (0.4252)	—
DMFP	-0.0366 (0.0279)	0.0382 (0.0268)	-0.0002 (0.0235)	0.0733*** (0.0195)

Note: Values in parentheses are standard errors. ***, ** and * indicate statistical significance at 1 percent, 5 percent, and 10 percent level, respectively.

Among the independent variables, women's schooling shows only positive and significant short-run coefficient at third lag, valued 0.0670. This indicates a delayed positive short-run effect of women's schooling on total fertility rate. Similarly, the short-run coefficient for demand for family planning is positive and significant only at third lag with a value of 0.0733. This indicates a delayed positive short-run effect of demand for family planning on total fertility rate. Finally, the short-run coefficient for infant mortality rate is positive and

significant at lag 0 (2.14 percent) and lag 1 (0.83 percent), while negative and significant at lag 2 (2.34 percent). This indicates short-term volatile effect of infant mortality rate on total fertility rate. Interestingly, women labor participation does not exhibit any short-term influence on total fertility rate, though it has long-term negative significant influence.

Women's schooling (WSCH) has a positive and statistically significant coefficient only at the third lag, while the coefficients at earlier lags are statistically insignificant. Similarly, the demand for modern family planning (DMFP) is positive and statistically significant only at the third lag. Although these positive short-run coefficients appear to contradict the conventional expectation that higher educational attainment and greater use of family planning reduce fertility, they should be interpreted with caution. In an ARDL framework, short-run coefficients capture temporary adjustments rather than long-term behavioural relationships. The positive lagged effects may reflect delayed demographic responses and transitional changes in reproductive behaviour rather than a continued positive impact of education or family planning on fertility. These short-run estimates not necessarily overturn the long-run relationship, which is more relevant for assessing the effects of socioeconomic factors on fertility behaviour.

The infant mortality rate (IMR) exhibits a mixed short-run pattern. The immediate effect is positive and highly significant which gradually turns to negative and highly significant in second lag. This changing pattern suggests that the influence of infant mortality on fertility is dynamic in the short run, reflecting temporary adjustments before converging toward the long-run equilibrium. This is consistent with the human tendency of gradual adaptation to changes.

Women's labour force participation (WL) does not show any short-run effect on fertility. This finding suggests that women's participation in the labour force do not immediately translate into changes in fertility behaviour. However, the long-run significant negative association with fertility imply that the influence of women's labour force participation materialises gradually over time rather than through immediate adjustments.

4.5. Post-estimation Reliability Check

Table 6
Results for Post-estimation Reliability Check

Name of Test	Test Result	Decision
Durbin-Watson d-statistic	2.087099	No autocorrelation
Breusch-Pagan/Cook-Weisberg test for heteroskedasticity	Prob > chi ² = 0.1441	Constant variance; homoscedastic data

The Durbin-Watson d-statistic test for autocorrelation and Breusch-Pagan/Cook-Weisberg test for heteroskedasticity confirm that the data is free from autocorrelation and heteroscedasticity. Hence the results are reliable.

Table 7
ARDL Bounds Test for Cointegration

Test	Statistic	10% I(0)	10% I(1)	5% I(0)	5% I(1)	1% I(0)	1% I(1)	Decision
F-statistic	13.144	2.539	4.011	3.116	4.82	4.531	6.785	Reject H ₀
t-statistic	-7.559	-2.421	-3.540	-2.803	-3.990	-3.588	-4.914	Reject H ₀

Model information: Case 3 (unrestricted intercept and no trend); 4 variables; 41 observations; 14 short-run coefficients.

The ARDL Bounds Test was conducted to examine whether a long-run equilibrium relationship exists among the variables in the model. The results are reported in Table 7. The calculated F-statistic is 13.144, which exceeds the upper-bound $I(1)$ critical values of 4.011, 4.820, and 6.785 at the 10 percent, 5 percent, and 1 percent significance levels, respectively. Similarly, the calculated t-statistic of -7.559 is more negative than the corresponding upper-bound critical values of -3.540 , -3.990 , and -4.914 . The approximate p-values associated with both statistics are 0.000.

Thus, the null hypothesis of no level relationship is rejected at the 1 percent significance level. The results provide strong evidence of cointegration among the variables, indicating the existence of a stable long-run equilibrium relationship. Consequently, the long-run coefficients estimated from the ARDL model can be interpreted as meaningful long-run relationships among the variables. The evidence of cointegration also justifies the estimation of the corresponding error correction model (ECM) to examine the short-run dynamics and the speed at which deviations from the long-run equilibrium are corrected.

4.6. Discussion

The decline of fertility in Bangladesh began around 1975, with a particularly pronounced decline observed from the 1980s onward, when the total fertility rate (TFR) was approximately 6.359. The fertility rate continued to decline steadily and reached around 2.029 in 2019. The empirical findings of this study indicate that fertility is closely associated with women's schooling, female labour force participation, infant mortality, and contraceptive use and family planning. These findings are broadly consistent with the existing literature, including Gani (2016); Kim (2023); Zhang & Zhao (2023), Brinker & Amonker (2013), Bradshaw, et al. (2023), Cosío-Zavala (2009), & Götmark & Andersson (2023). However, the observed associations do not necessarily imply that each variable independently and directly causes changes in fertility. Therefore, the results should primarily be interpreted as evidence of systematic relationships rather than definitive proof of causal effects.

Female education has played an important role in Bangladesh's social transformation. Historically, parents were less likely to send girls to school because of traditional gender norms and the perception that women's primary responsibilities concentrate in household. Promoting free or subsidised education for girls contributed to increased female school enrolment and may have altered attitudes of parents and children toward women's roles, marriage, and childbearing. In fact, education influence fertility through several channels such as increased awareness of reproductive health, greater autonomy in household decision-making, delayed marriage, and stronger preferences for smaller families. Thus, the observed inverse relationship between women's schooling and fertility is theoretically plausible and consistent with previous research.

Nevertheless, female education and fertility may suffer from endogeneity. Instead of being randomly distributed across women or households, education may be correlated with household income, urbanisation, parental education, access to health services, social norms, and geographic location. These factors may simultaneously affect both educational attainment and fertility decisions. Moreover, women who intend to have fewer children may invest more years in education. Consequently, the negative association between women's schooling and fertility can be interpreted beyond a purely causal effect of education. Hence, the long-run relationship identified in this study is therefore consistent with the argument that increased

female education contributed to fertility decline, as well as capture the influence of broader socioeconomic modernisation caused by the expansion of women's education.

Female labour force participation appears as another important explanation for the fertility transition. In the 1980s, women's labour force participation was approximately 10 percent, while the TFR was around 6.4 children per woman. Over subsequent decades, female labour force participation increased alongside a substantial decline in fertility. The inverse relationship is consistent with the opportunity-cost argument: when women participate in paid employment, childbearing and childcare cause sacrifice of earnings and career opportunities. This may reduce the expectation for additional children. Similarly, educated mothers may increasingly prioritise investment in the quality of children rather than the number of children, as raising children—particularly through greater investment in education—can be costly (Xu & Pak, 2021).

However, the relationship between labour force participation and fertility is also potentially endogenous and may not be unidirectional. Women with fewer children may find it easier to enter or remain in the labour market, meaning that declining fertility could itself increase female labour force participation. In addition, the expansion of employment opportunities, changes in industrial structure, particularly the growth of the ready-made garment sector, urbanisation, and rising household income may have simultaneously contributed to both higher female labour force participation and lower fertility. Therefore, the negative relationship observed in the analysis may reflect both a causal effect of employment on fertility and reverse causality from fertility decisions to women's labour market participation. The empirical results thus support the existence of a long-run association between these variables but should not be interpreted as establishing a one-way causal relationship.

The decline in infant mortality is another important component of the fertility transition. A high infant or child mortality rate may encourage parents to have additional births as a form of replacement or insurance against the loss of a child. Conversely, reductions in mortality may reduce the perceived need for larger families. In Bangladesh, the infant mortality rate declined substantially, from approximately 133.6 deaths per 1,000 live births in the 1980s to about 25.1 in 2019, while the TFR declined from approximately 6.3 to 2.029 over a similar period. These trends are consistent with the demographic transition hypothesis that declining child mortality contributes to lower fertility.

Nevertheless, infant mortality and fertility may engage common underlying determinants. For example, high fertility and short birth intervals may increase the risk of infant and child mortality, implying that fertility itself can affect mortality outcomes. At the same time, improvements in maternal education, nutrition, household income, sanitation, healthcare access, and public health infrastructure can reduce both infant mortality and fertility. Therefore, the positive relationship between infant mortality and fertility may imply a complex interaction beyond the causal effect running from mortality to fertility.

Contraceptive use and family planning constitute another important mechanism underlying fertility decline. The transition from traditional to modern contraceptive methods and access to reproductive health services, has enabled couples' ability to control the timing and number of births. Government initiatives such as family-planning infrastructure, dissemination of information about family-planning services, and promotion of contraceptive methods also played important role in promoting smaller family sizes (Rob, et al. 2003). The expansion of these services increased access to effective contraception, thereby contributing to the decline in fertility.

However, contraceptive use may suffer from endogeneity. Couples who already desire fewer children or achieved their desired family size are more likely to adopt contraception.

Thus, the observed negative relationship between contraceptive use and fertility may partly reflect reverse causality: lower desired fertility may cause greater contraceptive use rather than contraceptive use alone causing lower fertility. Furthermore, government family-planning programmes may have been targeted toward regions or populations with relatively high fertility, potentially creating selection or programme-placement effects. Changes in women's education, household income, access to healthcare, and social norms may also jointly influence both contraceptive adoption and fertility.

Overall, the empirical results indicate that women's schooling, female labour force participation, infant mortality, and contraceptive use are important correlates of Bangladesh's fertility transition, particularly in the long run. The findings are broadly consistent with demographic and economic theories of fertility transition. However, the relationships among these variables are likely to be dynamic and mutually reinforcing, and potential endogeneity, reverse causality, and omitted-variable bias mean that the estimated coefficients should not automatically be interpreted as structural causal effects. The long-run relationships identified in the study therefore provide evidence that these factors are systematically linked to fertility decline, while a delayed (at lag 3) statistically significant relationship for contraceptive use in the short run suggests that the effects of family-planning adoption may take time to materialise. More broadly, the findings suggest that Bangladesh's fertility transition is better understood as the outcome of an interconnected process involving improvements in education, women's economic opportunities, child survival, reproductive health services, and changing social norms, rather than as the result of any single causal factor operating in isolation.

5. CONCLUSION AND RECOMMENDATION

Following independence, Bangladesh faced rapid population growth as a threat to its socioeconomic development. This phenomenon prompted the introduction of its first population policy in 1976. Since then, the country has realized a gradual decline in fertility, supplemented by improvements in women's education, increased female labor force participation, reduced child mortality, and expanded access to modern family planning services. The findings further strengthen these factors as key determinants of fertility decline and provide important policy implications. To maintain the progress, policymakers should fortify investments in female education and employment, expand affordable childcare facilities, promote birth spacing through effective reproductive health programs, and further enhance family planning and population policies to support sustainable demographic and economic development.

This study has several limitations that offer future research directions. First, it could not examine the determinants of the total fertility rate (TFR) across different age groups of women, which would require primary or more detailed micro-level data. Second, differences in fertility behavior between urban and rural populations could not be adequately acquired because of using secondary aggregate data. The study also failed to evaluate the effects of factors such as delayed marriage, birth spacing practices and permanent sterilization on fertility outcomes because of data limitations. In addition, alternative indicators of fertility transition, such as the Crude Birth Rate (CBR), may be examined if suitable data are available. Finally, incorporating measures of son preference - identified as an important determinant of fertility behavior in previous studies (e.g., Hoque & Boulier, 2020; Javed & Mughal, 2022)—could further improve the model, although obtaining reliable data on this variable was a challenge.

APPENDIX: LAG-SELECTION TABLE

Table A1

Test Results for Lag-Selection

Variable	Lag	LR	FPE	AIC	HQIC	SBIC
TFR	0	—	0.099537	0.530637	0.545856	0.572432
	1	268.68	0.000149	-5.97378	-5.94335	-5.8902
	2	26.808*	0.000081*	-6.57885*	-6.53319*	-6.45347*
	3	0.04664	0.000085	-6.53121	-6.47033	-6.36403
	4	0.33302	0.000089	-6.49055	-6.41445	-6.28158
WSCH	0	—	401.916	8.83411	8.84933	8.8759
	1	174.92	5.92212	4.61649	4.64693	4.70008
	2	4.8668*	5.5232*	4.54657*	4.59223*	4.67196*
	3	0.43605	5.74002	4.58472	4.64559	4.7519
	4	0.43661	5.96669	4.62285	4.69895	4.83182
WL	0	—	31.0118	6.27224	6.28746	6.31403
	1	203.23	0.229109	1.36424	1.39468	1.44783
	2	12.788*	0.176136	1.10111	1.14677*	1.22650*
	3	0.90287	0.180978	1.12787	1.18875	1.29505
	4	3.1971	0.175875*	1.09868*	1.17477	1.30765
NI	0	—	0.453766	2.04769	2.06291	2.08949
	1	325.650*	0.000169*	-5.84617*	-5.81573*	-5.76258*
	2	0.00841	0.000178	-5.7976	-5.75194	-5.67221
	3	0.2331	0.000186	-5.7545	-5.69362	-5.58732
	4	0.02312	0.000195	-5.70628	-5.63019	-5.49731
IMR	0	—	0.289251	1.59741	1.61263	1.6392
	1	304.54	0.000181	-5.78159	-5.75115	-5.698
	2	112.24	0.000012	-8.47039	-8.42473	-8.34501
	3	0.20522	0.000013	-8.42662	-8.36574	-8.25944
	4	7.5573*	0.000011*	-8.56216*	-8.48606*	-8.35319*
DMFP	0	—	231.473	8.28233	8.29755	8.32412
	1	112.900*	15.4831	5.57755	5.60799	5.66114
	2	3.8065	14.8185	5.53349	5.57915*	5.65887*
	3	2.2284	14.7415	5.52792	5.5888	5.6951
	4	2.1543	14.6949*	5.52415*	5.60025	5.73313

Table A2

Summary Table for Lag-Selection

Variable	LR	FPE	AIC	HQIC	SBIC	Overall/Preferred Lag
TFR	2	2	2	2	2	2
WSCH	2	2	2	2	2	2
WL	2	4	4	2	2	2
NI	1	1	1	1	1	1
IMR	4	4	4	4	4	4
DMFP	1	4	4	2	2	2

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Declarations

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