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Original Article

Socio-Economic Factors Associated with Fertility Rate in Iran: An Ecological Study, 2017–2021

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Abstract

Introduction: Declining fertility rates have become a major demographic concern in many countries, including Iran. Identifying the socio-economic determinants of fertility is essential for designing effective population policies. This study aimed to investigate the association between selected economic and social factors and fertility rates in Iran.

Methods: This ecological panel study used aggregated data from 31 provinces of Iran over the period 2017–2021. The fertility rate was considered the dependent variable. Independent variables included economic indicators (household income and expenditure, food and non-food expenditure, inflation rate, unemployment rate, female employment rate, and GDP per capita) and social indicators (literacy rate, marriage rate, and divorce rate). Panel data models were estimated using fixed effects with cluster-robust standard errors.

Results: Social variables showed more consistent associations with fertility than economic variables. The marriage rate exhibited the strongest positive association with fertility ($\beta = 0.23$, $P < 0.01$), whereas the divorce rate showed the strongest negative association ($\beta = -0.34$, $P < 0.01$). Among economic factors, household income ($\beta = -0.11$, $P < 0.05$) and food expenditure ($\beta = -0.17$, $P < 0.01$) were negatively associated with fertility in the multivariate models. In contrast, macroeconomic variables such as inflation, unemployment, female employment, and GDP per capita were not statistically significant after controlling for other factors.

Conclusion: Fertility patterns in Iran appear more closely associated with social dynamics than with short-term economic conditions. These findings suggest that policies aimed at increasing fertility should prioritize strengthening family formation—particularly by facilitating marriage and reducing divorce—while also addressing household economic constraints. The results should be interpreted at the provincial level and do not imply causal relationships.

Keywords: Fertility rate, Socio-economic factors, Panel data, Ecological study, Iran

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Introduction

Population policymaking has become an essential component of governance in the modern world, focusing on the size, structure, and dynamics of populations and their interactions with broader socio-economic systems (1). As societies become more complex and industrialized, demographic considerations play an increasingly critical role in shaping economic, social, and political planning (2). Neglecting population structure can lead to imbalances in resource allocation and long-term development challenges(3). Among the key demographic components, fertility, mortality, and migration are the primary determinants of population size and composition (4).

Fertility, in particular, is a central indicator of demographic change. It is commonly measured by the total fertility rate (TFR), which represents the average number of children a woman is expected to have over her lifetime. Replacement-level fertility is generally considered to be around two children per woman; however, variations in marriage patterns, childbearing preferences, and socio-economic conditions can lead to substantial deviations from this level (5). Importantly, fertility trends do not follow a uniform pattern across countries and are influenced by a wide range of contextual factors (6).

Global evidence suggests that fertility rates have declined significantly over the past few decades. Between 2015 and 2020, the global fertility rate reached a historic low of 2.47 births per woman, and this declining trend is expected to continue in many regions (7). Iran, as a developing country, has experienced a rapid fertility transition over the past decades. The total fertility rate declined from approximately 7.7 in 1966 to 1.8 in 2006, then rose to 2.2 in 2014 and subsequently declined to 1.7 in 2018 (8, 9). This sustained reduction in fertility has raised concerns about population aging, labor force shrinkage, and long-

term economic sustainability.

A decline in fertility can have profound socio-economic consequences. Lower fertility rates may reduce the size of the future workforce, affect productivity, and influence human capital formation (10, 11). At the same time, fertility behavior is shaped by multiple interrelated factors, including economic conditions, educational attainment, labor market participation, and family-related institutions. For instance, household income and costs associated with childrearing, such as food and education expenses, can influence fertility decisions. Similarly, social factors such as marriage and divorce patterns play a crucial role in shaping reproductive behavior (12).

A growing body of literature has examined the determinants of fertility across different contexts. Lal et al. (7). found that variables such as contraceptive prevalence, female labor force participation, and inflation are negatively associated with fertility, while GDP also exhibits a negative relationship. In Iran, Nasiri et al. (9) reported that unemployment, female employment, and household expenditures were negatively associated with fertility, whereas GDP per capita was positively associated with fertility. Furthermore, Pourreza et al. (13) highlighted the importance of health, cultural, economic, and political factors in explaining fertility decline in the Middle East and North Africa region.

Despite the existing evidence, the relative importance of economic and social factors may vary across contexts and time periods. In recent years, Iran has experienced notable socio-economic changes, including fluctuations in inflation, employment conditions, and household costs, alongside shifts in marriage and divorce patterns. Understanding how these factors jointly influence fertility is essential for designing effective population policies.

Given the recent decline in fertility and its potential implications for demographic structure and sustainable development, identifying the key determinants of fertility has become a policy priority. However, limited studies have focused on recent provincial-level panel data in Iran. Therefore, this study aims to investigate the impact of selected economic and social factors on fertility rates across Iranian provinces over the period 2017–2021 using a panel data approach. The findings are expected to provide empirical evidence to inform policymakers in designing targeted and effective fertility-related interventions.

Methods

This study is an ecological panel study using aggregated provincial-level data. The dataset consists of annual observations for 31 provinces of Iran over the period 2017–2021 (1396–1400). All data were obtained from the Statistical Center of Iran. Given the availability of complete provincial data, the entire population was included, and no sampling was performed.

Variables

The dependent variable was the fertility rate (total fertility rate per woman). Based on prior literature and data availability, a set of economic and social variables was selected as explanatory variables. Economic variables include total annual household expenditure, annual household income, food expenditure, non-food expenditure, per capita GDP, inflation rate, unemployment rate, and female employment rate. Social variables include literacy rates, marriage rates, and divorce rates.

To avoid multicollinearity between total expenditure and its components, two separate models were specified. In Model 1, total household expenditure is included; in Model 2, it is disaggregated into food and non-food components.

Model specification

The empirical analysis uses panel data techniques to control for unobserved heterogeneity across provinces. The general form of the estimated models is as follows:

Model 1

$$\text{Fertility\_it} = \beta 0 + \beta 1 \ln(\text{TotalExpenditure\_it}) + \beta 2 \ln(\text{Income\_it}) + \beta 3 \ln(\text{GDP\_it}) + \beta 4 \text{Inflation\_it} + \beta 5 \text{Unemployment\_it} + \beta 6 \text{FemaleEmployment\_it} + \beta 7 \text{Literacy\_it} + \beta 8 \text{Marriage\_it} + \beta 9 \text{Divorce\_it} + \mu\_i + \varepsilon\_it$$

Model 2

$$\text{Fertility\_it} = \gamma 0 + \gamma 1 \ln(\text{NonFoodExpenditure\_it}) + \gamma 2 \ln(\text{FoodExpenditure\_it}) + \gamma 3 \ln(\text{GDP\_it}) + \gamma 4 \text{Inflation\_it} + \gamma 5 \text{Unemployment\_it} + \gamma 6 \text{FemaleEmployment\_it} + \gamma 7 \text{Literacy\_it} + \gamma 8 \text{Marriage\_it} + \gamma 9 \text{Divorce\_it} + \mu\_i + \varepsilon\_it$$

where i denotes province, t denotes year, μ_i captures unobserved time-invariant provincial effects, and ε_it is the error term. A logarithmic transformation is applied to selected economic variables to reduce skewness and facilitate interpretation in terms of semi-elasticities.

To determine the appropriate panel model, the Chow test (F-Limer) was used to assess the suitability of pooled OLS versus panel estimation. Subsequently, the Hausman test was used to choose between fixed-effects (FE) and random-effects (RE) models. The results indicated that the fixed effects model is more appropriate for both specifications.

Given heteroskedasticity and serial correlation (as indicated by the modified Wald and Wooldridge tests), the models were estimated using fixed effects with robust standard errors clustered at the provincial level. This approach provides consistent inference in the presence of heteroskedasticity and within-panel autocorrelation.

Multicollinearity among explanatory variables was assessed using variance inflation factors (VIFs), and no serious multicollinearity was detected.

Results

The panel dataset includes 155 observations (31 provinces over 5 years). The mean fertility rate during the study period was 1.84 children per woman, ranging from 1.01 to 3.65 across provinces and years. Summary statistics for all variables are presented in Table 1.

Table 1. Descriptive statistics of variables

Variable	Mean	Standard error	Min	Max
Fertility rate	1.84	0.48	1.01	3.65
Total annual household expenses (thousand rials)	4.21×108	1.97×108	1.55×108	1.35×109
Total annual household income (thousand rials)	1.85×108	8.41×107	6.93×107	4.56×108
Annual household non-food expenses (thousand rials)	2.93×108	1.45×108	9.29×107	1.06×109
Annual household food expenses (thousand rials)	1.29×108	5.9×107	4.82×107	3.23×108
Per capita GDP (thousand rials)	1.06×109	1.08×109	2.33×108	5.88×109
Inflation rate	29.7	11.9	6.8	48.2
Unemployment rate	10.8	2.86	6.2	21.7
Women's employment rate	81.8	7.25	61.3	94.2
Literacy rate	88.03	3.19	81.06	93.7
Marriage rate	7.22	1.42	4.1	10.5
Divorce rate	2.07	0.45	0.93	3.1

Model selection

The results of the Chow test rejected the null hypothesis of pooled OLS for both models ($P<0.001$), indicating the appropriateness of panel data estimation (Table 2). Furthermore, the Hausman test results favored the fixed effects model over the random effects model ($P<0.05$), suggesting that unobserved provincial effects are correlated with the explanatory variables (Table 2). Therefore, the fixed effects specification was adopted for both models.

The modified Wald test indicated the presence of heteroskedasticity, and the Wooldridge test confirmed serial correlation in the panel data ($P<0.001$) (Table 3). To address these issues, the models were estimated using fixed effects with cluster-robust standard errors.

Multicollinearity was assessed using variance inflation factors (VIFs), and the results indicated no serious multicollinearity among the explanatory variables (Table 3).

Univariate analysis

The results of univariate regressions (Table 4) show that most economic and social variables are statistically associated with fertility rate, except for per capita GDP. Household expenditure, income, inflation, female employment, literacy, and the divorce rate were negatively associated with fertility, while the unemployment rate and marriage rate were positively associated (Table 4).

Among these variables, divorce rate and total household expenditure exhibited the strongest negative associations with fertility, whereas marriage rate showed the strongest positive association (Table 4).

Multivariate analysis

Model 1 (Total expenditure model): After controlling for other variables, annual household income, literacy rate, marriage rate, and divorce rate remained statistically significant. Household income and divorce rate were negatively associated with fertility, while literacy rate and marriage rate were positively associated (Table 5).

Model 2 (Disaggregated expenditure model): When expenditure was decomposed, food expenditure, literacy rate, marriage rate, and divorce rate were significantly associated with fertility. Food expenditure and divorce rate were negatively associated, while literacy rate and marriage rate remained positively associated (Table 5).

Across both models, marriage and divorce rates demonstrated the most consistent and robust associations with fertility. The marriage rate showed the strongest positive association ($\beta=0.23$, $P<0.001$), whereas the divorce rate showed the strongest negative association ($\beta=-0.34$, $P<0.001$).

Most macroeconomic variables (inflation, unemployment, female employment, and GDP per capita) were not statistically significant in the multivariate models, suggesting that their associations may be mediated through structural social factors.

Discussion

The results of this study show that fertility rates are influenced by both economic and social factors. While most variables are significantly associated with fertility in the univariate models (except GDP per capita), several of these relationships weaken or become insignificant in the multivariate analysis after controlling for structural social factors. This suggests that part of the observed effects in simpler models reflects shared variation among explanatory variables rather than independent impacts. In particular, macroeconomic indicators such as unemployment, inflation, and female employment appear to affect fertility mainly through structural channels such as marriage behavior and educational attainment, or are influenced by multicollinearity in aggregated data. Overall, the findings indicate that social and institutional factors—especially marriage and divorce rates—play a more fundamental role in explaining fertility differences across provinces than short-term economic fluctuations, consistent with demographic transition theory and economic perspectives on fertility behavior.

Among the social variables, the marriage and divorce rates demonstrated the strongest and most stable relationships with the fertility rate in both models. Similar

Table 2. Results of the Chow and Hausman test

The second model		The first model		Parameter	Name of the test
***P*-value**	**Amount**	***P*-value**	**Amount**		
<0.001	51.16	<0.001	50.73	F	Chow test (F-limer)
0.001	26.96	<0.001	25.50	Chi2	Hausman test

Table 3. Results of the heteroscedasticity, autocorrelation, and collinearity tests

Test	Statistic	*P*-value	Statistic	*P*-value
	Model 1		**Model 2**	
Modified Wald test for groupwise heteroskedasticity	χ^2=615.48	<0.001	χ^2=512.57	<0.001
Wooldridge test for autocorrelation	F=14.49	<0.001	F=15.49	<0.001
Mean variance inflation factor (VIF)	5.18	—	4.22	—

Table 4. The economic and social variables influencing fertility rate (univariate linear regression)

Variable	Coefficient	Std. Error	*P*-value
Total household expenditure	-0.41*	0.02	<0.001
Total household income	-0.38*	0.02	<0.001
GDP per capita	-0.02	0.06	0.720
Non-food expenditure	-0.34*	0.03	<0.001
Food expenditure	-0.38*	0.02	<0.001
Inflation rate	-0.01*	0.005	<0.001
Unemployment rate	0.07*	0.008	<0.001
Female employment rate	-0.02*	0.002	<0.001
Literacy rate	-0.08*	0.007	<0.001
Marriage rate	0.26*	0.02	<0.001
Divorce rate	-0.41*	0.08	<0.001

*A *P*-value<0.05 was considered statistically significant

Table 5. The economic and social variables influencing fertility rate (multivariate linear regression)

Variable	Model 1 Coefficient (*P*-value)	Model 2 Coefficient (*P*-value)
Total household expenditure	-0.06 (0.06)	—
Total household income	-0.11* (0.05)	—
Non-food expenditure	—	0.004 (0.06)
Food expenditure	—	-0.17* (0.06)
GDP per capita	-0.01 (0.03)	-0.01 (0.03)
Inflation rate	-0.001 (0.001)	-0.001 (0.001)
Unemployment rate	0.005 (0.007)	0.003 (0.007)
Female employment rate	-0.001 (0.002)	-0.001 (0.002)
Literacy rate	0.04* (0.007)	0.03* (0.008)
Marriage rate	0.23* (0.01)	0.23* (0.01)
Divorce rate	-0.34* (0.04)	-0.35* (0.04)

*A *P*-value<0.05 was considered statistically significant

findings were reported by Jafari et al. (14), who observed that the divorce rate had a significant negative effect on the total fertility rate, while a significant positive relationship was found between the marriage rate and the fertility rate. In 2012, Burger et al.(15). Also reported that declining marriage rates were among the factors contributing to fertility decline in South Africa. These findings are fully consistent with the theoretical framework.

In the present study, a significant positive relationship was observed between literacy rate—as a macro-level indicator of development—and fertility rate in both models. Specifically, within a given province, an increase in the literacy rate during the study period was, on average, associated with an increase in the province's fertility rate. These findings are not necessarily inconsistent with the studies by Reshadat et al. (16) and Adhikari(17), which reported an inverse relationship between women's educational attainment and fertility. The differing results may reflect differences in the level of analysis and in the underlying causal mechanisms. At the macro level, high literacy rates are generally associated with improvements in health indicators, reductions in child mortality, and an overall enhancement of quality of life, which, at certain stages of demographic transition, may exert a positive or moderating effect on fertility. In contrast, at the micro level, higher education among women directly influences individual preferences, age at marriage, and the opportunity costs of childbearing, thereby reducing fertility. Contrary to the findings of Pourreza et al. (13) and Lal et al. (7), which reported an inverse relationship between the female employment rate and fertility rate, the present study found no statistically significant relationship between these variables. This study used aggregate-level data. At this level, higher female employment rates may indicate greater economic development, which is associated with improved healthcare services, reduced child mortality, and, consequently, a reduced need for replacement fertility. These developmental characteristics may partially explain why no statistically significant association was observed between female employment and fertility at the macro level.

The significance pattern of the economic variables appeared to depend on the model structure. Specifically, in the first model, annual household income, and in the second model, annual household food expenditure, showed a significant inverse relationship with fertility rate. In a given province, a one-percent increase in these variables during the study period was, on average, associated with a decline in fertility rate within the same province. These findings are consistent with the studies by Țarcă et al. (18), Martine et al. (19), and Nasiri et al. (9), which suggest that improvements in household economic conditions are generally associated with a lower likelihood

of having children. In addition, food expenditures, as part of the direct costs of children, may intensify the financial burden on households and thereby influence decisions regarding additional childbearing. In the present study, no statistically significant relationship was observed between inflation rate and fertility, whereas Zulqarnain et al. (20) and Lal et al. (7) reported a significant inverse relationship between these two variables. Previous studies used long-term time-series data, whereas the present study employed panel data with a shorter time span. The effects of inflation may emerge with a time lag and therefore may not be observable within a specific short-term period. Similarly, no statistically significant relationship was observed between unemployment rate and fertility. Jafari et al. (14), in their study examining the impact of economic and social factors on fertility rate, also concluded that there was no statistically significant relationship between unemployment and fertility. In contrast, Adsera et al. (21) reported in a 2011 study that economic recession and rising unemployment were among the causes of fertility decline in the United States. Unemployment reduces income and increases economic uncertainty. From a rational-choice perspective, this situation would be expected to delay or discourage childbearing. However, the pattern of this relationship may differ across population groups. For example, unemployment among men—who are often considered the primary breadwinners—may exert a stronger negative effect on fertility, whereas among women the effect may be weaker or even reversed. In the present study, unemployment rates were not analyzed separately for men and women, which may have neutralized the negative effect of unemployment on fertility.

No statistically significant relationship was observed between GDP per capita and fertility rate in this study. In contrast, Nasiri et al. (9) and Audi (22) reported a statistically significant positive relationship between these two variables, whereas Lal et al. (7) found a statistically significant inverse relationship. This inconsistency may be explained by the possibility that the positive effects of development through reductions in child mortality and the negative effects associated with the opportunity costs of childbearing (through women's employment and education) offset one another.

This study, like any scientific research, is subject to several limitations that should be considered when interpreting the findings. First, the use of aggregated macro-level data may not adequately capture behavioral differences at the micro level (e.g., across income deciles), leading to aggregation bias or the ecological fallacy. Second, although the present model incorporated a broad range of social and economic variables, the possibility of omitted-variable bias cannot be completely ruled out, particularly with respect to unmeasured attitudinal and cultural factors such as family norms and individual preferences. Third, although province fixed effects were included to control for unobserved heterogeneity, the absence of year fixed effects may limit the ability to account for common temporal shocks affecting all provinces. Therefore, the results should be interpreted as associative rather than causal relationships. Finally, the findings of this study are specific to Iran and the study period (2017–2021); therefore, generalizing the results to other settings or time periods should be undertaken with caution. Nevertheless, identifying these limitations provides valuable directions for future research, including the use of micro-level data to investigate heterogeneous mechanisms and the integration of attitudinal variables into quantitative analytical frameworks.

Conclusion

This study examined the determinants of fertility using panel data models with a range of economic and social variables. The results indicate that social factors, particularly marriage and divorce rates, along with literacy, exhibit the most consistent associations with fertility across specifications. In contrast, the effects of economic variables vary across model specifications, with household income and food expenditure significant in different models. Overall, the findings suggest that fertility variation is more strongly linked to socio-demographic structures than to short-term macroeconomic conditions. These results highlight the importance of considering both structural social factors and economic constraints in understanding fertility dynamics, while also indicating that the influence of economic factors may operate through different dimensions of household well-being.

Authors' Contribution

Conceptualization: Fatemeh Esmaili
Data Curation: Fatemeh Esmaili
Formal analysis: Fatemeh Esmaili
Investigation: Fatemeh Esmaili
Methodology: Fatemeh Esmaili
Project administration: Mohsen Barooni
Resources: Fatemeh Esmaili
Software: Fatemeh Esmaili, Mohsen Barooni
Supervision: Mohsen Barooni
Validation: Mohsen Barooni
Visualization: Fatemeh Esmaili

Competing Interests

The authors declare no competing interests.

Declaration

Artificial intelligence (AI) tools were used to assist with language editing, translation, and word refinement. The authors reviewed and verified all content and take full responsibility for the final manuscript.

Ethical Approval

All data used in this study were publicly available from the Statistical Center of Iran and did not contain any personally identifiable information. Accordingly, this study did not require approval from an ethics committee. However, the researchers adhered to all ethical principles in the study, including scientific accuracy and transparency.

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