

Explaining the Spatial Changes of Fertility in Iran's Counties: Patterns and Determinants (2011-2016)

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Abstract

Background: Fertility rates in Iran have undergone significant changes in recent decades, raising concerns about population dynamics and the country's future demographic structure. This study investigates the spatial distribution of fertility across Iranian counties and examines the impact of socioeconomic and demographic variables on fertility patterns.

Methods: This study employs a secondary data analysis approach. The dataset comprised 429 counties in Iran from 2011 to 2016, derived from national census data. Descriptive statistics, ordinary least squares (OLS) regression, and geographically weighted regression (GWR) were employed to investigate the spatially varying relationships between socioeconomic and demographic factors and fertility rates.

Results: The findings indicate that central counties exhibit favorable economic and social conditions, including higher levels of female education. Fertility rates were highest in southeastern and eastern counties, which shared similar socioeconomic contexts. GWR results showed that female education had the strongest influence on fertility in Western, Northern, and Northeastern counties, while its effect was lowest in Sistan and Baluchestan.

Conclusion: Although all examined variables significantly contribute to explaining fertility variation, their relative influence differs across geographical regions. Spatial analysis methods, which emphasize the role of location and place, reveal that the effects of determinants vary locally, providing a more precise understanding of county-level fertility patterns and their spatial interconnections.

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Introduction

The fertility rate in Iran has undergone remarkable and unprecedented transformations in recent decades. Since the 1990s, the country has experienced a sharp decline in its total fertility rate (TFR), which peaked at approximately 6.5 children per woman in the 1980s and fell to 2.01 by 2016.¹ According to the latest reports from the Iranian Statistics Center, the estimated TFRs

for 2017, 2018, 2019, and 2020 were 2.07, 1.97, 1.77, and 1.71, respectively.

Despite the overall downward trend, fertility experiences vary significantly across Iranian counties. For example, in southeastern cities such as Mehriz, Sib o Soran, and Saravan, fertility remains above five children per woman, and, compared to 1996, these counties have even witnessed an increase in fertility. By contrast, in northern counties such as Bandar-e

Anzali, Lahijan, and Taleghan, the TFR has dropped to below 1.2. Overall, the decline in fertility continues in most counties.²

Official statistics indicate that since the early 1980s, Iran has experienced a 3.5-fold reduction in total fertility, a change that has raised considerable concern about the country's demographic future. In response, various policies have been introduced in recent years to reverse the trend and encourage higher fertility. Examples include the *General Population Policies* declared by the Supreme Leader of the Islamic Republic of Iran in 2014 and the *Youth Plan for Population and Family Support* adopted by the Islamic Consultative Assembly in 2021.

The significance of elucidating and comprehending fluctuations in fertility rates in Iran for accurate and systematic policymaking cannot be overstated. Considerable research has been conducted to investigate these fluctuations, focusing on a wide range of determinants. Some studies have examined proximate factors such as changes in the age at marriage and contraceptive use.³ Others have explored the influence of demographic and social characteristics, including religion and family status,⁴ as well as broader themes such as family and fertility transitions,⁴ women's independence, and gender equality within households.⁴⁻⁶ In addition, the *tempo effect* has been highlighted, particularly regarding secular shifts in childbearing age that create discrepancies between the total fertility rate (TFR) and the completed fertility rate (CFR).⁷

Economic insecurity,⁸ occupational characteristics,⁹ the shifting value of children,¹⁰ religiosity,¹¹ social networks,¹² and media consumption¹³ have also been identified as influential factors. Collectively, these studies emphasize structural and value-based dimensions as the primary drivers of fertility fluctuations in Iran.

Space is a dimension of fertility research in Iran that has been largely neglected and warrants further attention. Population phenomena are inherently spatial, as they are shaped by the distribution of human populations across distinct geographical regions.¹⁴ This is particularly true of fertility. In fact, fertility variation within countries is often greater than that observed between countries.¹⁵ Demographic studies confirm that, following the transition to low fertility, substantial differences in reproductive patterns persist across regions and local communities.¹⁶

Such differences arise because migration, fertility, and mortality behaviors interact with the unique economic, social, and demographic characteristics of each region, which are themselves spatially dependent. Thus, focusing solely on rural–urban distinctions is insufficient; fertility must be examined at the level

of specific regions within Iran. Existing fertility studies in Iran have primarily focused on rural–urban disparities, consistently highlighting higher fertility rates in rural areas compared to urban ones.¹⁶

Given the significance of spatial dimensions in analyzing fertility, this study applies spatial analysis techniques to identify fertility patterns across Iran and to relate these patterns to demographic, economic, and social conditions unique to each region. The study is also politically significant, as it introduces a novel methodological approach to the study of Iranian fertility. Its findings suggest that a uniform national policy to address declining fertility is impractical. Instead, policies should account for spatial heterogeneity and the specific socio-economic and demographic interconnections of each geographical unit.

The remainder of this paper is structured as follows. Section 2 reviews the literature on spatial variations in fertility. Section 3 describes the materials and methods, including a detailed explanation of the variables and data. Section 4 presents descriptive statistics for all variables and illustrates the LISA cluster maps generated from the data. Section 5 discusses the main findings, and Section 6 concludes with final remarks and implications.

Methods

This study is a secondary analysis that utilizes data from the Statistical Center of Iran. The analytical dataset comprises 429 counties spanning the period 2011–2016, derived from national census data.^{17, 18} The independent variables—demographic, socioeconomic, and environmental indicators—were obtained from the Statistical Center of Iran.^{17, 18} The dependent variable is the total fertility rate (TFR).

The aggregate fertility rate for the 429 counties was estimated using the indirect method of Relé's Technique, based on 2016 census data. A detailed description of the independent variables employed in the analysis is provided in Table 1.

To investigate spatial autocorrelation, we employed Moran's I index and the Local Indicators of Spatial Association (LISA), both of which are commonly used to assess spatial dependence in demographic and socioeconomic data.

Furthermore, to evaluate the influence of independent variables on fertility, we applied two regression approaches: Ordinary Least Squares (OLS) and Geographically Weighted Regression (GWR). While OLS provides global parameter estimates, GWR implements local linear regression, allowing the estimation of coefficients that vary across space. This enables the capture and interpretation of the spatial heterogeneity in relationships between fertility and its determinants.¹⁹⁻²¹

Table 1: Independent Variables definition

Variables	Definition
Rural rate	The proportion of the total population residing in rural areas for each county.
Tenant rate of population	The proportion of the population that is not the owner of a dwelling but rather leases one.
Highly educated women	Females who enrolled in and completed their tertiary education.
Unemployment rate of young women	Unemployed women between the ages of 15 and 35.
Population aged 15-35	The proportion of individuals aged 15-35 (of both sexes) relative to the total population in each county.
Out-migration	Exit population as a percentage of the total population of a county.

Table 2: Descriptive statistics

	Variable	Min	Median	Mean	Max	Q1	Q2	Q3	Moran's I
Dependent variable	Total fertility rate	1.17	2.37	2.45	5.87	2.04	2.37	2.78	0.744***
Independent variables	Rural rate	0.49	42.85	44.02	94.23	28.3	42.8	58.16	0.261***
	Tenant rate of population	2.18	20.18	21.68	57.99	14.95	20.17	26.73	0.362***
	Highly educated women	2.76	15.82	16.05	38.57	11.10	15.82	20.04	0.275***
	Unemployment rate of young women	21.37	57.63	58.52	94.51	50.08	57.63	67.86	0.318***
	Population aged 15-35	28.43	37.24	35.82	65.27	34.15	35.72	37.24	0.154***
	Out-migration	0.40	4.42	4.59	17.27	3.25	4.42	5.77	0.309***

Table 3: Descriptive statistics for each variable

Variable	Coefficient	Std. error	T-value	P value	VIF
Intercept	2.44		86.7	0.000	-
Rural rate	-0.095	0.001	1.76	0.084ns	2.66
Tenant rate of population	-0.226	0.003	4.49	0.000***	2.31
Highly educated women	-0.469	0.004	10.41	0.000***	1.84
Unemployment rate of young women	0.084	0.001	2.26	0.013*	1.24
Population aged 15-35	0.521	0.007	13.47	0.000***	1.36
Out-migration	-0.135	0.011	3.88	0.003***	1.10
OLS diagnostics	AICc	902.7	Koenker (BP)	18.63***	Moran's I = 0.070***
	R2	0.531	Jarque-Bera	821.80***	

***Significant at 1% level; **significant at 5% level; *significant at 10% level; ns: Nonsignificant

Results

Table 2 presents the descriptive statistics (five-number summary) for all variables assessed at the county level. The last column also reports Moran's I values, which provide evidence of spatial dependence. The dependent variable, total fertility rate (TFR), ranged from 0 to 5.87, with a mean of 2.37. Moran's I coefficient of 0.744 indicates strong spatial autocorrelation, suggesting that those of neighboring counties highly influence fertility levels in each county.

Figure 1 illustrates the quantile distribution maps of the main variables, while Figure 2 presents the LISA cluster maps. The LISA analysis of TFR identified four county-level classifications: high-high (64 counties), low-low (131 counties), low-high (5 counties), and high-low (16 counties). High-high clusters (red) indicate areas of high fertility surrounded by high-fertility neighbors, predominantly located in the East, Southeast, and South. Conversely, low-low clusters were concentrated in the North, Central, and Western counties.

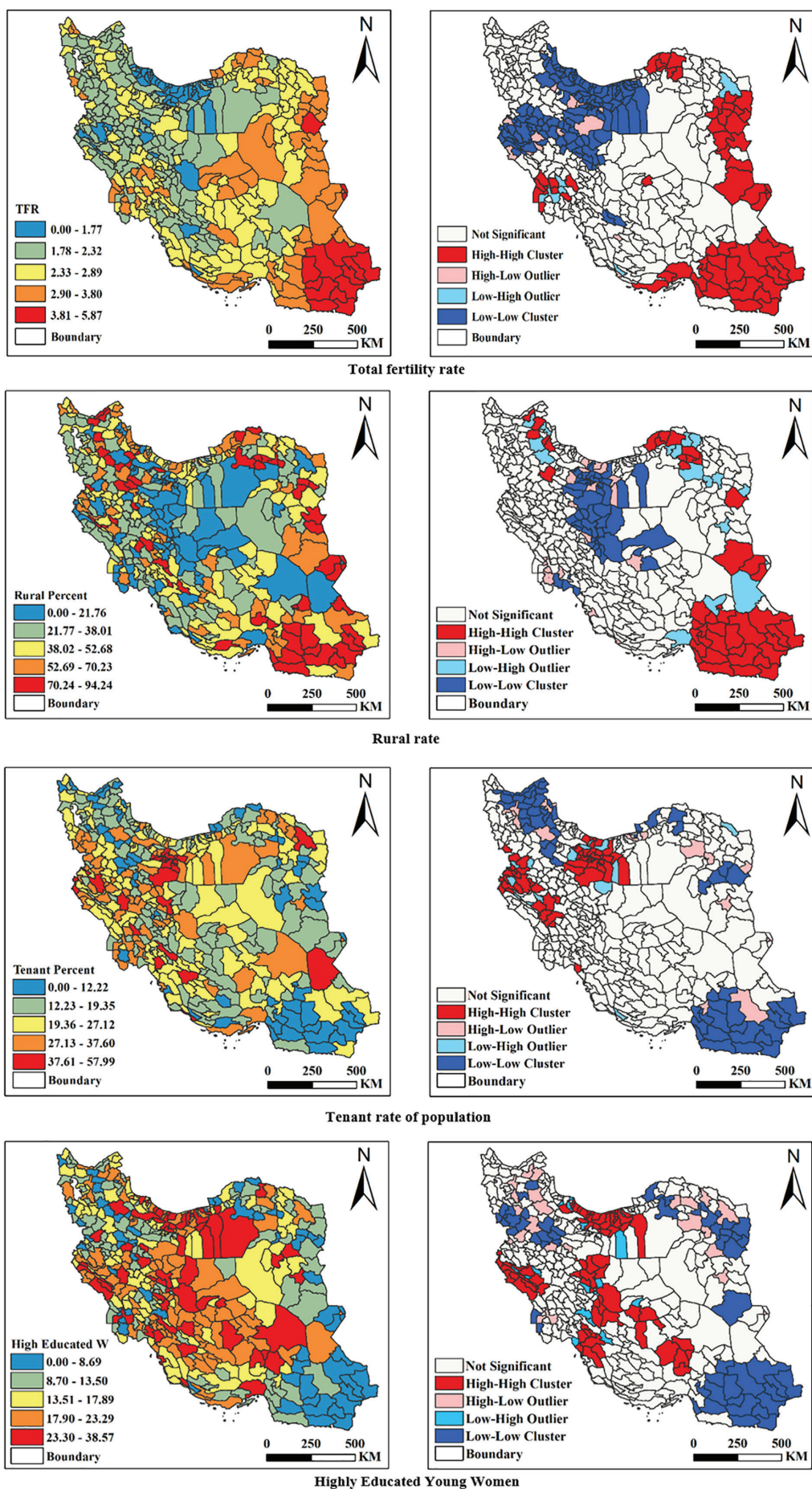
For the percentage of the rural population, LISA identified 46 counties as high-high, 57 as low-low,

17 as low-high, and 18 as high-low. High-high rural clusters were concentrated in the Southeast, while low-low clusters were observed in central regions.

In terms of tenant households, 56 counties were classified as high-high, 53 as low-low, 13 as low-high, and 61 as high-low. High-high clusters appeared mainly in central and western counties, whereas low-low clusters were concentrated in the Southeast and Northwest.

For women's higher education, the LISA analysis classified 75 counties as high-high, 54 as low-low, 21 as low-high, and 20 as high-low. High-high clusters of educated women were predominantly observed in central counties, while low-low clusters were concentrated in the Southeast.

Regarding the youth unemployment rate, 95 counties were identified as high-high, 66 as low-low, 14 as low-high, and 17 as high-low. High-high clusters were largely concentrated in the West and Southwest, whereas low-low clusters appeared in the South, East, and selected central and northeastern counties.



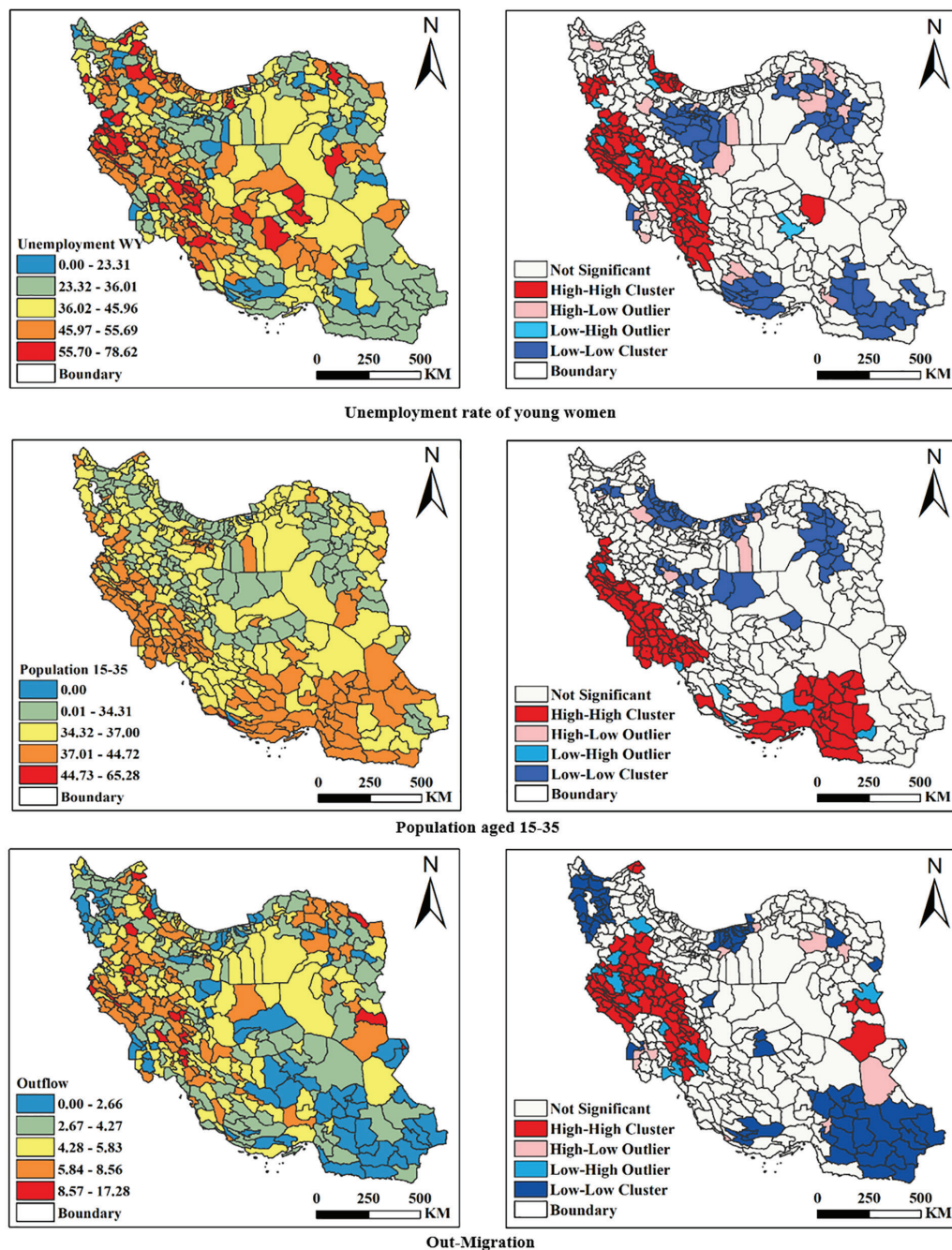


Figure 1: Quantile and Lisa cluster map (design by authors)

Finally, for the population aged 15–35 years, 85 counties formed high–high clusters (mainly in the South and Southwest), 68 were classified as low–low (mostly in the North and some central areas), five as low–high, and 11 as high–low. For out-migration, LISA identified 79 counties as high–high, 74 as low–low, 17 as low–high, and 11 as high–low. High–high out-migration clusters were concentrated in the Western counties, while low–low clusters were found in the Southeast.

The comparison between GWR and OLS models is presented in Table 3. variance inflation factor (VIF) scores indicated that multicollinearity was not a concern for the global OLS model. Except for the

rural population percentage, all variables exhibited significant relationships with fertility rate, collectively explaining 22% of the variance in fertility (corrected Akaike information criterion (AICc)=762.6) across all Iranian counties.

At the global level, the OLS results revealed that the unemployment rate of young women and the population aged 15–35 were positively associated with the fertility rate. In contrast, other variables demonstrated negative associations. These findings indicate that counties with a younger population and higher unemployment among young women tend to have higher fertility rates. Conversely, fertility rates are lower in counties with a higher proportion of renter



Figure 2: The map of provinces and counties in Iran, 2016

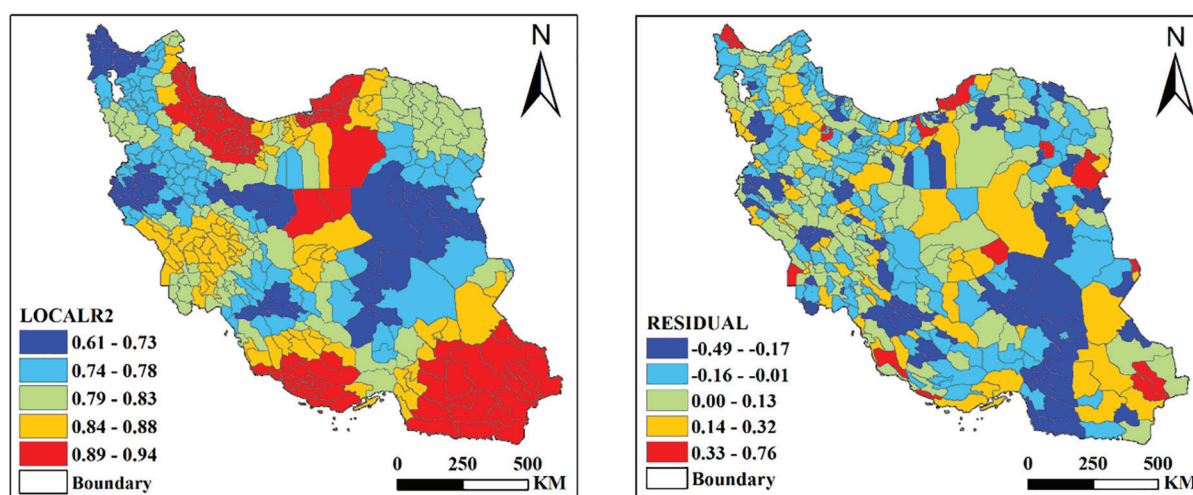


Figure 3: local R2 according to GWR output (designed by authors)

households, among highly educated women, and in areas experiencing significant out-migration, where the young population appears to be leaving (Figures 3 and 4).

The golden selection search identified an optimal adaptive bandwidth of 58 counties for the GWR models. With an AICc of 387.3, the GWR models explained 90% of the variance in fertility rates, indicating a markedly better fit than the OLS regression (Table 3). The parameter summary for the GWR models is also presented in Table 3.

In the GWR fertility rate model, the minimum negative coefficients were associated with the proportion of highly educated women and the

population aged 15–35 years. In contrast, the maximum positive coefficient was linked to the percentage of tenant households. The coefficients for each variable spanned both negative and positive values. For individuals aged 15–35 years, coefficients ranged from -1.267 to 0.982, with a median of 0.431; notably, negative coefficients were observed in the eastern and southern counties. In the southeast counties, the effect of highly educated women ranged from -1.058 to -0.035, with a median of -0.359, indicating a minimal impact. The tenant population coefficients varied between -0.889 and 0.668, with southeast and parts of central counties experiencing a significant negative effect (Table 4). Overall, almost all counties exhibited positive associations with structural factors.

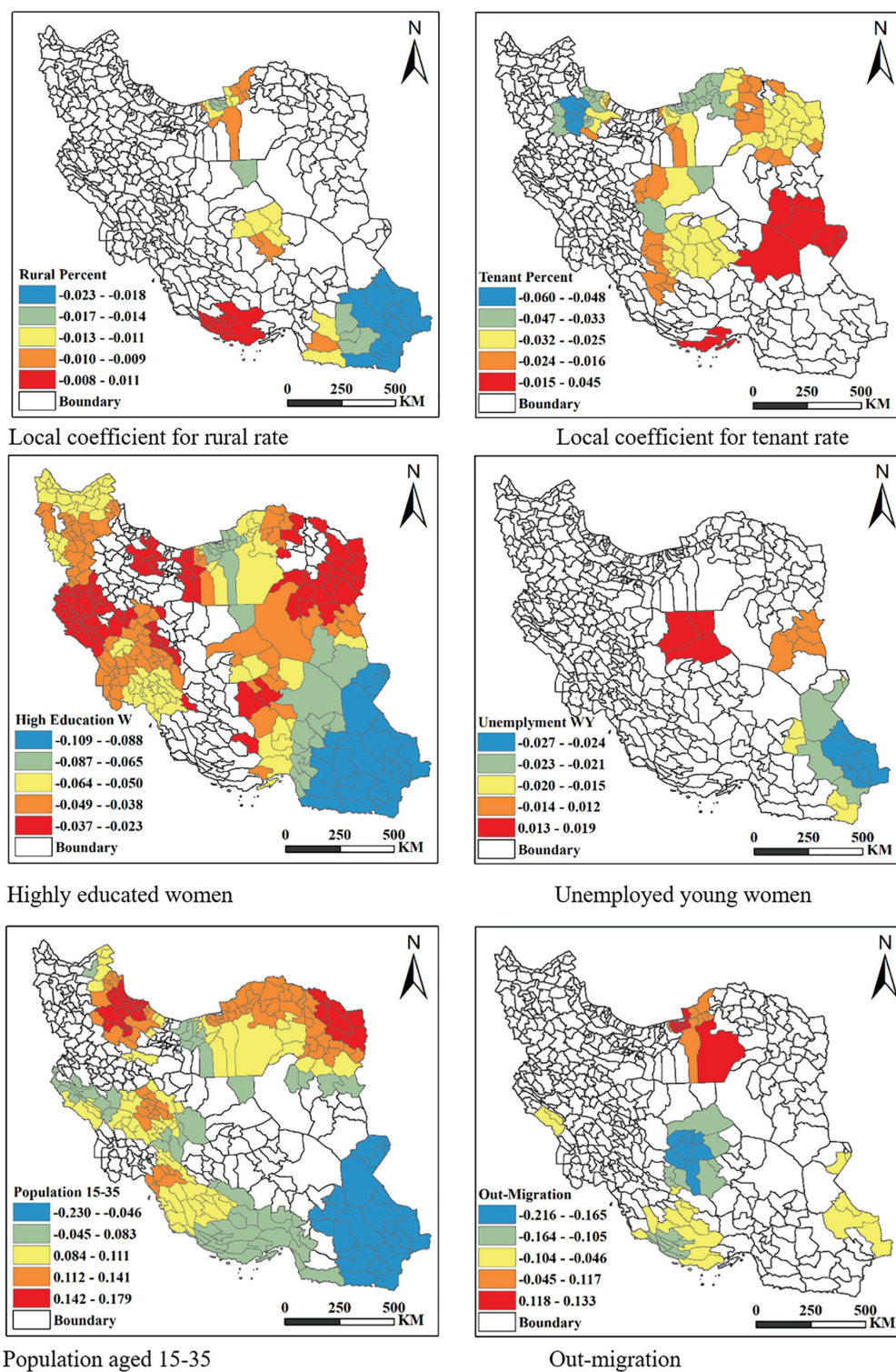


Figure 4: Spatial distribution of GWR local coefficients (designed by authors)

Discussion

Fertility studies in Iran have predominantly focused on structural, ideological, and value-based factors to explain changes in fertility. However, evidence suggests that social behaviors, including fertility, vary across different geographical environments. This spatial dimension has been largely overlooked in Iranian fertility research, with

analyses often limited to urban–rural distinctions, even though these differences should be examined at the level of specific regions or counties. To address this gap, the present study employed a spatial analytical approach to elucidate the patterns and determinants of fertility across Iran.

The findings suggest that demographic, economic, and social conditions are closely linked to fertility

Table 4: Variables' coefficients statistics

Variables	GWR coefficients				
	Min	Max	Mean	Std.	Median
Rural rate	-0.777	0.356	-0.142	0.181	-0.142
Tenant rate of population	-0.889	0.668	-0.170	0.234	-0.151
Highly educated women	-1.058	-0.035	-0.409	0.210	-0.359
Unemployment rate of young women	-0.489	0.360	-0.027	0.121	-0.021
Population aged 15-35	-1.267	0.982	0.386	0.376	0.431
Out-migration	-0.691	0.407	-0.056	0.156	-0.050
GWR diagnostics		0.90	AICc	387.3	

Adaptive bandwidth method with golden selection search; optimal bandwidth=58

patterns across geographical areas. In the Central counties, economic and social conditions were favorable, reflected in lower unemployment rates among young women, higher tenant percentages, and elevated levels of women's education. In contrast, higher fertility rates were observed in the southeastern and eastern counties, which exhibited similar economic and social characteristics. These results are consistent with previous research by Abbasi Shavazi, Hosseini Chavoshi, McDonald, Delawar,⁴ and Mirzaee & Shams-Ghahfarokhi.¹¹ Overall, favorable economic and social conditions, alongside demographic factors, appear to play a significant role in shaping fertility and reproductive behaviors.

The OLS model indicates that the overall fit of the local GWR models is highly variable, as reflected by local R^2 estimates for the fertility rate, which range from 0.53 to 0.90. At the county level, the relationship between independent variables and fertility is clearly non-stationary across Iran. These findings underscore the value of employing local spatial models and spatially informed modeling strategies when investigating fertility patterns.

The effects of the population aged 15–34 and women with higher education demonstrate substantial influence on fertility rate models, as evidenced in both the OLS and GWR outputs. Specifically, women's higher education has the strongest effect in Western, Northern, and Northeastern counties, and the weakest effect in Sistan and Baluchestan. These results align with the findings of Dorahaki & Nobakht⁷ and Abbasi Shavazi & Kiani.⁹ In contrast, fertility rates in southeastern counties exhibit a negative correlation with women's education, highlighting the potential for education to reduce fertility.

While a few central counties show a positive correlation between the unemployment rate of young women and fertility, this relationship is negative in southeastern counties. This suggests that, beyond economic factors, cultural norms—including traditional and religious values favoring larger families and male offspring—also influence fertility in these regions, which contrasts with the findings of Sadeghi and Esmacili²² regarding women's employment.

Demographic factors, including the proportion of the population aged 15–34, rural residency, and out-migration, have a significant impact on fertility. This is consistent with Shiri, Noorolahi, and Rostami,²³ who emphasize the critical role of regional demographic characteristics in shaping fertility variations. The proportion of rural residents has a substantial negative effect in southern and central counties, corroborating Abbasi Shavazi, McDonald, and Hosseini-Chavoshi,³ who noted convergence of fertility rates between urban and rural regions. The population aged 15–34 exerts a significant positive influence in northern, southern, and western counties, reflecting the importance of youthful demographics in these regions. Out-migration exhibits a heterogeneous impact, positively influencing fertility in northern counties while having a negative effect on central and southern counties.

One of the main limitations of this study stems from the availability of location-based data and the panel structure of these data. Although fertility data for counties across multiple time periods can be obtained using methods such as the Own-Children Method, corresponding economic, social, and demographic characteristics of these counties during those periods are not readily available. Unfortunately, such information is even more limited for smaller geographic units, including cities and municipalities. The availability of spatially detailed data at provincial, municipal, and village levels would enable more precise spatial analyses and could substantially enhance evidence-based policy-making and planning.

Conclusion

While numerous studies have investigated fertility in Iran, the role of space and location has received comparatively less attention. The findings of this study indicate that, although all examined variables significantly contribute to explaining fertility, their relative importance varies across different geographical areas. Spatial analysis methods, such as Geographically Weighted Regression (GWR), highlight the heterogeneous effects of independent variables on fertility across Iran.

For instance, counties in central Iran exhibit relatively low fertility rates, despite having a high

economic and social status, although this pattern does not hold for all central counties. Conversely, southeastern counties, characterized by less favorable social conditions, generally display high fertility rates, though exceptions exist. This study avoids presenting a uniform view of the determinants of fertility; instead, it specifies precisely which independent variables significantly affect fertility in each county and quantifies the magnitude of these effects. Such insights provide policymakers with targeted knowledge to develop region-specific policies and interventions that address fertility issues.

Authors' Contribution

Reza Noubakht: Conceptualization, Formal analysis, Writing - original draft, review & editing, Investigation, Project administration. Ahmad Dorahaki: Conceptualization, Formal analysis, Writing - review & editing.

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Conflict of Interest

The authors declare that there are no competing interests.

References

- Iran Statistics Center (2015). The results of the country's general population and housing census. Tehran.
- Fathi E. (2019). Fertility perspective of Iran from 2016 to 2019. Tehran: Bureau of Population, Labor and Census of Iran Statistics Center.
- Abbasi Shavazi MJ, McDonald P, Hosseini-Chavoshi M. (2009). The Fertility Transition in Iran: Revolution and Reproduction. Springer. doi: 10.1007/978-90-481-3198-3_2.
- Abbasi Shavazi MJ, Hosseini Chavoshi M, McDonald P, Delawar B. (2004). Fertility Change in Iran: evidence from selected provinces. Tehran: Ministry of Health, Treatment and Medical Education.
- Abbasi Shavazi, MJ, Askari Nadushan A. (2005). Family Changes and Fertility Decline in Iran: A Case Study in Yazd Province. *Sociology of Art and Literature*, 11(3), 35-75.
- Abbasi Shavazi MJ, Ali Mandgari M. (2009). Investigating the dimensions of women's independence on fertility. *Women in Development and Politics*, 8(1), 31-51.
- Dorahaki A, Nobakht R. (2019). The effect of gender equality within the family on women's intention to have children in urban areas of Bushehr province. *Women in Development and Politics*, 18(1), 151-172. doi: 10.22059/jwdp.2020.294291.1007761.
- Aini Zeinab H, Shams Ghafarokhi F. (2011). The effect of tempo (timing of children) on the total fertility rate in Iran. *Journal of Population Association of Iran*. 7(13), 177-196.
- Abbasi Shavazi MJ, Khani S. (2013). Economic insecurity and fertility: a case study of married women in Sanandaj city. *Journal of Population Association of Iran*. 13(1), 37-76. doi: 20.1001.1.1735000.1393.9.17.2.8.
- Mirzaee M, Shams-Ghahfarokhi M. (2014). The importance of women's employment characteristics on the likelihood of their fertility during five years of period 2010-2014 (Case Study: Isfahan). *Journal of Population Association of Iran*. 9(17), 113-139. doi: 20.1001.1.1735000.1393.9.17.4.0.
- Kalantari S, Abbaszadeh M, Mozafari FA, Rakei Bonab N. (2010). Sociological study of propensity to have children and some factors related to it (Case study: married young people of Tabriz city). *Applied Sociology*, 21(1), 83-104. doi: 20.1001.1.20085745.1389.21.1.5.4.
- Modiri F, Razeghi-Nasrabad HB. (2015). A study on the relationship between religiosity and fertility intention in Tehran. *Journal of Population Association of Iran*, 10(20), 128-163. doi: 20.1001.1.1735000.1394.10.20.5.4.
- Dorahaki A, Koshkaki N. (2019). The effect of social network characteristics on women's fertility in urban areas of Bushehr Province. *Women's Strategic Studies*, 22(85), 51-72. doi: 10.22095/JWSS.2019.109566.
- Weeks JR. (2004). The role of spatial analysis in demographic research. *Spatially integrated social science*, 381-399. doi: 10.1093/oso/9780195152708.003.0019.
- Campisi N, Kulu H, Mikolai J, Klüsener S, Myrskylä M. (2020). Spatial variation in fertility across Europe: Patterns and determinants. *Population, Space and Place*. 26(4), e2308. doi: 10.1002/psp.2308.
- Abbasi Shavazi MJ, Esmaeili N. (2021). Media, culturalization and fertility: identifying and ranking factors affecting fertility using analytical hierarchy process approach. *Strategic Studies of Culture*, 1(1), 7-46. doi: 10.22083/sscj.2021.136357
- Statistical Center of Iran (2011) Detailed results of the general census of population and housing.
- Statistical Center of Iran (2016) Detailed results of the general census of population and housing.
- Tiefelsdorf M. (2002). The saddlepoint approximation of Moran's I's and local Moran's I's reference distributions and their numerical evaluation. *Geographical Analysis*. 34(3), 187-206. doi: 10.1353/geo.2002.0018.
- Harris R. (2016). *Quantitative Geography*. Sage Publication Ltd, London, UK. doi: 10.4135/9781473920446.n10.

- 21 Anselin L. (1995). Local indicators of spatial association—LISA. *Geographical Analysis*, 27(2), 93-115. doi: 10.1111/j.1538-4632.1995.tb00338.x.
- 22 Sadeghi R, Esmacili N. (2010). Multilevel analysis of individual and provincial correlations of fertility in Iran. *Strategic Studies of Women*. 23(90), 37-65. doi: 10.22095/JWSS.2021.224036.2302.
- 23 Shiri M, Noorolahi T, Rostami E. (2013). Examining factors affecting fertility based on a multi-level approach. *Marefat*, 189, 89-99.