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ARAŞTIRMA MAKALESİ • RESEARCH ARTICLE

THE DETERMINANTS OF BIRTH RATE: EVIDENCE FROM TÜRKİYE PROVINCES AMID THE COVID-19 PANDEMIC

DOĞUM ORANININ BELİRLEYİCİLERİ: COVID-19 PANDEMİSİNDE TÜRKİYE İLLERİNDEN KANITLAR

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Öz

Bu çalışma, 2018-2023 yılları arasında Türkiye'nin 81 ilinde doğum oranını, etki eden faktörlerle modelleyerek özellikle COVID-19 salgınının etkisine odaklanmakta ve evlilik oranı, yaşlanan nüfus ve kişi başına düşen GSYH'nin etkilerini araştırmaktadır. İllere özgü heterojenliğin yarattığı zorlukları ele almak için, çalışmada hem Sabit Etkiler (FE) hem de Rassal Etkiler (RE) modellerini tahmin etmek için panel veri analizi kullanılmıştır. Ayrıca, Hausman testi kullanılarak, en iyi model olarak, Sabit Etkiler modeli olarak seçilmiştir. Bulguların sağlamlığı değişen varyans testinin uygulanmasıyla sağlanmıştır. Bu çalışmanın bulguları, evlilik oranı ile doğum oranı arasında pozitif bir ilişki olduğunu göstermektedir. Buna karşılık, 65 yaş ve üzeri insanların toplam nüfusdaki oranı ile hesaplanan yaşlanan nüfus, doğurganlık oranlarında düşüşle ilişkilidir. Kişi başına düşen GSYH'nin ise anlamlı negatif etki gösterdiğini ortaya koymaktadır. Ayrıca bulgular, pandeminin doğum oranları üzerindeki önemli etkisinin altını çizmekte ve pandemi sırasında ve sonrasında COVID19 değişkeninin istatistiksel olarak anlamlı ve negatif etkisi ile demografik örüntülerde azalan değişimleri vurgulamaktadır. Bu çalışma, Türkiye'nin il düzeyinde ampirik bir analizini sunarak mevcut literatüre önemli bir katkı sağlamaktadır. Demografik eğilimler, aile planlaması ve ekonomik kalkınma konularında politika yapıcılar için değerli katkılar sunmaktadır.

Anahtar Kelimeler: Doğum oranı, Yaşlanan nüfus, Ekonomik Büyüme, COVID-19, Panel Veri Analizi, Türkiye.

JEL Sınıflandırılması: J11, J13, I18.

Abstract

This study investigates the determinants of birth rate across 81 Turkish provinces from 2018 to 2023, focusing on the effects of marriage rate, aging population, and GDP per capita with a particular focus on the effect of the COVID-19 pandemic. To address the challenges posed by province-specific heterogeneity, the study employs panel data methods to estimate both Fixed Effects (FE) and Random Effects (RE) models. Furthermore, the selection of the most appropriate model specification is facilitated by the Hausman test, confirming the appropriateness of the FE model. while the robustness of the findings is ensured through the application of heteroskedasticity test. The estimation results of this study suggest a positive relationship between the marriage rate and the birth rate while the aging population, defined as the ratio of people aged 65 and over in the population and GDP per capita show significant negative effects. Moreover, the COVID19 pandemic is found to have a statistically significant negative impact on birth rates. Furthermore, the findings underscore the substantial impact of the pandemic on birth rates, highlighting declining shifts in demographic patterns during and following the pandemic. This study has made a significant contribution to the existing literature by offering a province-level empirical analysis of Türkiye. It provides valuable insights for policymakers on demographic trends, family planning, and economic development.

Keywords: Birth rate, Aging Population, Economic Growth, COVID-19, Panel Data Analysis, Türkiye.

JelCode: J11, J13, I18.

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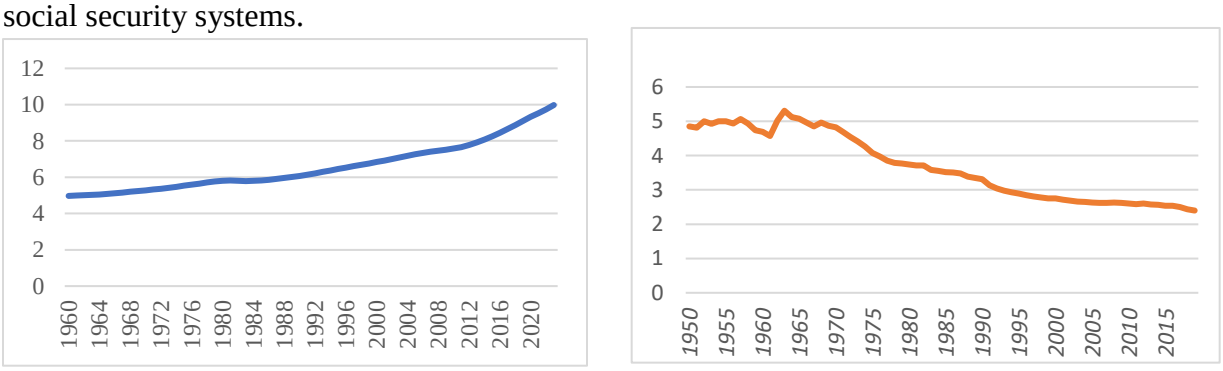
Introduction

The aging population is among the most critical demographic shifts of the 21st century, affecting economies, healthcare systems, and social structures worldwide. As the global population continues to experience an increase in life expectancy and a decline in fertility rates, numerous countries are witnessing a rise in the proportion of elderly individuals. The world's population is expected to increase from 7.7 billion to 9.7 billion. However, this increase will be caused by elderly population. As it can be seen from Graph 1 below, the aging population is a problem in all over the world. Aging population is increasing while fertility rate is decreasing sharply[2]. Fertility rate summarizes the total number of births per woman. As life expectancy increases and fertility rates decline, many countries, including Türkiye, are experiencing an aging population that may have profound effects on birth rates. The decline in birth rates, coupled with an increasing elderly population, poses challenges for sustainable economic development, labor force participation, and social security systems.



a. World population ages 65 and above (% of total population), 1960-2023

b. Fertility rate, historical, 1950-2019

Graph 1: World demographic statistics

Source: Drawn by the author by using World Bank data.

This study aims to investigate the relationship between birth rates and key economic and demographic factors such as the marriage rate, aging population, and GDP per capita across Turkish 81 provinces over the period 2018–2023. Additionally, the main motivation of this study is to include the COVID19 pandemic as a dummy variable to assess its potential impact on birth

[2] https://ourworldindata.org/fertility-rate

rates, as the pandemic has been widely recognized as a disruptive force affecting economic stability, healthcare access, and family planning decisions.

The birth rate is an incredibly important issue that affects the countries all around the world. The literature focused on especially economic indicators, some demographic and health indicators are essential for birth rate. As marriage rate is increasing, the birth rate is tended to be increase while GDP and aging population are expected to reduce birth rate. COVID19 pandemic is expected to reduce the birth rate, as Çelik, Özdemir, Öztürk, & Başar, 2023 has found Covid19 pandemic has led to birth fear in individuals in the pre-pregnancy period and it has negative effect on birth rate. In most of the developing countries, birth rates fell during pandemic (Krombholz, 2024) . As far as we know, there is no additional study that analyze the effect of COVID19 pandemic on birth rates in Türkiye.

Türkiye, like many nations globally, is undergoing a significant demographic shift characterized by an aging population, declining birth rates, and the recent disruptive impact of the COVID19 pandemic, all of which have profound implications for its economic situations. Understanding the intricate relationships between these demographic forces and economic growth is crucial for policymakers to formulate effective strategies for sustainable development and long-term prosperity. The aging of the population, driven by increased life expectancy and decreased fertility rates, presents both opportunities and challenges for the Turkish economy.

This study examines the impact of marriage rate, aging population, and GDP per capita on birth rates across 81 Turkish provinces from 2018 to 2023. Given the economic and social transformations Türkiye has undergone, it is important to analyze how these factors influence fertility patterns at the regional level. Moreover, the outbreak of the COVID-19 pandemic introduced additional challenges, affecting economic stability and social behavior, which may have had significant consequences on birth rates. To capture this effect, a COVID-19 dummy variable is included in the analysis.

To empirically investigate these relationships, we employ panel data analysis, estimating both Fixed Effects (FE) and Random Effects (RE) models. The Hausman test is conducted to determine the most appropriate model specification, while heteroskedasticity test ensures the robustness of

our findings. Using panel data analysis, we employ fixed-effects and random-effects models to explore the determinants of birth rates at the provincial level. The Hausman test is conducted to determine the appropriate model specification, and robust standard errors are applied to address heteroskedasticity. Our results suggest that the aging population has a statistically significant and negative effect on birth rates, while marriage rates positively influence birth rates. Furthermore, the COVID-19 pandemic is found to have a significant negative effect on birth rates, highlighting the impact of economic uncertainty and health crises on demographic shifts.

This study contributes to the literature by offering a province-level empirical analysis of Türkiye, providing insights into how demographic and economic factors influence fertility rates (Tuncer, 1971; Ozbay Das, 2020). The findings are expected to be valuable for policymakers in designing regional development strategies, family planning initiatives, and economic policies that address demographic challenges. By understanding the economic and social determinants of birth rates, policymakers can develop strategies to encourage sustainable population growth and economic stability. This is a basic study, therefore advanced models, for example time series analysis, according to data availability, and additional explanatory variables can be tested for future implications.

The reminder of this paper is organized as follows: Section 2 reviews the relevant literature, Section 3 presents the data and methodology, Section 4 discusses the model estimation, and Section 5 concludes with policy implications.

1. Literature review

On the one hand, a larger elderly population can contribute valuable experience and expertise to the workforce, while on the other hand, it can strain social security systems and healthcare infrastructure. In European Central Bank working paper, Bodnar & Nerlich (2022) studied the macroeconomic and fiscal impact of aging population. The euro area, as one of the advanced economies are facing elderly population demographic change. They are expecting sharp decline in Euro Area population in 2035. This will make an increase in old age dependency ratio. There are also other studies that focus on the economic effect of aging population (Acemoglu and Restrepo (2017); Feyrer, 2007; Hansen (1939); Maestas, Mullen and Powell (2016); Lindh and Malmberg

(1999)). Acemoglu and Restrepo (2017) focused on the effect of aging on economic growth. As there is an increasing trend in aging population in all over the world, however, OECD countries have higher aging population ratio compared to all over the world. Acemoglu and Restrepo (2017) found that there is no evidence of a negative relationship between aging and GDP per capita. On the contrary, they found significant and positive relationship especially for post-1990 era. They explain this positive relationship by technological changes, robotics and artificial intelligence. The relationship between aging and adoption of robotics technology is established in (Acemoglu & Restrepo, 2017). They use the data from the International Federation of Robotics (IFR).

Eryer (2024) studied health expenditures and aging population for G7 countries for the period 2000-2022. They found that elderly people cause higher health expenditures and it has statistically significant effect. Getzen (1992) analyzed this relationship for G20 countries and found statistically significant positive effect.

Aging population and fertility rate are one of the most important global problems in today's world and essential threats for the future. According to the literature, fertility rate is decreasing while aging population is increasing, especially in developed countries. Birth rate and fertility rate are also global issues studied commonly with the perspective of economic growth.

Economic factors as determinants and the causality between economic indicators and birth rates are studied recently. Economic factors can be said the most important variables affect the demographic statistics. Yie and Choi (2024) also studied the economic causes of low fertility rate in Korea. Korea's fertility rate has sharply decreased from 4.12 in 1972 to 0.72 in 2023. Following this result, sudden increase in economic growth and women's education have happened. Increase women education lead to an increase in Women's wages. Therefore, the authors suggest some supports on women laborship in order to increase fertility rate. Women employment rate is also included a model in the literature on China. China, even it has the 2nd highest population in the world, suffers from decreasing birth rate and increasing aging population. Yang&Zang (2023) analyze the effect of aging population, birth rate, disposable income on birth rate by considering COVID19 effect. They compared the East and the West part in terms of birth rate. Eastern region has lower birth rate than Western region. Marriage rate affects birth rate significantly positive while education level and female employment have negative impacts on birth rate.

Kim (2025) analyzed the relationship between economic indicators and low birth rates for 30 years between 1994 in South Korea. They pointed out the effects of rising education costs, job concentration, climate change and preference of single living on low birth rates. Low birth rates also cause less young laborship, less working population in the long-run, shrink in the consumer market. They also found that consumer price affects birth rate negatively. Cimpoeru & Pisica (2023) have also studied economic determinants of birth rate for Romania by employing spatial analysis. They analyzed economic growth, number of immigrants, the amount of financial support received by the families and unemployment rate. They found statistically significant and negative effect of GDP on birth rate.

Despite the limited number of existing literature, there are some studies on Türkiye ((Turk, 2025); (Bol, 2025)). Turk (2025) investigated the effect of employment rate, gender inequality index, GDP per capita on birth rates. They applied time series methods including period 1999-2022. According to their findings, female employment increases birth rates significantly in the long run. Gender equality index has impact on birth rates and GDP per capita has statistically significant impact on birth rates. They concluded that birth rates are affected from social and economic factors significantly. On the other hand, Bol (2025) has analyzed the effects of economic factors on fertility rates in Türkiye between 1990-2022. They couldn't find evidence that fertility rates are affected by economic factors in the long-run.

The effect of Covid19 pandemic is another essential factor for demographic variables such as fertility rate, birth rate, marriage, aging population, mortality rate. There are few studies that analyzed the effect of Covid19 pandemic on birth rates. One of them is Oguejiofor, Ebubechukwu, Eleje, et al. (2023), they studies impact of COVID19 pandemic on the birth rate in Nigeria. They found birth rates decreased significantly during the pandemic. The other one is Krombholz (2024), they analyzed seasonality of births during pandemic in Germany.

In conclusion, the literature claims that economic indicators such as economic growth, female employment affect birth rate significantly, while few studies show Covid19 pandemic reduced the birth rate.

2. Data and Methodology

A comprehensive analysis of the interplay between aging population, birth rates, and economic growth in Türkiye, further complicated by the COVID-19 pandemic, necessitates a robust methodological framework. This involves employing econometric techniques to quantitatively assess the impact of these demographic and health-related factors on key macroeconomic indicators.

The panel data utilized in this study are obtained from *Turkish Statistical Institute (TURKSTAT)*. The annual data set covering the period from 2018 to 2023 is used for 81 provinces of Türkiye. The definitions of the data used in this study are summarized in Table 1 below. lngdp_percapita takes ln of GDP per capita to avoid heteroscadasticity. Explanatory variables are decided parallel to Yang&Zang (2023)'s study on China.

This study examines the impact of marriage rate, aging population, and GDP per capita on birth rates across 81 Turkish provinces from 2008 to 2023**.** Additionally, a COVID-19 dummy variable is included to capture the pandemic's effect on birth rates. The dataset is structured as a balanced panel with observations for each province over six years. We combine cross section data of provinces and time series data from 2018 to 2023, the panel data analysis is employed. Panel data approach allows longitudinal analyses across different dimensions simultaneously both individuals and time observations, i refers the provinces while t is for all time periods (Baltagi, 2008)**.**

Table 1: The definition the variables in the model

Variables	**Definition**
birth_rate	Crude birth rate (%)
gdp_percapita	Gross domestic product per capita by provinces, $ (2009 base)
Marriage	Crude marriage rate by provinces
aging_pop	Proportion of elderly population (65+) in total population (%)
covid19	Covid19 dummy variable, takes the value 1 for years 2020-2021**,** and 0 otherwise**.**

Source: TurkStat, www.tuik.gov.tr

The crude marriage rate is defined as:

$$CR = \frac{Number\ of\ marriages\ in\ a\ year}{Total\ midyear\ population} x1000$$

This measure expresses the number of marriages per 1,000 people in the total population and is widely used in demographic and economic studies.

To account for unobserved heterogeneity across provinces, we estimate both Fixed Effects (FE) and Random Effects (RE) models. Fixed Effects (FE) Model captures the impact of time-invariant province-specific factors that may influence birth rates, such as cultural differences, infrastructure, and long-term economic conditions. The FE model assumes that these factors are correlated with the independent variables.

To analyze the relationship between the explanatory variables and birth rates, we use the following FE panel regression model:

$$birth\_rate_{it} = \beta_0 + \alpha_i + \beta_{1i} marriage\_rate_{it} + \beta_{2i} aging\_pop_{it} + \beta_{3i} lngdp\_percapita_{it} + \beta_{4i} covid19_t + u_{it} \quad (1)$$

Where, i represents cross section part for provinces, t stands for time period from 2018-2023.

u_{it} is the error term, αi represents province-specific fixed effect, capturing unobserved characteristics of each province that do not change over time. The key assumption is that any omitted variables that might influence birth rates are constant within each province and can be controlled by the fixed effects transformation.

Random Effects (RE) Model assumes that unobserved province-specific effects are uncorrelated with the explanatory variables, allowing for more efficient estimation. Instead of differencing out fixed effects, The RE model treats them as part of the error structure.

RE Model specification is as below:

$$birth\_rate_{it} = \beta_0 + \beta_{1i} marriage\_rate_{it} + \beta_{2i} aging\_pop_{it} + \beta_{3i} lngdp\_percapita_{it} + \beta_{4i} covid19_t + \varepsilon_i + u_{it} \quad (2)$$

where, i represents cross section part for provinces, t stands for time period from 2018-2023.

u_{it} is the idiosyncratic error term capturing time varying shocks ($u_{it} \sim N(0, \sigma_u^2)$)

ε_i is the province-specific random effect. assumed to be uncorrelated with the explanatory variables, ($u_{it} \sim N(0, \sigma_\varepsilon^2)$). ε_i is assumed to be uncorrelated with the explanatory variables ($E[u_i]X] = 0$). Random effect model allows estimations of time-invariant variables. If ε_i correlates any explanatory variable, the model will be *biased and inconsistent*. Hausman test will decide which model (random effect or fixed effect) can used.

Hausman Test is used to determine whether the FE or RE model is more appropriate. If the test suggests significant correlation between the unobserved effects and independent variables, the FE model is preferred**;** otherwise, the RE model is used**.**

By employing a province-level panel dataset and incorporating COVID-19 effects**,** this study provides empirical evidence on how marriage trends, aging population, and economic growth impact birth rates in Türkiye by provinces. The findings will contribute to policy discussions on demographic challenges and economic planning.

3. Model estimation results

The estimation results for Panel data Analysis Fixed Effect, Equation (1) and random Effect Equation (2) are presented in Table 2 below.

Table 2. Estimation results birth rate is the dependent variable

Variable	Fixed Effect	Random Effect
marriage_rate	0.815***	0.729***
	(0.092)	(0.116)
aging_pop	-110.055***	-90.5***
	(8.107)	(5.571)
lngdp_percapita	-4.575***	-4.988***
	(0.402)	(0.334)
covid19	-0.224**	-0.347***
	(0.108)	(0.0712)
Intercept	60.795	62.89
N	486	486
F or χ_2 [p value]	23.36 [0.00]***	578.3 [0.00]***
R2- within	0.7117	0.709
R2- between	0.8684	0.8722
R2- overall	0.8525	0.857
(rho)	0.849	0.79
Hausman Test [p value]	13.27 [0.0041]***	

Notes: ***, ** and * denotes significance of coefficients at level <0.01, <0.05 and <0.10 respectively. () reports standard errors and [] reports p value.
The calculations are provided by Author by using Stata 13.0.

Hausman test

Ho: Difference in coefficients not systematic (No correlation between individual effects u_i and regressors, the random effect model is appropriate)

Ha: The fixed effect model is preferred (correlation between u_i and regressors)

Hausman test determines whether a Fixed Effects (FE) or Random Effects (RE) model is more appropriate for the panel data. According to Hausman test in Table 2, we can reject the Null hypothesis at 99% confidence level, *that means Fixed Effect is preferred* over random Effects because the province-specific effects (u_i) are correlated with the explanatory variables. That means unobserved province-effects are important for policy makers.

According to the FE model estimation results presented in Table 2, the marriage rate has positive and significant effect, while aging population demonstrate negative and significant effect on the birth rate. Additionally, GDP per capita is found to have a negative and significant impact on birth rate at 99% confidence level. During the period of COVID19 pandemic, the birth rate declined. At a 95% confidence level, the FE model suggests a negative and significant impact of the pandemic on birth rates. F test statistics show ($p<0.05$), the model is statistically significant. Therefore, we tested FE model for heteroscedasticity.

Table 3. Wald test for group wise heteroskedasticity in FE regression model

χ_2	4581.10
p	0.000

Note: The calculations are provided by Author by using Stata 13.0.

Table 3 results present Wald test group wise heteroskedasticity results. As p value: 000< 0.05, we reject the null hypothesis, therefore, heteroskedasticity is detected. This means the variability of birth rates differs across provinces, leading to inefficient standard errors. We estimate FE regression with heteroskedasticity-robust standard errors and Table 4 presents the robust estimation results below. The significance and sign of the variables are same as Table 3 as the marriage rate has positive and statistically significant effect, aging population and GDP per capita

have negative and statistically significant effect on the birth rate at 99% confidence level. COVID19 pandemic has negative and statistically significant effect at 95% confidence level. Therefore, during pandemic, we can expect lower birth rates. The model is significant ($p<0.05$) and according to the coefficient of determination, R^2 is 0.8525, the explanatory variables in the model explains the changes in the birth rate at 85% level, 15% of the changes can be explained by other factors.

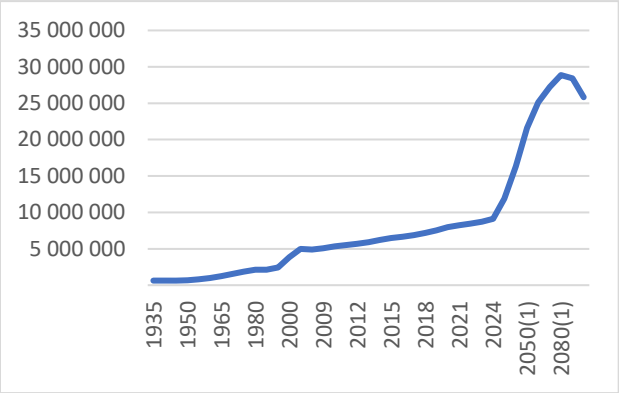
Table 4. Estimation results (with heteroskedasticity-robust standard errors) birth rate is the dependent variable

Variable	**Fixed Effect**
marriage_rate	0.815***
	(-0.119)
aging_pop	-110.055***
	(-11.564)
lngdp_percapita	-4.575***
	(-0.478)
covid19	-0.224**
	(0.093)
Intercept	60.795
N	486
F or χ_2	99.39
[p value]	[0.00]***
R^2- within	0.7117
R^2- between	0.8684
R^2- overall	0.8525
(rho)	0.849

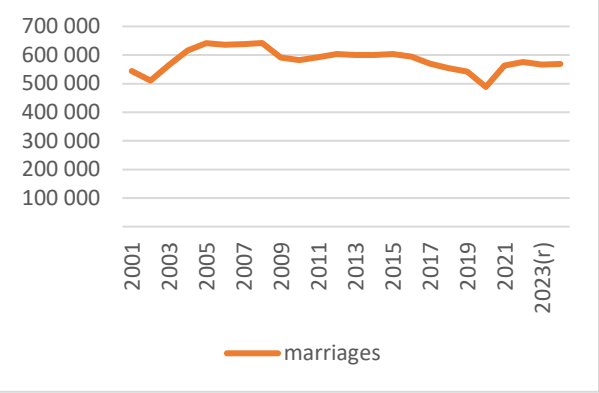
Notes: ***, ** and * denotes significance of coefficients at level <0.01, <0.05 and <0.10 respectively. () reports standard errors and [] reports p value.
The calculations are provided by Author by using Stata 13.0.

As demonstrated in Graph 2, the overall demographic trend in Türkiye is that the elderly population (age 65+) has been increasing over time since 1935, moreover a sharp jump is expected after 2024.

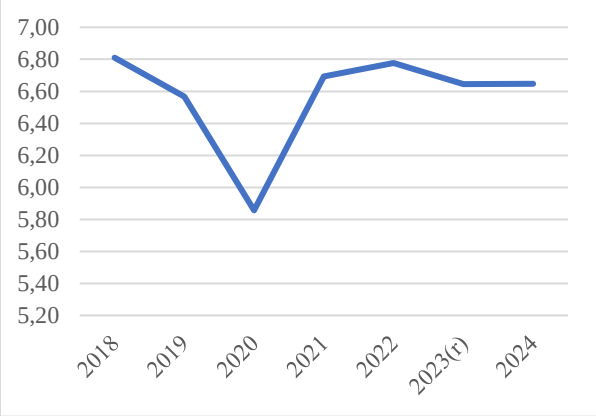
The number of marriages and marriage rate have exhibited a decline during the pandemic; however, following the conclusion of the pandemic, the number has once again approached close to 600,000 and appears to be stable. Since 2014, there has been a downward trend in the total fertility rate, and current data indicates that this trend is persisting.



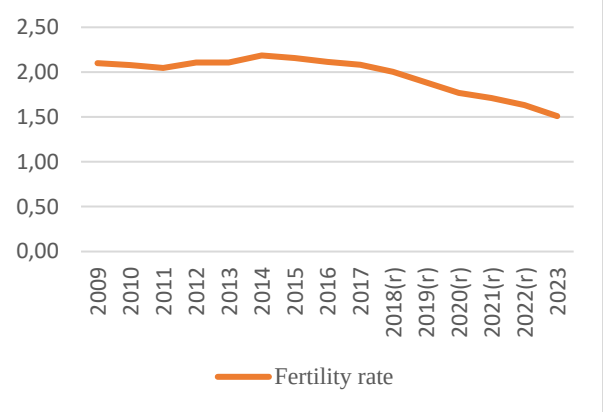
a. Elderly Population in Türkiye: 1935-2100



b. Marriage numbers in Türkiye (2001-2023)



c.Crude Marriage rate for Türkiye (2018-2023)

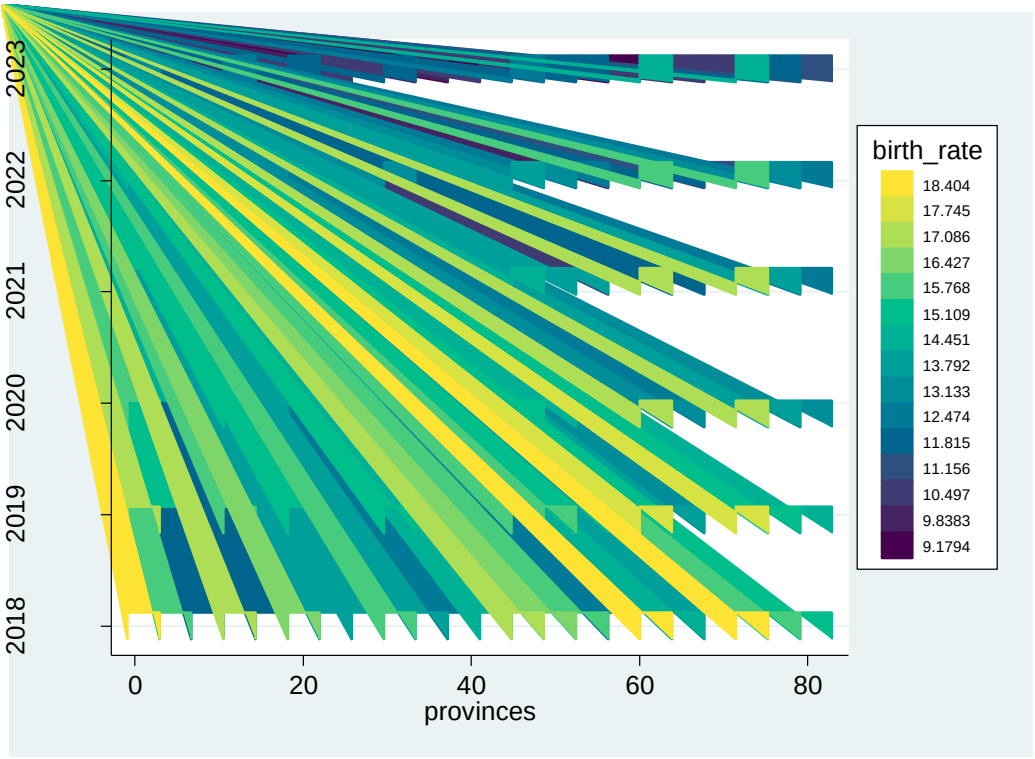


d. Total fertility rate in Türkiye (2009-2023)

Graph 2: Selected Demographic Statistics in Türkiye

Source: The graphs are provided by Author.

As presented in Graph 3, an analysis of birth rates by year and province reveals a decline in birth rates across 81 provinces, particularly since 2022, the lighter segments of the graph have become less prominent.



Graph 3: Birth rates by Year& Provinces in Türkiye, 2009-2013 period

Source: The graph is provided by Author by using Stata 13.0.

Conclusion and policy recommendations

This study employs GDP per capita, aging population, marriage rate and COVID19 pandemic effect on birth rates in 81 provinces in Türkiye from 2018 to 2023. One of the striking finding is that, COVID19 pandemic negatively affected birth rate in Türkiye across 81 provinces. This finding contributes to the existing literature by presenting the evidence for the first time. Marriage rate has positive effect while aging population and GDP per capita have negative and significant effect on birth rate. Our model findings are consistent with the existing literature such as Turk (2025) and Bol (2025).

Aging population includes various threats for many areas including economic growth, the labor market, healthcare systems, social welfare, and the adaptation of technology and policy. Aging populations also present global challenges including declining fertility rates. If the birth rate does not compensate this decline, it can lead to population decline and ultimately economic stagnation.

Fewer working age individuals cannot support a growing number of retirees and this causes higher taxes and increased financial pressure on younger generations in the future. Aging societies may prioritize policies for elderly care over investments in youth and innovation. This potential shift in priorities could give rise to intergenerational conflicts concerning resource allocation and government expenditure. Developing countries, such as Türkiye, India and Nigeria still have young populations while, advanced economies in Europe and East Asia are struggling with rapidly aging population. To conclude, to mitigate the challenges of an aging population and declining birth rate, governments and institutions must implement policies that promote higher birth rates, including family benefits, free or affordable childcare services, maternity leave support, employment support for the elderly and lifelong learning programs, strengthened healthcare and pension systems to ensure sustainability.

To encourage higher birth rates, the implementation of province-specific policies is essential. The different policies on aging population, GDP per capita and marriage rate can be recommended for the respective provinces. The implementation of flexible work hours and social support programs should be encouraged. Furthermore, the systems should be more resilient to any potential shocks. Additionally, by obtaining data at the provincial level, the provinces with higher COVID statistics (patient numbers, mortality rates etc.) can be searched for higher birth rates declines as a future research recommendation.

As Acemoglu and Restrepo (2017) suggested the adaptation of technology (robotics, artificial intelligence) to avoid negative effect of aging population on economic growth. This can also help to reduce the possible negative effect of lower birth rate on GDP, laborship etc. Türkiye can reduce the negative impact of aging population and lower birth rate by implementing robotics and AI in production process.

Demographic changes and economic conditions play a crucial role in shaping birth rates across regions. In recent years, Türkiye has experienced significant shifts in its demographic structure, characterized by declining fertility rates, an aging population, and economic fluctuations. Understanding the key determinants of birth rate is essential for policymakers aiming to develop effective family planning and socio-economic policies. As far as we know, this is the first study that searches the effect of Covid19 pandemic on birth rates at provinces level in Türkiye.

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