Eskişehir Osmangazi Üniversitesi
Sosyal Bilimler Dergisi
Temmuz 2023(2), 424-439
DOI: 10.17494/ogusbd.1294814

The Impact of the Demographic Transition on the Total Factor Productivity in Türkiye

Sevgi COŞKUN YILMAZ[1]

Türkiye'de Demografik Geçişin Toplam Faktör Verimliliğine Etkisi

Öz

Ölüm ve doğurganlık oranlarının yüksekten düşüğe doğru bir değişimi olan demografik geçiş, hayatın hemen hemen her alanını etkilemekte ve sosyal ve ekonomik alt sistemlerde önemli değişikliklere ve sonuçlara yol açmaktadır. Ayrıca, demografik geçiş ekonomide hayati bir faktöre sahiptir. Bu nedenle, sonuçları daha iyi yönetmek ve geleceğe dair daha iyi hazırlanmak için demografik geçişlerin, özelliklerinin ve boyutlarının derinlemesine anlaşılması önemlidir. Bu çalışmanın amacı, Türkiye'deki 1970-2021 yılları arasındaki demografik geçişin toplam faktör verimliliği (TFP) üzerindeki etkisini bir Probit modeli kullanarak analiz etmektir. Sonuçlar, bağımlılık oranı, yaşlı nüfus oranı, genç nüfus oranı, 1000 kişi başına düşen ölüm sayısı, yaşam beklentisi, nüfus yoğunluğu, kişi başına brüt sermaye oluşumu ve imalat üretimi gibi faktörlerin TFP büyüme olasılığını artırabileceğini ortaya koymaktadır. Bununla birlikte, sermaye stoku, kentsel nüfus ve 1000 kişi başına düşen doğum sayısı gibi faktörlerin ise bu olasılığı azaltabileceğini göstermektedir.

Anahtar Kelimeler: Demografik Geçiş, Toplam Faktör Verimliliği, Probit Model

Makale Türü: Araştırma Makalesi

The Impact of the Demographic Transition on the Total Factor Productivity in Türkiye

Abstract

The demographic transition would affect almost every aspect of life and our surroundings and could lead to significant changes and consequences in the social and economic sub-systems. In addition, it is a vital factor in economics. Therefore, a deep understanding of demographic transitions, characteristics, and dimensions would be helpful due to better managing the consequences and preparing for the future. The aim of this paper is to explore the impact of Türkiye's demographic transition on total factor productivity (TFP) from 1970 to 2021 using a Probit model. The results indicate that factors such as dependency ratio, elderly population ratio, youth population ratio, deaths per 1000 people, life expectancy, population density, gross capital formation per capita, and manufacturing production can increase the likelihood of TFP growth. However, factors such as capital stock, urban population, and births per 1000 people are shown to potentially reduce this likelihood.

Keywords: Demographic Transition, Total Factor Productivity, Probit Model

Paper Type: Research Paper

[1] Asst. Prof. Dr., Istanbul Medeniyet University, Faculty of Political Science, Economics Department, Istanbul, Türkiye. sevgi.coskun@medeniyet.edu.tr, ORCID: https://orcid.org/0000-0002-9561-7200

Makale Gönderim Tarihi: 09.05.2023
Makale Kabul Tarihi: 02.07.2023

1. Introduction

Economic growth is one of the country's most important goals. Recognizing the elements that affect an economy to reach a high and steady economic growth rate is among the chief principal of any country. The population age structure of a country is one of the effective elements in economic growth and production process. Demographic structure and population impact on economic growth can be complicated and sophisticated. On one side, a country's age distribution of a population could affect workforce participation rate and workforce age structure, on the other hand, this structure could affect consumption, saving, and productivity. Moreover, there are some theoretical considerations regarding the interaction between TFP and demographic transition. For example: changes in population size and an age structure can affect labor supply and dependency ratio. A higher dependency ratio can strain the labor force and productivity, while a balanced age structure with a sufficient working-age population can support higher TFP. Also, there are some other theories suggest that a larger population can cause an increase in productivity due to economies of scale, specialization and a larger labor force (Liu and Westelius, 2016). In addition, Inokuma and Sanchez (2023) investigate the influence of population growth on TFP and explore its potential consequences for future economic development. They find that the productivity life cycle profile of a business plays a crucial role in determining the direction of the effect of growth on TFP. Based on their theoretical framework, TFP growth will decrease in the fortcoming decades due to the decrease of population growth. Jones (2022) also explains that in numerious economic models, the engine of economic growth lies in the discovery of new ideas and assuming a constant or growing population. However, the high income countries today, fertility rate have already fallen below replacement levels. Therefore, in his paper, he investigates the implications for economic growth when population growth becomes negative.

Even though growth in economic output and population densities have coincided with higher life expectancy rates over the last few decades, and most evidence contradicts the Malthusian theory, any study in this area may prove helpful to a country's future because any future success will belong to its human capital and workforce productivity. For example, by expanding people's skills and knowledge, human capital contributes to economic growth. In addition, the population age structure has an influence on the workforce and human capital on one side, and consumer spending and business investment affect the supply of skilled labor needed and can be an essential factor in economic development. As a result, population and demographic variables can have an important effect on a country's productivity and economic development. A country's population growth rate may be detrimental or advantageous. Total factor productivity (TFP), on the other hand, was thought to be the most critical driver of economic development. Because of technical improvements that boost TFP, more viewpoints are centered on maximizing resource allocation, improving capital mobility, and improving R&D efforts. TFP is crucial to the advancement of economic change. Consequently, it is urgent to investigate whether the demographic change can lead to increased or decreased TFP growth in Türkiye. The novelty of this study lies in its incorparation of econometric analysis to empirically test and quantify the population and TFP relationship. This paper offers a unique perspective and generates valuable insights that can be applied to policy-making. This study will also help us to advance our understanding of the population-TFP relationship and contributes to the existing literature and offers valuable insights for policymakers and practitioners.

In this paper, firstly, we will discuss the demographic pattern of Türkiye, secondly, we will look at the relationship between demography and TFP and lastly we will investigate the impact of the demographic transition on TFP between 1970-2021 using the Probit model. To achieve this aim, we will use the data for capital stock, urban population, and births per 1000 people, age dependency ratio, elderly population portion, young population portion, deaths per 1000 people, life expectancy,

population density, gross capital formation per capita, and manufacturing output and urban population.

In this study, Section 2 reviews the existing literature. Section 3 shows the demographic pattern of Türkiye over the years. Section 4 shows the data and methodology. Section 5 discusses the results of the study and Section 6 concludes.

2. Literature Review

Solow's (1957) fundamental theory of TFP is where the connection among TFP and GDP originates. In Solow model, TFP is examined as an independent variable, whereas GDP is considered as a dependent variable. Griliches (1998) supports the link between the two variables. At first, Solow described TFP as a "technical change" and an equation residual. TFP and R&D spending are two other important areas. Some well-known linked articles will be discussed in the following paragraphs.

Mason (1988) investigates the link among investment, saving, and economic development over the past thirteen years in various nations. Results showed declining fertility might not increase savings, particularly in stagnant or slow-growing economies. For modeling the population's contribution to economic growth, Kelley and Schmidt (2005) created an adaptable framework. In their framework, a "productivity" model that explained the increase in output per worker was combined with a "translation" model that expressed the growth in terms of per-capita growth. The research team found that about 20% of the per capita output growth impacts were due to demographic changes across a cross-country panel spanning 1960-1995. Furthermore, Asia and Europe had greater shares of these impacts. Becker et al. (1999) examines how population growth affect productivity and economic growth and they find that it can have both positive and negative effects on productivity and economic growth. For positive effect, if a country has a large population, it will have an abundant labor force as well as a significant number of consumers. This hence leads to accelerate economic growth. On the other hand, it causes a decrease in productivity and a slowndown in economic growth due to the diminishing returns.

Feyrer (2007) found that the age groups significantly influences TFP in OECD nations, and the majority of TFP's contributors are aged 40 to 49. Moreover, Skans (2008) examined the impact of age structure on productivity regionally applying a lagged population structure. They find that employees between the ages of 50 and 60 have a positive impact on productivity. Also, Aksoy et al. (2015) investigates how the young, old dependents and the working-age population impact the economic growth. They explore that the young and old dependent population has a negative effect on economic growth but the working age population has a positive effect on economic growth. According to Wu (2010), human capital with tertiary education and TFP have a negative correlation, which can be attributed to ineffective resource allocation. In addition, Wei and Rui (2011) explored how human capital influenced TFP growth in China's provinces between 1985 and 2004. They observed that human capital positively influences TFP growth in Chinese provinces.

Furthermore, the ageing of the working-age population, according to Liu and Westelius (2016), negatively influenced total factor production in Japan between 1990 and 2007. The data support the notion that demographic pressures may have a major impact on deflationary pressures and total factor productivity. Fischer (2016) asserts that a decline in long-term productivity growth has an effect on the ratio of savings to investments. A slowdown in the growth of productivity reduces the future income of households. Families reduce spending and increase savings to make up for the anticipated reduction in income growth if this is anticipated. The percentage of workers who save more than the average amount of money increases as the population ages, which raises the overall amount saved. This has an impact on real interest rates and inflation.

Goodhart and Pradhan (2017) extrapolates future lessons from the effects of China's economic inclusion into the global economy. The article makes the case that China's integration has resulted in a shock for savings positively (compared to investment) and labor supply (relative to capital), which has led to a drop in interest rates, the marginal product of labor, wages, and inflation. Also, Dzeha et al. (2018) explored the link among TFP and human development in Africa as a function of remittance levels using panel data from 21 African states between 2010 and 2014. They discovered that remittances had a favorable influence on human development, but TFP has the opposite effect. As a result, countries that receive more remittances may be able to offset TFP's negative impacts. Todaro (2012) examines the effects of population growth on both developed and developing countries. He finds that in developed countries higher population growth leads to higher increases in productivity due to their abundant capital and limited resources. However, since developing countries have low GDP and low living standard, higher population growth becomes a burden on the economy.

Li and Zhao (2019) explored the long run and short-run impacts and basis among aging and technological innovation in China using a unidirectional causality metric. It appeared that population aging would ultimately affect technological innovation, even if its impact on innovation is minimal. In contrast to old-age dependence ratios, the child-raising ratio has unidirectionally a notable causal influence on technological innovation. Furthermore, the total dependency ratio affects technological and scientific innovation more than the elderly dependency ratio. In the other study, Li and Zhao (2022) measured total factor productivity with the DEA-Malmquist method based on provincial panel data for 1998-2017 in China and constructed a panel data model to estimate the link among birth rates and human capital as well as the impact of labor in various age components on TFP. The findings indicated that the building of human capital is considerably harmed by rising birth rates. Additionally, because of low birth rates, the percentage of people aged 50 to 59 will remain high and cause a decline in the productivity of all factors. Lastly, Bloom et al. (2010) find that aging population in OECD countries would decrease economic growth by reducing labor force participation and savings but they noted that this effect will be small. On the other hand, they explored that in most OECD countries, the declining birth rates would reduce the proportion of young people in the population but this decline would ocur at a faster rate than population aging, leading to an increase in the ratio of the workforce to the population.

3. Türkiye’s Demographic Pattern

Demographic changes affect almost every aspect of life and our surroundings, and this could lead to significant changes and consequences in the social and economic systems; also, it is a vital factor in economics. Therefore, a deep understanding of demographic transitions, characteristics, and dimensions would be helpful due to better managing the consequences and preparing for the future. Hence, the purpose of the first part of the paper is to identify the pattern of changes in the age structure of Türkiye by analyzing the changes in the population age structure and some related indicators in the labor market in Türkiye.

Based on the Solow model, if a country has a lower population growth rates, then this country will have a higher steady-state capital stock per worker (Nguyen, 2020). So, the first indicator that will be analyzed is population growth. Based on the World Bank data, in Figure 1, Türkiye’s population rate was about 2.7 percent in 1961 and dropped to its least rate in the last year, 2021. Even if this indicator has a decreasing rate in the whole period, there is an unusual fluctuation from 2011 to 2018. In this period, the population growth rate rocketed from 1.33 percent in 2011 to almost 2 percent in 2014 and then dropped to less than half of 2014 in 2018 with 0.9 percent.

Apart from age structure determining effects on all aspects of social life, demographers and economists have paid special attention to its economic effects. In this regard, emerging topics and

concepts such as the Demographic Window (Peng 2005), Window of Opportunity (Birdsall and Sinding 2001), Demographic Opportunity, Demographic Dividend (Bloom 2004), Demographic Bonus (Birdsall and Sinding 2001) and Demographic Golden Age has been proposed. According to recent approaches, both the behavioral effects of the economic life cycle and the combined effects of the labor supply affect the growth and development of an economy (Bloom 2003). These theories have proven that people's economic behavior changes along with age changes.

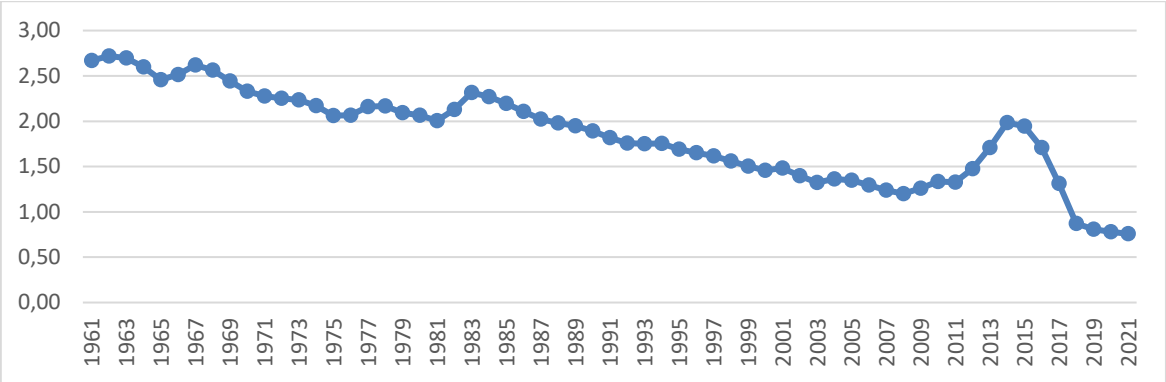

Figure 1: Population Growth (annual %) - 1960-2021
Source: The World Bank Data.

The transition of the age structure with the youth inflation of the population is clear and prominent. Young people are vital not only in terms of demographic weight, but also in economic, social, and political terms. The young population has development characteristics, such as higher education, which can be the source of significant economic and social developments in the country. This topic will be discussed in the following paragraphs, and it will focus on the population distribution by main age groups, their age pyramids, and some parameters regarding workforce and employment.

Based on the World Bank data, the children's population increased from 11.6 million in 1960 to 19.9 million in 2021 and increased to more than 1.7 times, while old adults (65 and above) enhanced around seven times, from 1.1 million in the first year to 7.1 million in the last year. The young and middle-aged adult population raised from 14.8 million in 1960 to 57.8 million in 2021 (Figure 2). The demographic transition is an important subject to study because there is a strong connection between people's behavior (especially in terms of consumption and saving), and their supply to the labor market. Despite the importance of all dimensions and components of population dynamics, population studies, policies, and programs have mainly focused on the dynamics of population growth and less attention has been paid to the changing age structures of the population, the opportunities, and challenges arising from it. Simultaneously, with the completion of the demographic transition process, changes and transitions in the population's age structure become the most pressing issue of the country's population and development. Population concentration at certain ages has its own needs, consequences, and, of course, its plans.

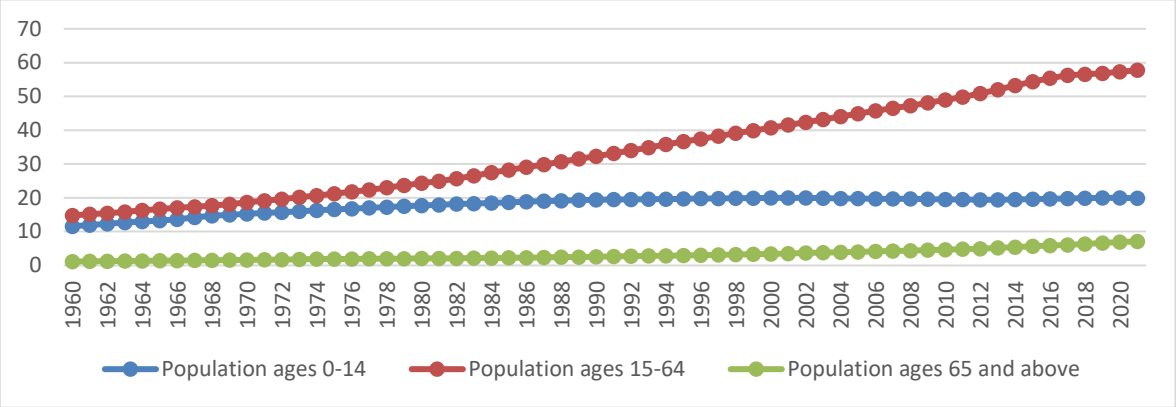

Figure 2: Population Distribution by Main Age Groups- Unit: Million person -1960-2021
Source: The World Bank Data.

According to the demographic transition theory by Notestein[2], societies transition from one demographic regime to another by changing the mortality, fertility, and growth (Figure 3).

- During the first stage, which is called the pre-transition, birth and death rates fluctuate significantly. In this phase, population growth stands at a low and positive rate.
- Second, we have an early transition, which occurs at the start of the transition process. At this step, the death rate falls, and the birth rates stay high. This step is related to rapid population growth.
- The next stage is called the Late Transition. At this stage, birth rates decline, and population growth slows down.
- The last stage is post-transition. The birth rate and mortality rate are low in this phase.

The birth rate, an effective parameter in the demographic transition, is the total number of births in a year per 1,000 individuals and mortality is the number of deaths in a particular population. Recently, the birth rate has continued to lessen in Türkiye. A reduction in birth will result in an increase in aging, which will negatively affect the labor supply, and will negatively influence future economic growth. Based on Figure 4, birth rate of 15.41 per 1000 people in 2021, the mortality rate of 5.54, and a population growth rate of 0.76 percent (Figure 4). By a comparison between the general demographic transition figure and the demographic transition of Türkiye, we can say this country now experiences phase three, if the birth rate continues based on the OECD foresight; this country will step into phase four which is the post-transition stage.

In 2021, the working-age population aged between 16-64 accounted for 57.77 million, or 68.1% of the total population, while the working-age population aged 65 and above accounted for 24.949 million, or 8.4% of the total population (Figure 5). Population pyramids, which illustrate the population's demographic structure, represent that in the last four decades, the number of births broadened the base layer of the population pyramid in 1980 (Figure 6). In this period, Türkiye had both high fertility and mortality rates among younger members. However, the population structure of society changed in the next 40 years. During this time, the child mortality rate fell, and this leads to a bump in the adult age groups, especially the 15 to 65 years age groups. As health develops and mortality drops, people are expected to live in longer period. Hence, the mortality rate has increased from 1980 to 2020, and the elderly population has enhanced from 2 million to 6.8 million. In comparing 1980 and 2020, the number of children born has increased from 17.6 to 20 million in the last year.

[2] Frank W. Notestein (1902-1983).

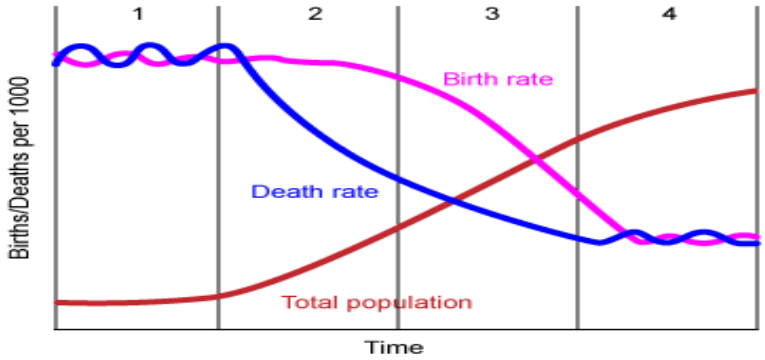

Figure 3: Demographic Transition
Source: https://papp.iussp.org/sessions/papp101_s01/PAPP101_s01_090_010.html

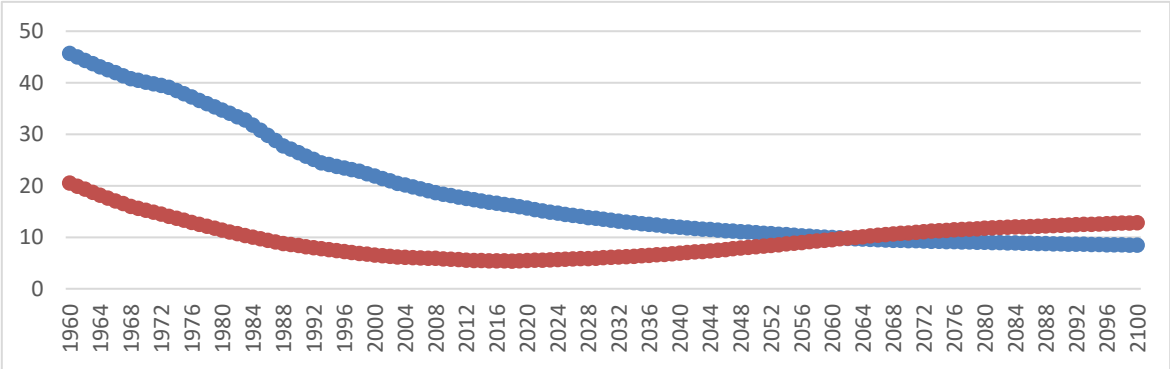

Figure 4: The Birth Rate and Death Rate (1950-2100).
Source: United Nations-World Population Prospects.

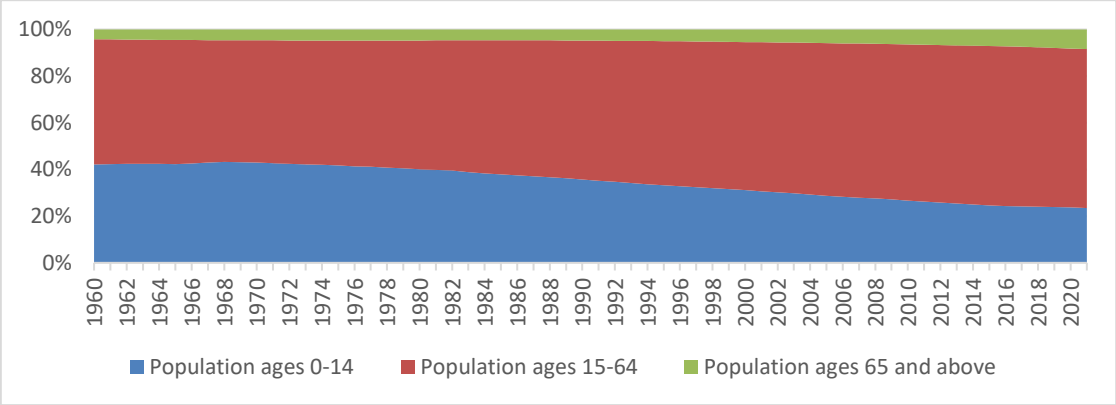

Figure 5: Age Structure (1960-2021).
Source: The World Bank Data.

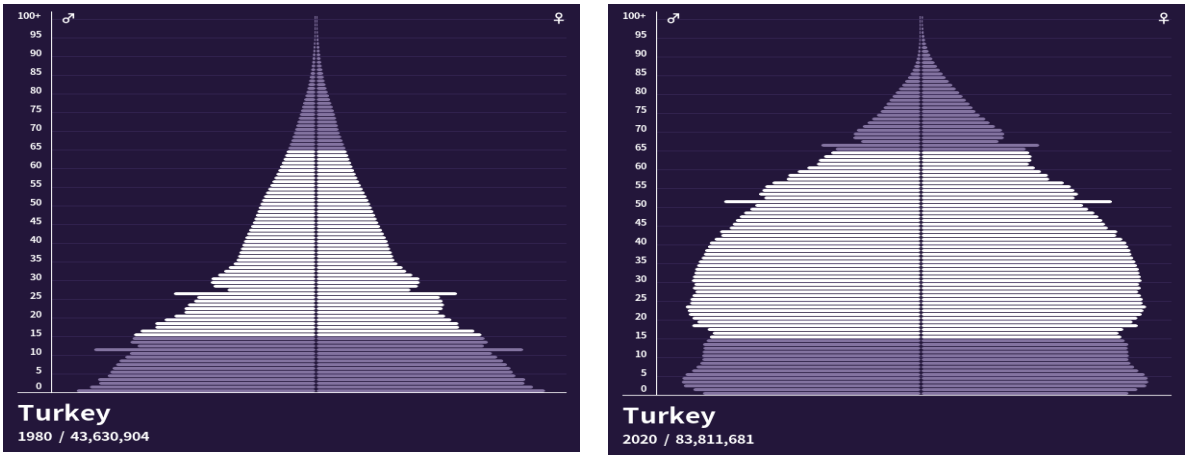

Figure 4: The Demography of Türkiye's Population- 1980-2020
Source: United Nations

The dependency ratio which is equal to 0-14 years old group and 65 years or over old group to 15-64 years old group in a country, and it aims to show the effects of changes in age structure of population for economic growth. According to the World Bank statistics, Türkiye's reliance ratio climbed to 91.5 percent in 1969; however, dropping fertility numbers cause the dependency ratio to reduce initially (Figure 7). Because the proportion of children is decreasing while the proportion of people of working age is increasing, this metric fell to 46 percent in 2017. However, a slightly bettering epoch has begun in Türkiye in the coming years.

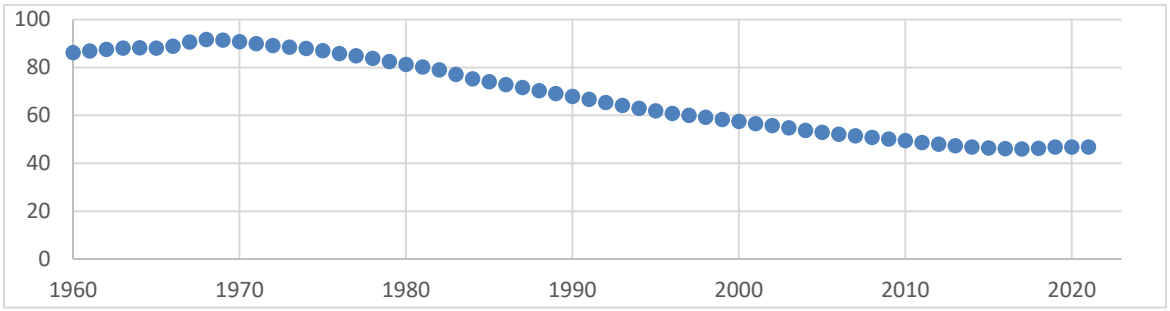

Figure 7: Dependency Ratio (% of working-age population).
Source: The World Bank Data.

According to the United Nations data, in the next 60 years, the 0 to 14 years group will fall significantly. Moreover, by increasing life expectancy and access to medical care, a noticeable change will happen in the upper part of Türkiye's population pyramid. Based on the United Nations' forecast, the ratio of people in the working age will decline between 2050 and 2080 (Figure 8). The number of children will barely increase from 2020 to 2050, then fall until 2080. The working age population and older population will rise substantially from 2020 to 2050. However, this trend will change in 2080 when considerable growth is likely to happen, due to the UN's forecast, for the elderly population.

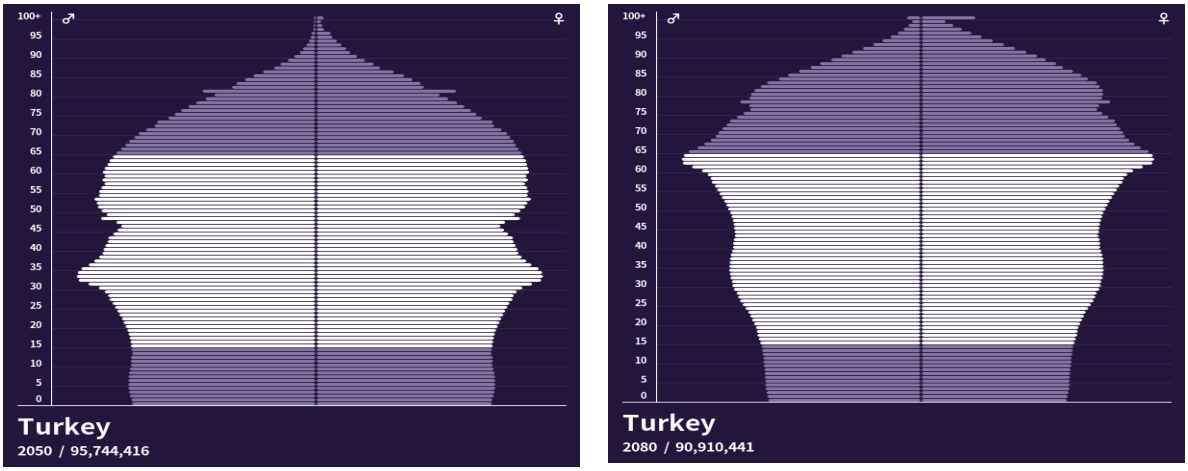

Figure 5: The Demography of Türkiye's Population (2050-2080)
Source: United Nations.

3.1. Coherence of Total Factor Productivity Growth and Demographic Transition

In this section, we will discuss the total factor productivity growth and demographic transition. Based on previous studies, demographic maturity affect positively economic development by reducing the dependency ratio and raising the working age population.

Demographic shifts in both size and structure affect working-age populations, which might have a significant impact on physical and human capital accumulation. Falling birth rates impact the structure of the working-age population, making one country more mature than another, even if both have workforces of the same size. A society with a big proportion of prime-age people (35-54-year-olds) should have a higher productive potential than one with a huge number of new entrants into the labor market. This is because of the proper balance of formal education and experienced human capital. A society with a large proportion of persons in the prime working age range (35 to 54 years old) should have a greater level of productivity than one with a considerable number of new employees. Firm-level findings both support and undermine this position. The optimal number of prime-age employees to maximize production necessitates both workers with experience and workers with the correct balance of youth and maturity (Gomez and Hernandez, 2003).

Furthermore, as the demographic transition proceeds, a transition in human capital occurs, with fundamental changes in the working age population and their skills and productivity. Likewise, changing demographics influence capital accumulation and worker productivity beyond human capital changes. A growing working-age population will influence savings and the productivity of labor force, but the direction of these channels is not clear. Although the savings trend follows a lifecycle profile, human capital varies by worker's age (Gomez and Hernandez, 2003). Generally, individuals smooth consumption throughout their lifetimes under the standard life-cycle model, therefore borrowing when they are young and saving when they are economically active-in, particularly saving when they reach prime working age. Because of fewer dependents and a rise in the number of people in prime age, a demographic transition will positively have an impact on savings. Furthermore, an increase in exogenous savings due to a growing and maturing population should boost per capita output in a positive (second-order) way.

4. Methodology and Data Description

Based on Bloom and Canning (2003), in the long run, labor supply will not affect economic growth, but it will accelerate growth on a reasonable timeline. So, the period that has been considered in this

paper is from 1970 to 2021. The data set that has been used in this empirical work is a time series data set and the software that has been used for estimation are R and STATA.

4.1. Conceptualizing Empirical Model Framework

The suggested exploratory study will look at correlation as well as association, direction, and inaccuracy. Probit regression is the most fundamental technique to apply. The model will be estimated using a Probit model that links changes in total factor productivity to demographic parameters. Note that this model, commonly used for binary or categorial data analysis, has attracted critiques and concerns. Specifically, there is a concern regarding the sharp values generated by the Probit model, which range between 0 and 1. These sharp values near 0 and 1 might limit the ability to precisely evaluate and compare the impacts of predictor variables. Notwithstanding, it is important to use this model as it provides a natural and intuitive interpretation of the estimated coefficients as probabilities (Hoetker, 2007).

4.2. Estimation Technique

There are some different methods that can be used to analyze the impact of some independent variables on dependent variable; however, in this study, based on some other previous studies, a Probit model has been considered. Probit and logit models need a normalization of the error variance for model identification (Choe et al, 2017). To reach the Y^*, a model has to be considered, which is:

$$Y^* = X_i\beta^* + \varepsilon_i^*$$

Where ε_i^* has a standard normal distribution, and Yi is a binary variable. Hence, the Probit model could be defined by:

$$Prob(Y^*) = Prob(X_i\beta^* + \varepsilon_i^* > 0)$$

$$Prob(Y^*) = Prob(\varepsilon_i^* < X_i\beta^*)$$

$$Prob(\frac{Y^*}{\sigma_\varepsilon}) = Prob(\frac{\varepsilon_i^*}{\sigma_\varepsilon} < \frac{X_i\beta^*}{\sigma_\varepsilon})$$

$$Prob(Y_i = 1|X_i) = Prob(\varepsilon_i < X_i\beta)$$

The parameter σ_ε is not identified; therefore, it is normalized to 1 for the Probit model. Based on the assumption, if TFP is greater in the year "*t*" than in year "*t-1*", the dependent variable will be 1, and if TFP is less than in year "*t-1*", the dependent variable has a value of 0. The chance of TFP increase is therefore represented by the dependent variable.

4.3. Data Description

The yearly data that has been used in this paper are from 1970 to 2021. The data vary from different resources from United Nations (UN), World Bank, World Development Indicators (WDI), Organization for Economic Co-operation and Development (OECD), Penn World Table (PWT), and Federal Reserve.

Tablo 1. Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
TFP	52	.4230769	0,4988675	0	1
GNIPerCap	52	6638975,00	2933,634	3349,079	13671,32
CapitalStockPerCap	52	54541.86	32856,53	16123,92	131363,2
UrbanPop	52	3.74e+07	1,59E+07	1,36E+07	6,49E+07
AgeDependencyRatio	52	64.4355	14,98343	45,96018	90,81835
ElderlyPopPortion	52	5.948178	1,591792	4,202214	9,625194
YoungPopPortion	52	32.08354	6,305575	22,60571	41,69288
BirthsPer1000	52	25.64904	7,973327	15,408	40,137
DeathsPer1000	52	8.407519	3,025782	5,398	15,241
LifeExpectancy	52	66.48585	7,979803	51,968	77,994
PopDensity	52	77.5725	19,3752	46,17932	109,9
ManufacturingOutput	52	60.58638	55,36828	2,704698	181,8877
GrossCapitalFormationPerCap	52	1706.201	772,6869	892,5992	4222,373

Table 1 shows the data. The variables are TFP, PPP; GNI per capita (constant 2015 US$); capital stock per capita (constant 2015 US$); urban population (% of the total population); age dependency ratio (% of working age-population); elderly population portion (% of all population); young population portion (% of all population); births per 1000 people; deaths per 1000 people; life expectancy at birth, total (years); population density (people per sq. km of land area); and gross capital formation per capita (constant 2015 US$). Some of those variables are taken from Ursavaş (2020)'s work and some are from the literature (Feyrer, 2007; Liu and Westelius, 2016; Li and Zhao, 2019; Bloom et al., 2010). These variables are important for analyzing TFP as they provide insights into different aspects of an economy. For example: higher income levels are linked to increased resources for investment and technological advancement, higher capital stock increase productivity capacity as facilitating more efficient production processes. The people who lives in urban areas have a better access to infrastructure and market. Life expectancy affect labor force participation, saving behaviour, affecting TFP. Also, if there is an increase in capital formation, it will affect technology adopting which positively impact TFP. For manufacturing output, it plays an important role in overall economic productivity.

5. Empirical Results

The performance- in terms of the probability of successful rating at completion- of changes in the total productivity factors from 1970 to 2021 how has been affected by Türkiye's demographic variables. Table 2 shows the results of Probit regression for demographic factors. As can be seen in Table 2, 8 of 12 variables are significant. Among the significant variables, capital stock, elderly population portion, and deaths per 1000 people are strongly significant to TFP growth probabilities. Also, young population portion, births per 1000 people, life expectancy at birth, population density, and gross capital formation per capita are substantially regarding total factor productivity growth probabilities. Furthermore, the findings imply that, whereas income per capita improves the chance of overall TFP growth, capital stock per capita declines the likelihood. Moreover, according to the findings, capital stock, urban population, and births per 1000 people may reduce the likelihood of TFP growth, whereas elderly population portion, young population portion, deaths per 1000 people, life

expectancy, population density, gross capital formation per capita, and manufacturing output may increase it. Furthermore, the variable urban population is not statistically significant.

Tablo 2. Probit Regression Results

Coefficients:				
	Estimate	**Std. Error**	**z value**	**Pr(>|z|)**
(Intercept)	-4,88E+02	2,08E+02	-2,347	0,01891*
GNIPerCap	3,14E-04	5,48E-04	0,573	0,56695
CapitalStockPerCap	-1,68E-05	5,81E-06	-2,721	0,00386**
UrbanPop	-1,32E-06	1,15E-06	-1,149	0,25046
AgeDependencyRatio	8,90E-01	8,27E-01	1,076	0,28178
ElderlyPopPortion	5,09E+00	2,19E+00	2,323	0,02016*
YoungPopPortion	4,80E+00	2,53E+00	1,902	0,05722.
BirthsPer1000	-3,50E+00	1,67E+00	-2,095	0,03619*
DeathsPer1000	7,97E+00	4,09E+00	1,948	0,05147.
LifeExpectancy	1,80E+00	1,85E+00	0,974	0,33028
PopDensity	3,06E+00	1,45E+00	2,116	0,03435*
GrossCapitalFormationPerCap	4,00E-03	1,92E-03	2,087	0,03691*
ManufacturingOutput	5,86E-02	4,06E-02	1,444	0,14888

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

AIC: 77.518

Table 3 emerges the result of the significant variables of the Probit model. Based on the regression estimation, an increase in young population ratio, birth rate, and death rate decrease the probability of TFP growth. In comparison, a rise in population density, adult's population ratio and gross capital formation per capita enhance the probability of TFP growth.

Tablo 3. GLS Estimates of Effect of Demographic Transition on TFP

Dependent variable:	TFP							
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
CapitalStockPerCap	0	-0.00001	-0,00001	0	0	-0,00001	-0.00002*	-0.0001**
	(0.00000)	(0.00001)	(0.00001)	(0.00000)	(0.00000)	(0.00001)	(0.00001)	(0.00004)
ElderlyPopPortion		0.167						0.637**
		(0.180)						(-0.307)
YoungPopPortion			-0.029					0.498**
			(0.032)					(0.242)
BirthsPer1000				-0.015				-0.215
				(0.018)				(0.175)
DeathsPer1000					-0.019			0.670**
					(0.039)			(0.301)
PopDensity						0.010		0.259
						(0.012)		(0.155)
GrossCapitalFormationPerCap							0.001*	0.001**
							(0.0003)	(0.0004)
(Intercept)	0.463***	-0.105	1.680	1.033	0.705	0.001	0.450***	-35.016*
	(0.136)	(0.625)	(1.328)	(0.701)	(0.510)	(0.598)	(0.134)	(19.309)
Observations	52	52	53	54	55	56	57	58
Log Likelihood	-38.059	-37.605	-37.612	-37.696	-37.930	-37.727	-36.431	-31.629
Akaike Inf. Crit.	80.119	81.210	81.224	81.392	81.861	81.454	78.863	79.257

Note: *p<0.1; **p<0.05; ***p<0.01

Lastly, it is important to mention that our study is close to Ursavaş (2020)'s study. He examines the impact of demographic factors on TFP growth in Türkiye from 1986 to 2017 using Probit regression. The difference between our work and his work is that we have more variables and more extended data to analyze this relationship in Türkiye. Our study is largely campatible with his study in many aspects. He finds that an increase in income per capita is associated with a higher likelihood of TFP growth while an increase in capital stock per capita is associated with a lower likelihood. He also explores that the likelihood of TFP growth may be reduced by factors such as the dependeny rate and fertility rate, while factors such as urban population, life expectancy at birth, and population density may increase the likelihood. Moreover, results support the main idea of the previous studies, which is when labor markets increase at a certain level, sustaining low birth rates can have an important impact on human

resource endowments. The younger the laborers, the more the labor population grows, and social innovation and TFP are more likely to develop faster. Thus, to maintain a certain level of labor force growth and total factor growth rate correlates positively with the working age population in a country (Gomez and Hernandez, 2003; Liu and Westelius, 2016; Li and Zhao, 2022).

6. Conclusion

Macroeconomic studies have concentrated on the problem of population position in economic studies and the relationship between macroeconomic factors and age structure throughout the previous two decades. This research also looks into the relationship between age structure and TFP. The main motivation reason for this idea back to the changes in the demographic structure of Türkiye. The World Bank forecast of Türkiye's population in the next 50 years demonstrates that the number of people ratio who are in their old and middle-aged years will decrease, and it will cause a significant change in their demographic structure. Based on the evidence from the changes in the fertility rate, mortality rate, and all of the changes related to healthcare facilities will move the probability that the ratio of these groups will decline and goes to contrariwise. Consequently, demographic changes will have a greater impact on directed automation adoption and TFP.

Our results show that capital stock, the percentage of the old population; deaths per 1000 people, age dependency ratio, young population portion, births per 1000, and life expectancy at birth, population density, and gross capital formation per capita out of 12 variables are significant to the likelihood of TFP. While age dependency ratio, elderly population portion, young population portion, deaths per 1000, life expectancy, population density, gross capital formation per capita, and manufacturing output may increase the likelihood of TFP growth, capital stock, urban population, and births per 1000 may decrease it. It is also not statistically significant to incorporate the changing urban population. Lastly, note that the results of this study might vary depending on the selection of variables, data sources, econometric models used for analysis. The limitation of our work is the lack of previous research studies on the effect of demographic change on total factor productivity in Türkiye.

Statement of Research and Publication Ethics

This study does not require ethical permission.

Funding Statement

The author received no specific funding for this work.

Contributions of the Authors to the Article

The author's contribution to the article is 100%.

Conflicts of Interest

The author states that there is no conflict of interest.

References

Aksoy, Y., Basso, H. S., Smith, R. & Grasl, T. (2015). Demographic Structure and Macroeconomic Trends. *Madrid, Spain: Banko de Espana.*

Becker, G., Glaeser, E. & Murphy, K. (1999). Population and economic growth. *American Economic Review*, 89(2), 145-49.

Birdsall, N. and Sinding, S. W. (2001). How and Why Population Matters: New Findings, New Issues. Book: *Population Matters: Demographic Change, Economic Growth, and Poverty in the Developing World Population,* Oxford University Press: 3-23.

Bloom, D. E. and Canning, D. (2004). Contraception and the Celtic Tiger. *Economic and Social Review 34.*

Bloom, D. E., Canning, D. & Sevilla, J. (2003). The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change. *Population Matters Monograph* MR-1274, RAND, Santa Monica.

Bloom, D. E., Canning, D. & Fink, G. (2010). Implications of ppulation ageing for economic growth. *Oxford Review of Economic Policy*, 26 (4), 583_612.

Choe, C., Jung, S. and Oaxaca, R. L. (2017). Identification and Decompositions in Probit and Logit Models. *IZA DP* No. 10530.

Dzeha, G. C., Turkson, F., Agbloyor, E. K. & Abor, J. Y. (2018). Total Factor Productivity Growth and Human Development: The Role of Remittances in Africa. *African Journal of Economic and Sustainable Development* 7 (1): 47 – 72.

Gomez, R. and Hernandez, P. (2003). Demographic Maturity and Economic Performance: the Effect of Demographic Transitions on Per Capita GDP Growth. *Working Papers 0318, Banco de España*.

Feyrer, J. (2007). Demographics and Productivity. *The Review of Economics and Statistics*, vol. 89, issue 1, 100-109.

Fischer, S. (2016). Why Are Interest Rates So Low? Causes and Implications. *Remarks at the Economic Club of New York*.

Goodhart, C. and Pradhan, M. (2017). Demographics will reverse three multi-decade global trends. *BIS Working Paper* No 656.

Griliches, Z. (1998). R&D and productivity: The econometric evidence. *University of Chicago Press.*

Hoetker, G. (2007). The use of logit and probit models in strategic management research: Critical issues, *Strategic Management Journal, Wiley Blackwell*, vol. 28(4), pages 331-343.

Inokuma, H. and Sanchez, J. M. (2023). From Population Growth to TFP Growth. *Working Papers 006, Federal Reserve Bank of St. Louis.*

Jones, C. I. (2022). The End of Economic Growth? Unintended Consequences of a Declining Population, *American Economic Review, American Economic Association*, vol. 112(11), pages 3489-3527.

Kelley, A. C., and Schmidt, R. M. (2007). *Evolution of recent economic-demographic modeling: A synthesis*. In A. Mason & M. Yamaguchi (Eds.), *Population change, labor markets and sustainable growth: Towards a new economic paradigm* (pp. 5–38). Amsterdam: Elsevier.

Li, X., and Zhao, X. (2019). Interaction between population aging and technological innovation: A Chinese case study. *Journal of Advanced Computational Intelligence and Intelligent Informatics*, 23(6), 971–979.

Li, X. and Zhao, X. (2022). Does low birth rate affect China's total factor productivity? *Economic Research-Ekonomska Istrazıvanja*, VOL. 35, NO. 1, 2712–2731.

Liu, Y. and Westelius, N. (2016). The Impact of Demographics on Productivity and Inflation in Japan. *IMF Working Paper.*

Mason, A. (1988). Saving, Economic Growth, and Demographic Change. *Population and Development Review* 14(1): 113-144.

Macrotrends Data Set (2023), http://www.macrotrends.net/ (Accessed on 15 April 2023).

Nguyen, A. (2020). Patterns of Growth, Demographic Pattern and The Role of Total Factor Productivity in Growth in Taiwan, *SSRN.*

OECD (2023), Population (indicator). DOI: 10.1787/d434f82b-en (Accessed on 15 April 2023).

Peng, X. (2005). The Demographic Window, Human Capital Accumulation and Economic Growth in China: An Applied General Equilibrium Analysis, Asian Population Studies, 1 (2): 169-188.

Skans, O. N. (2008). How does the age structure affect regional productivity? *Applied Economics Letters*, 15(10), 787–790.

Solow, R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, 39(3), 312–320.

Todaro, M. (2012). *Economic Development.* 11th Ed., New York, London.

Ursavaş, U. (2020). Total factor productivity growth and demographics: The case of Turkey. *Ekonomi Politika ve Finans Araştırmaları Dergisi*, 5(1), 81-90.

Wei, Z.A. and Hao, R. (2011). The role of human capital in China's total factor productivity growth: A cross-Province analysis. *The Developing Economies* 49(1):1 – 35.

Wu, J. X. (2010). Knowledge diffusion, human capital composition and total factor productivity: A research based on Chinese provincial data. *Journal of Huizhou University (Social Science Edition),* 30(2), 60–65.