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RESEARCH ARTICLE

Application of a breakpoint model to population growth in Türkiye

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Abstract: Using data from the Macrotrends database, this paper investigated the change and differences in population growth (POPG) as a result of the impact of its key determinants employing a breakpoint model. A regression analysis confirms the presence of persistent differences in the POPG in Türkiye over the period 1965 – 2021. Using the Bai-Perron sequential breakpoint method, four statistically significant breaks at 1976, 1984, 2004, and 2013 and consequently to that five regimes were ascertained. The results clearly show a worthy of attention difference in the mean of the crude death rate, total fertility rate, as well as net migration rate within all of these five regimes. Furthermore, the results reveal clear evidence that the POPG is characterized with statistically different trends compared to the period prior and after the years of breaks and different regimes. This indicates that circumstances affecting the mortality, migrations, and fertility in terms of the number of live births and deaths as well as migration trends in the country before and after these indicated years in Türkiye have been largely influenced by the different dynamics of the socioeconomic conditions and different contexts in Turkish society.

Keywords: Population growth rate; Total fertility rate; Crude mortality rate; Net rate of migration; Breakpoint model; Türkiye

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1. Introduction

One of the fundamental equations in demography research specifies that a population grows or declines in size as the result of the combined effect of births, deaths, in-migration, and out-migration (Weinstein and Pillai, 2016). Consequently, given demographic definitions, demographers define the "growth" as all change in the size of a population or other aggregate measures even when an absolute loss or no change occurs, or when there is zero (negative) population growth (POPG). In general, decline in POPG can be associated heavily with the decreasing surplus of births more than deaths. As discussed by Avdeev *et al*. (2011), in the recent decades, the increasing differences in POPG rates in Europe are not due to natural increase but to net migration. As claimed by Bongaarts and Bulatao (1999), the future course in population size is determined by the decisive factors as the future trends in fertility and mortality, migration movements, as well as by the current population structure by age. Hence, natural growth is a result of fertility, mortality, and momentum. The current population structure by age determines future POPG, this alluding to the phenomenon demographic "momentum." In other words, population momentum signifies that a population that increases continues to increase in size further for some more years later than its fertility shift to replacement level fertility (Schoen, 2018). Thus, according to Horiuchi and Preston (1988), the present population age structure is a result of the population rates of fertility, mortality, and migration in the past.

According to a more common formulation given in Preston, Heuveline, and Guillot (2001), the term refers to the fact that a POPG does not depend only on current levels of fertility and mortality but also on the age structure of the population which, in turn, is an inheritance of the fertility and mortality in the past. In this regard, Horiuchi (1995) points out that the population momentum shows the difference's effects between actual and inherited growth rates of the final size of the stationary population, or the path to steady increase. Populations whose fertility is significantly below replacement level and whose age distribution did not have time to fully adjust to the new fertility regime will tend to have high values of unstable momentum (Espenshade, Olgiati, and Levin, 2011). It is expected that the population in areas with a rapid ageing process will have a natural growth under effect of the general mortality rate, that is, will gradually increase even if the general rate of birth is stable. Migrations are often considered as the key factor of POPG or decline at a regional or at a country level making an influence on population change of the regions or countries where migration happens. As an especially significant kind of movement, in the reasoning of Ediev and Yüceşahin (2016), migrations could be considered in two aspects. As argued from a pure demographic standpoint, migration component jointly with natural increase determines the extent and POPG rate. Differently from the purely demographic standpoint, the second aspect refers to the impact of migrations on population change usually at two places: The origin and destination of the migration movement. Especially in places with clearly visible regional fertility differences, largely in low fertility regions, migration may be a driver to compensate for lower births (Ediev and Yüceşahin, 2016). As a consequence, the region of destination may offset for its POPG. Furthermore, Lee (2011) explains that international migration could have an indirect effect on POPG at the global level and that it undoubtedly does affect POPG in many more developed countries, where low fertility in any other way would cause a population decrease. As a matter of fact, immigration is sometimes considered as a means to reduce population aging. In line with this, Lee (2011) adds further that it is more difficult to make predictions of net immigration than for fertility or mortality, because indeed immigration is more sensitive to differences in economic growth, political and military disruption, and policy changes. This study attempts to find an answer to the question whether and how much the POPG change in Türkiye varies as a consequence of observations of its key determinants within a breakpoint model for the period 1965 – 2021. Starting from June 2022, Turkey was replaced by Türkiye as its official name. Thus, the aim of this paper is to consider the breakpoint model as capable of capturing the structural changes of the POPG for Türkiye.

One of the reasons for specifying the initial period in 1965 for our research work is to say that the period between 1968 and 1971 in Türkiye was interesting for a lot of reasons. Thus, prior this period, there was not such a rising social protest initiated by students, workers, farmers, teachers, and administrative workers. It is considered that there was not enough interest for these social movements by the academic experts and the extant literature. Namely, the research paper of Alper (2010) attempted to provide mostly a political clarification for the social protests of 1968 – 1971. Thus, his explanation suggests that the shift in the balance of power of political groups has led to a prolonged elite conflict between the Kemalist bureaucracy and the center-right political elite, which has provided significant opportunities to under-represented groups to organize and raise their voices. In this regard, Pekesen (2014) adds that as in other countries in the world, during the 1960s, Türkiye also experienced substantial social changes, mass mobilization, and many-sided forms of public protests. The fast pace urbanization and the migration from rural regions to the industrial cities beginning in the 1950s changed severely the structure of society and the political environment as well. Consequently, the state and its weak social welfare system have not been able to manage unemployment and widespread poverty. Governments in the 1960s in Türkiye and opposition parties such as the Republican People Party were obviously not able to respond to the growing dissatisfaction and deprivation among considerable important parts of the population (Pekesen, 2014). As a second reason for choosing this period is that during this period, Türkiye was already covered with the second demographic transition, when the fertility rate reached a high level and the mortality rate decreased (Figure 1).

Overall, our findings represent an important contribution in POPG dynamics relative to Türkiye. Therefore, somehow related to the previous sentence, the actual motivation for doing this research is expanding the empirical research with inclusion of the breakpoint methodology to explore the changes in POPG for Türkiye. The rest of the research paper is organized in the following way: Section 1.1. defines the theoretical background of this research study and Section 1.2. introduces the trend and development of the POPG in Türkiye. Furthermore, Section 2 shows the data and methods approach. Section 3 presents the practical results of the application of the breakpoint model for Türkiye, while in Section 4, the gained results are discussed. Section 5 provides conclusions.

1.1. Theoretical background

During the process of demographic transition, populations change from a condition of high levels of mortality and fertility to a context with low levels of mortality and fertility (Lee, 2011). The "classic" demographic transition or also known as first demographic transition makes reference to the past events of decreases in mortality and fertility, seen since the 18th century ahead in some of the European populations and with continuity until the present time in most of the developing societies (Lesthaeghe, 2014). Hence, the first demographic transition is supposed to finish when there will be an older stationary population that will correspond with replacement fertility, that is, 2.1 children on average, with zero POPG,

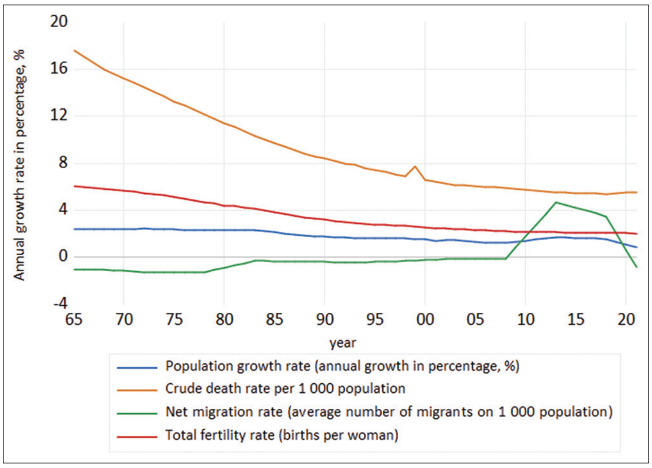

Figure 1. Population growth rate, total fertility rate, crude death rate, and net migration rate in Türkiye, 1965 – 2021. Source: Author's design based on real data.

and an average level of life expectancy higher than 70 years. The point of view of the second demographic transition, jointly developed by Lesthaeghe and van de Kaa in 1986 (Lesthaeghe, 2014) in opposite, does not see such a balance as an ending. To a certain extent, the founders of the second demographic transition stated that new progressive processes since 1970s onward may bring about sustainable sub-replacement fertility, a new partnerships and unions differently from the marriage, relationships with no strings attached and with little interest for marriage and procreation, and an absence of a stationary population. Furthermore, if there are no additional new migrants, the population will face declines in sizes and would also be much older than it is foreseen by the first demographic transition. Therefore, this situation would be as a result of the less fertility and the substantial further longevity gains. In general, as stated by Lesthaeghe (2014), the second demographic transition points to a different new challenges in a society, which include challenges related with more advanced aging, the integrating of immigrants, adjustment to new cultures, more risk to stability of the partnerships, many different kinds household, and more poverty or exclusion among particular kinds of household, for instance, single persons at different ages and single parents. During the first demographic transition, as fertility declined that there was not an enormous pressure for emotional and financial investment in the child, that is, in that part, the parents were somehow relieved. While during the second demographic transition, the motivation was self-realization of an adult within the role or way of life as a parent or completely successful and fulfilled adult (Lesthaeghe, 2011).

According to Lee (2011) usually, first mortality starts to decline and continues to decline gradually and with stable pace, and then later a fast-moving decline in fertility starts which in a longer period of time, for example, more than 2 decades, may change from a high level to a relatively lower level. The changes in these vital rates usually bring about substantial changes in the population size and its age structure as well as in the POPG rate. In addition, it is important to note that in a period when mortality is declining and fertility remains high, the growth rate of the population is rising and the percentage of young people in the population is also rising. When fertility begins to decline, the percentage of the working-age population increases and continues to rise for more than 5 decades, until fertility decline (Lee, 2011). Strictly speaking, Ahmad and Khan (2018) indicate that the process of demographic transition is completing in four stages: The first stage is with a high mortality rate and a high birth rate; the second stage explains the period of decline in the mortality rate; the characteristics of the third phase are a decline in the birth rate in response to changes in behavior and social networks, and finally, the fourth phase shows the cessation of POPG where there is an replacement level of fertility. In addition, Lee (2011) cites behavioral theories of fertility that has been developed and tested by sociologists and economists, emphasizing that these theories have not proved practical for prediction. Thus, according these theories, fertility in less developed countries is difficult to predict because unlike mortality in a given country, fertility can begin to decline suddenly and rapidly and then equalize, and therefore can be very difficult to predict the initial year of decline, the pace of decline, and the level at which it ceases. Becker's theory was very dominant in understanding the demographic transition, but was most concerned with the fertility transition (Lee, 2015). As is well known, its precise mechanisms and measures were concerned with how economic development could increase children's costs and lead to a decline in fertility despite rising incomes. In the demographic literature, there have been ongoing debates on the causes of fertility decline. In this regard, Willekens (2015) mentions a dominant school that explains fertility changes as a response to changes in mortality. In addition, some other theories associate the demographic transition with economic and social development.

Furthermore, as a result of the continued work in this area done by the social scientists and epidemiologists, Lee (2011) provides well-ground reasons for decline in mortality during the process of demographic transition as well as for international migration changes. During the demographic transition, the decline in mortality is due to economic progress, improved waste disposal and water supply, public health interventions, and medical treatment. As fertility and mortality declined during the demographic transition, as a result of the globalization process, there was increased international migration as well as growing foreigners born in many countries. Certainly, international migration can affect POPG in more developed countries where low fertility would otherwise lead to population decline. Actually, immigration is often encouraged as a means of reducing the aging population.

Willekens (2015) discusses both consequences of the role of diffusion process in the demographic transition. The first consequence is a divergence followed by a convergence. Because some numbers of people respond before others do, the divergence in a population increases. When more people respond, convergence puts in. The second consequence is the increased response rate among settlers. When the population starts the transition late, that is, when other populations or other countries were already at an advanced stage, then this population has a higher response rate. In the developing countries and less developed countries, mortality and fertility declined more quickly than in Europe, where the start was much earlier. Furthermore, Willekens (2015) points out that people respond to opportunity structures in their close and more far away circumstances (e.g., family, community, country, and at the global level). People also respond to what others do. Thus, when some groups in society change ideas about family and children, birth control, living a healthy life, or about the need to emigrate to improve their living conditions, other people are likely to follow it so these conceptual changes may make diffusion to all groups in a society. These social interactions and the resulting diffusion of ideas show the mechanism of social change.

1.2. Trend and development of the POPG in Türkiye

When speaking about the POPG in Türkiye, it may be openly said that the growth has remained still and has been shaped under the effects of diverse factors. Almost until 1990, the annual POPG rate of the Turkish population remained steadily above 2%, simply slowing down in the 1990s (Kröhnert, 2010). So far, according to the World Bank (2022a) with an annual growth rate of 1.2% in 2008, and a current rate of 1.08 in 2020, Türkiye is above the European average. Regarding population dynamics and transition periods in Türkiye, Doğan (2015) mentions about three different periods. The “first” period takes place between 1927 and 1955. In this “first” period, birth and death rates were at the highest level. There were seven children during this first period on average, and the population doubled in 28 years. The second period of the demographic transition in Türkiye covers the period between 1955 and 1985, when the fertility rate was high and the mortality rate was low (Doğan, 2015). During this period, the yearly POPG rate was 2.8%. The so-called “third period” started in 1985 and still continues. According to Doğan (2015), the most important feature of this period is the considerable decline in the birth rates. It has been observed that the fertility rate in Türkiye has been slowly decreasing since the 1990s (Gönder, 2017). This author emphasizes that the fertility rate has decreased to 2.05 in 2011 compared to 2001 when it was 2.37, and from 1990 as well when it was 3.08. It is well known and accepted that after the 2000s, Türkiye entered the last phase of demographic transition (Yüksel, 2015). The demographic transition of Türkiye is considered an exceptional one. Compared with the averages of the less developed, least developed, and the world, the total fertility rate (TFR) and the life expectancy for Türkiye are the closest to those of more developed countries, especially when observed for the period 2003 – 2010 (Aykut, 2013). Despite this rapid transformation, the aging population in Türkiye is still at a very early stage and Türkiye is one of the slowest aging countries in the world (Aykut, 2013; Gönder, 2017). Türkiye’s current demographic structure is still in the final stages of the demographic transition process (Canpolat-Bese, Ucar, and Karakaya-Dogu, 2013). According to these authors, the rapid POPG in Türkiye is now a thing of the past and there is no likelihood of accelerating POPG again, and it can certainly be said that the annual POPG rate will continue to decline thereafter. Doğan (2015) further noted that the “fourth period” will begin after the end of this “third” period. Accordingly, in the “fourth” period, birth and death rates will be expected to be low and equal to each other. As a consequence, the POPG rate would be zero. One of the conditions of the “fourth” period is the reaching of the net reproduction rate to one and this process was expected to be reached in 2014. The stabilization of the population, as a second important condition during this “fourth” period, is expected to be achieved in 2050.

According to the TURKSTAT baseline scenario, the TFR by 2013 is 1.99 (below the 2010 replacement level) and with projections that the rate will drop to 1.85 in 2023 (commonly mentioned in national documents) and to 1.65 in 2050, and then, it is expected that after 2050, the POPG rate will be approximately “zero” and that the total population will begin to decline after that date (Yüksel, 2015). During that period, the population pyramid of Türkiye will turn to a "pillar" shape and will look like the population pyramids in developed countries (Yüksel, 2015, p.24). According to Kröhnert (2010) and based on the National Institute of Statistics and the UN, the Turkish population will continue to grow until 2050 due to its age structure. Hence, the National Institute for Statistics in Türkiye predicted a total population of 95.0 million for 2050, and the UN predicted as much as 97.3 million. In addition to the above, using the "Address Based Population Registration System" registers and the Central Civil Registration System and cohort-component method in projections, where the components are births, deaths and migration, Canpolat-Bese, Ucar, and Karakaya-Dogu (2013), showed that the POPG rate will decrease by 2023 in Türkiye according to Türkiye's projections as a whole. Based on these projections, the POPG rate in Türkiye would reach very low levels by the next century and could reach zero during that time, and possibly even reach negative values. Given the results of these projections, Canpolat-Bese, Ucar, and Karakaya-Dogu (2013) are pessimistic that the dream of "Turkey of 100 million population size" will ever come true. It is proper here to note also the forecasting by Ergöçmen and Özdemir (2005). They predict that in the next 15 years, the number of children aged 0 – 14 will stabilize, and the size of the working (productive) population, aged 20 – 54, will almost double. Therefore, as a consequence of changes in the fertility rate and mortality, the population age structures will begin the process of rapid ageing. In addition, Ergöçmen and Özdemir (2005) predict that the number of elderly people will increase from 3.6 million in 2005 to 10 million in 2030 and 15 million in 2050. Hence, the "demographic window of opportunities" in Türkiye is expected to lead to significant changes not only in social and economic development trends but also in vital rates and population structure.

What is very interesting to know for Türkiye as noted by Ergöçmen and Özdemir (2005) is that the changes in population trends were not identical, that is, uniform all over the country. Despite the observed convergence in the past, there are still significant differences in demographic trends and population structures between urban and rural communities and in the geographical regions of Türkiye. Internal and international migrations are two other very important demographic issues for Türkiye (Ergöçmen and Özdemir, 2005). With regard to internal migration, Western Türkiye in general and Istanbul in particular are recipient regions, while the Black Sea region and eastern parts of Anatolia are sending regions. In the past, the direction and size of emigration from Türkiye have been linked to foreign labor requirements. For example, during the 1960s, some 810.000 people migrated from Türkiye to European countries, especially Germany, to meet the labor demands of some European countries. That number dropped to 105.000 during 1975 – 1980 as these countries began to restrict their immigration policies. Here, it is worth noting that migration plays an important role in supplementing or counteracting fertility in population replacement in some Turkish regions. In the long run, most regions in Türkiye have a combination of fertility and internal migration that hinders significant population decline. In Istanbul, East Marmara and West Anatolia – despite the relatively low TFR, especially in the first two regions, net migration is so positive that combined reproduction in these regions reaches around 2.5 or even higher (Ediev and Yüceşahin, 2016). Combined reproduction is a composite product of the original TFR in the population of interest and of the migratory fertility. Thus, it enables dynamic POPG in those three regions, by about 25 – 50% every 30 years. Alternatively, in Northeast Anatolia, Central East Anatolia, and Southeast Anatolia, combined reproduction also reaches 2.5 – 3.0; so far in these regions, the combined reproduction continues to be so high due to the high TFR despite the noticeable out migration. These three regions are known as high POPG regions and as stable suppliers of migrants for other regions in Türkiye. The Kurdish community of Türkiye represents at least 18% of the country's overall population and it dominates the southeastern region of the country and has a high birth rate (Gönder, 2017). Due to the unequal economic and socioeconomic development of the country, considerable regional disparities in the population development are present in Türkiye. This generates social disruptions, because the highest POPG and the largest share of the younger population are found precisely in the agrarian, economically underdeveloped provinces in East Türkiye (Kröhnert, 2010).

Accordingly, it may be said that the migration has a capacity as a demographic stabilizer mostly in the western and eastern provinces in Türkiye. Ediev and Yüceşahin (2016) point out that recent estimate of the United Nations High Commissioner for Refugees shows that there are currently more than 2 million Syrian refugees in Türkiye. Assuming the permanent residence of the majority of Syrians in the country, it can be predicted that the population dynamics of the Syrians is likely to have an impact on the population change in Türkiye and its models of reproduction in the near future. Hence, for instance, Gönder (2017) notices that after Türkiye opened its door to Syrian refugees, TFR increased to 2.14 in 2015 compared with 2011 when its level was 2.05. Gönder (2017) notes that the fertility rate has increased in recent years, despite the fact that the Turkish population has not increased. The influx of more than 2 million refugees can have a significant demographic impact both nationally and for the particularly affected regions (Ediev and Yüceşahin, 2016, p.391). Figure 1 shows the POPG rate, TFR, crude mortality rate (CMR), and net migration rate (NMR) in Türkiye for the period 1965 – 2021.

2. Data and Methods

Within our research study, a multivariate regression model of the Turkish POPG rate was applied. Data are provided consisting of 57 annual observations for the period 1965 – 2021 on the POPG rate, CMR, TFR, and net rate of migration (NMR) from the Macrotrends database (https:///www.macrotrends.net/countries/topic-overview), (Macrotrends, 2022). It is worth noting that data sources on key demographic indicators for Türkiye within this Macrotrends web platform are available from the United Nations – World Population Prospects.

There is increasing attention in statistical and econometric research studies devoted to detecting structural breaks in long time series datasets and then to specify the effect from major breaks (Zarei, Ariff, Hook, *et al*., 2015). Structural changes happen if at least one parameter in the model has changed at some period, that is, date (Czech, 2016). This change could include a change in mean or a change in other parameters in the procedure that generates the series. By identifying when the structure of time series changes, the researchers are provided with understanding into the analyzed problem. Furthermore, to determine when and whether there is a significant change in data, structural break tests can be applied. The researchers in demography have obviously paid little attention to this aspect, so this research on POPG is based on this method of identifying and then explaining the periods of the POPG as a result of the impact of the main demographic events embedded in the dataset used. As shown in this research study, this method uses a rigorous pre-analysis filter procedure which will be applied to POPG and other demographic time series. Furthermore, testing for structural change has always been an important matter in econometrics because a multitude of political and economic factors could cause the relationships among studied variables to change over time (Önel, 2005).

The breakpoints may be known *a priori,* that is, from theory or to be estimated using different approaches. For instance, the maximum breaks and maximum levels setting restricts the number of breakpoints permitted through global testing as well as in sequential or mixed versus l+1 testing and the user-specified method permits to determine break dates by the user (IHS Global Inc., 2017). Therefore, the breakpoint estimation methods can be in general considered into two categories: Global maximizers for the breakpoints and sequentially determined breakpoints (IHS Global Inc., 2017). In Bai and Perron from 1998, the global optimization techniques are described in order identifying the multiple breaks and connected coefficients which minimize the sums-of-squared residuals of the regression model (IHS Global Inc., 2017). If the preferred number of breakpoints is known, the global break optimizers represent the set of breakpoints and the appropriate coefficient estimates that minimize the sum-of-squares for that regression model. If the preferred number of breakpoints is not known, there may be specification of the maximum number of breakpoints and to apply testing to determine the "optimal" number of breakpoints. A large number of test approaches are available. In Bai from 1997, an intuitional approach for obtaining estimates for more than 1 break has been described (IHS Global Inc., 2017). The procedure includes sequential application of breakpoint tests. If the number of breakpoints is pre-determined, then the estimation of the specified number of breakpoints is used simply with the one-at-a-time method. The sequential evaluation method selects the last significant number of breaks, determined sequentially. In other words, the procedure is employed sequentially, starting with a single break until the null is not rejected.

The Quandt-Andrews framework, as it was known earlier, was extended later by Bai (1997) and also by Bai and Perron in 1998, 2003 to obtain multiple unknown breakpoints. The latest tests developed by Bai and Perron in 1998; 2003 comprise an efficient algorithm that is based on dynamic programming method (Zarei, Ariff, Hook, *et al*., 2015). This method allows global minimizers of the sum of squared residuals in a simple regression test model in a very common framework that permits for pure as well as partial structural changes. With this general structure, the tests can control for different serial correlations, distributions of data, and the errors across divided parts. In 1998, Bai and Perron evaluated the estimation of multiple structural changes in a linear model estimated by least squares. Thus, they proposed a test for structural shift in case without trend regressors and a procedure based on a sequence of tests to estimate consistently the number of break points (Önel, 2005). The adequacy of these methods was assessed through simulation. The size and power of tests for structural change, the coverage rates of the confidence intervals for the break periods, as well as the advantages and disadvantages of model selection procedures were studied by Bai and Perron (2003). Hence, Bai and Perron developed a methodology for finding multiple structural breaks in time series and testing their statistical significance (Antoshin, Berg, and Souto, 2008). In the opinion of Antoshin, Berg, and Souto (2008), the simulation analysis handled in Bai and Perron shows that the size and power of their tests may be significantly distorted by several factors, such as small sample sizes, small break size, breaks clustering and apply of heteroskedasticity, and autocorrelation corrections. The sequential Bai-Perron test is considered a more advanced and compounded way to detect structural breaks. The worth of this test could be seen in identifying more than 1 breakpoint. There are some presumptions that should be made before conducting the sequential Bai-Perron test, like: The maximum number of breaks is 5, trimming percentage to be 15, and the significance level for sequential testing is 0.05 (Czech, 2016). The Trimming percentage, $e = 100(h/T)$ without reserve determines *h*, the minimum segment length allowed when constructing a test (IHS Global Inc., 2017). Small values of the trimming percentage may lead to estimates of coefficients and variances which are grounded on a very small number of observations. The optimal number of breaks is based on the sequential methodology. In sequential methodology, the methods differ in whether the test is performed for a given *l* breakpoints, for an additional breakpoint in each of the *l*+1 segments (sequential tests all subsets), or whether the single added breakpoint that most reduces the sum-of-squares (sequential L+1 breaks vs. L), (IHS Global Inc., 2017). The structural change, the change of the parameters in the sample period, plays an empirically relevant role in applied time series analysis. In our study, a standard multiple linear regression model with *T* periods and *m* potential breaks (producing *m*+1 regimes) was considered. For the observations T_j, T_j+1., $T_{j+1}-1$ in regime *j,* the following regression model has been shown:

$$y_t = X_t'\beta + Z_t'\delta + \varepsilon_t \tag{1}$$

for the regimes $j = 0,\dots, m$. The regressors are divided into two groups. The X variables are those whose parameters do not vary across regimes, while the Z variables have coefficients that are regime specific. ε_t is the error term. Once the number and identity of the breakpoints are determined, the model may be estimated using standard regression techniques. The equation specification above may be rewritten as a standard regression equation:

$$y_t = X_t'\beta + \bar{Z}_t{}'\bar{\delta} + \varepsilon_t \tag{2}$$

where β and $\bar{\delta}$ are fixed parameters and $\bar{\delta} = \left(\delta_0{}', \delta_1{}', \dots, \delta_m{}'\right)$ and $\bar{Z}_t{}'$ is an expanded set of regressors interacted with the set of dummy variables corresponding to each of the *m*+1 regime segments (IHS Global Inc., 2017). In our research work, the regression model consists of a regime-specific crude death rate (CDR), TFR, NMR regressors, and a C constant regressor. The estimated equation is a multivariable regression model in which some of the variables interact with regime dummy variables. Thus, the equation of the breakpoint model is defined exactly as in the standard least square regression. In other words, the method used was least squares with breaks. Therefore, dichotomous date functions before, during, and after a given period are used to generate regime dummy variables that interact with regressors. To the best of the author's knowledge, there is no such study that applies the Bai and Perron's methodology for demographic time series data. Therefore, this is the motivation for conducting and announcing the results from this research paper.

The Bai-Perron test computes the F statistics without structural change ($p = 0$) on the null hypothesis and $p = r$ when there are structural changes. If M is a standard matrix, such as $(M\lambda)' = (\lambda'_1 - \lambda'_2., \lambda'_r - \lambda'_{r+1})$, then

$$F_T(\beta_1,\dots\beta_r;q) = \frac{1}{T}\left(\frac{T-(r+1)q-p}{rq}\right)\hat{\lambda}'\mathrm{M}'(\mathrm{M}'\hat{V}\left(\hat{\lambda}\right)\mathrm{M}')^{-1}\mathrm{M}\hat{\lambda} \tag{3}$$

where *r* is breaks, and $\hat{V}\left(\hat{\lambda}\right)$ evaluates the variance-covariance matrix of $\hat{\lambda}$ which is robust to serial correlation and heteroskedasticity (Phoong, Phoong, and Phoong, 2020). The breakpoint F-test is given in Equation (4):

$$F = \frac{\left[\tilde{u}'\tilde{u} - (u_1u_1 + u_2u_2)/k\right]}{(u_1u_1 + u_2u_2)/(T-2k)} \tag{4}$$

where $\tilde{u}'\tilde{u}$ is the residual of the limited sum of squares, $u_j'u_j$ is the sum of squared residuals from a sample drawn from a larger sample *j*, the number of parameters is denoted with *k,* and *T* marks the whole number of observations (Phoong, Phoong, and Phoong, 2020).

3. Application of A Breakpoint Model for Türkiye: Key Findings

This study provides an empirical approach by applying the method of Bai and Perron from 1998 and 2003 using POPG rate time series, the CMR, the TFR, and the NMR time series for a sample of Türkiye with data extending over a long period of 57 years of annual observations. Hence, the task is to identify all breaks in this long time series to ensure that the breaks in terms of the POPG are accurately and quantitatively identified. Therefore, a breakpoint model was estimated with POPG regressed on CDR, TFR, NMR, and a constant. The regression output is presented in Table 1.

As can be seen, four statistically significant breaks at 1976, 1984, 2004, and 2013 have been determined using the Bai-Perron tests of sequentially determined breaks, with a maximum of 5 regimes, 15% trimming, and a test size of 0.05. Coefficient covariances for the tests and estimates are computed using white estimator with no d.f. correction. Table 1 shows each regime, as well as the corresponding coefficients estimates, standard errors, and p-values. At the bottom of the table, the standard summary statistics are shown. The results clearly show a significant difference in the mean of CDR,

Table 1. Estimation of breakpoint model for population growth in Türkiye, 1965 – 2021.

Variable	Coefficient	Std. error	t-Statistic	Prob.
1965 – 1975----11 observations				
C	0.1288	0.0835	1.5439	0.1311
CDR	−0.0096	0.0028	−3.4351	0.0015
NMR	−0.2076	0.0305	−6.8126	0.0000
TFR	0.1160	0.0139	8.3255	0.0000
1976 – 1983-----8 observations				
C	0.5681	0.0306	18.557	0.0000
CDR	0.0242	0.0080	3.0408	0.0043
NMR	0.0638	0.0126	5.0669	0.0000
TFR	0.0080	0.0191	0.4237	0.6742
1984 – 2003-----20 observations				
C	−0.2486	0.0361	−6.8855	0.0000
CDR	0.0078	0.0193	0.4029	0.6893
NMR	0.0775	0.0492	1.5753	0.1237
TFR	0.2465	0.0413	5.9706	0.0000
2004 – 2012----9 observations				
C	−3.3897	0.5522	−6.1388	0.0000
CDR	0.4881	0.1298	3.7598	0.0006
NMR	0.1319	0.0106	12.473	0.0000
TFR	0.3136	0.1127	2.7823	0.0084
2013 – 2021-----9 observations				
C	2.0629	3.1275	0.6596	0.5136
CDR	−0.6869	0.2861	−2.4008	0.0215
NMR	0.1077	0.0359	2.9987	0.0048
TFR	0.8271	2.0888	0.3960	0.6944
R-squared	0.9967			
Adjusted R-squared	0.9949			
S.E. of regression	0.0180			
Sum squared resid.	0.0120			
Log likelihood	160.40			
F-statistic	579.45			
Prob (F-statistic)	0.0000			
Mean dependent var	0.5729			
S.D. dependent var	0.2529			
Akaike info criterion	−4.9265			
Schwarz criterion	−4.2096			
Hannah-Quinn crit.	−4.6479			
Durbin-Watson stat	2.0280			

***Dependent variable: Log (population growth). Method: Least squares with breaks. **Break type: Bai-Perron tests of L + 1 versus L sequentially determined breaks. Breaks: 1976, 1984, 2004, and 2013. *Selection: Trimming 0.15, Max breaks 5, Sig. level 0.05. White heteroskedasticity-consistent standard errors and covariances. Source: Author's calculations

TFR, and NMR within all of these regimes, that is, prior and after 1976, 1984, 2004, and 2013. With these results, there is some clear evidence that within the period after 1976, 1984, 2004, and 2013, the POPG is characterized with statistically different trends compared to the period prior 1976, 1984, 2004, and 2013.

The results estimate that the CDR effect is negative and statistically significant at the 5% level in the first regime (1965 – 1975) and fifth regime (2013 – 2021), thus the effect of the CDR was to decrease the POPG rate during these regimes. The effect of CDR during the second regime (1976 – 1983) and during the fourth regime (2004 – 2012) is with positive signs and statistically significant at 5% level. The effect of TFR on POPG was found to be with positive signs in all of the regimes but only statistically significant at 5% level in three regimes: (1965 – 1975), (1984 – 2003), and (2004 – 2012). Thus, the explanation is that higher TFR led to higher POPG. From Table 1, it is revealed that the NMR has a negative statistically significant effect on POPG only during the first regime (1965 – 1975) and with a positive effect for the rest of the regimes, except for the third regime (1984 – 2003) where its effect was positive but not significant at 5% level. In the model, the rate of POPG was greatly influenced by the effect of the change of the constant (intercept), from the second to the fourth regime, that is, from 1976 to 2012. What was interesting is that especially during the third and fourth regimes, that is, during 1984 – 2012, the POPG was under negative influence from the constant (intercept). There are, however, some unique and specific aspects or features of the breakpoint regression in Table 1 that deserves discussion. Thus, in leverage plots, Figure 2 shows graphs which are labeled with the fully dummy variable interactions.

Leverage is a measure of how much each data point influences the regression. Leverage plots are the multivariate equivalent of a simple residual plot in a univariate regression. Like influence statistics, leverage plots can be used as a method for identifying influential observations or outliers. From our Figure 2, it can be observed that there are a lot of observations that have more leverage on, that is, the potential to influence the regression line, either in a positive or negative direction. Moreover, according to that, they tend to be closer to the regression fit with a large influence on the analysis. Thus, the influential points have a large influence on the fit of the model. An especially important influence of the outliers on the regression line is worth mentioning: the data points of NMR during 1984 and 2003, during 2004 and 2013, and after 2013. Also, it is worth to mention the influence of the data points of TFR during 2004 and 2012 and after 2013.

Influence statistics are a method of discovering influential observations or outliers. This method serves to measure the difference that one observation makes on the regression results, or how different one observation is from other observations in a sample equation (IHS Global Inc., 2017). A plot of the influence statistics of R Student test (Figure 3) clearly shows that observations of 2000 – 2001 and 2017 – 2001 years are outliers. The influence statistics of DFFITS plot

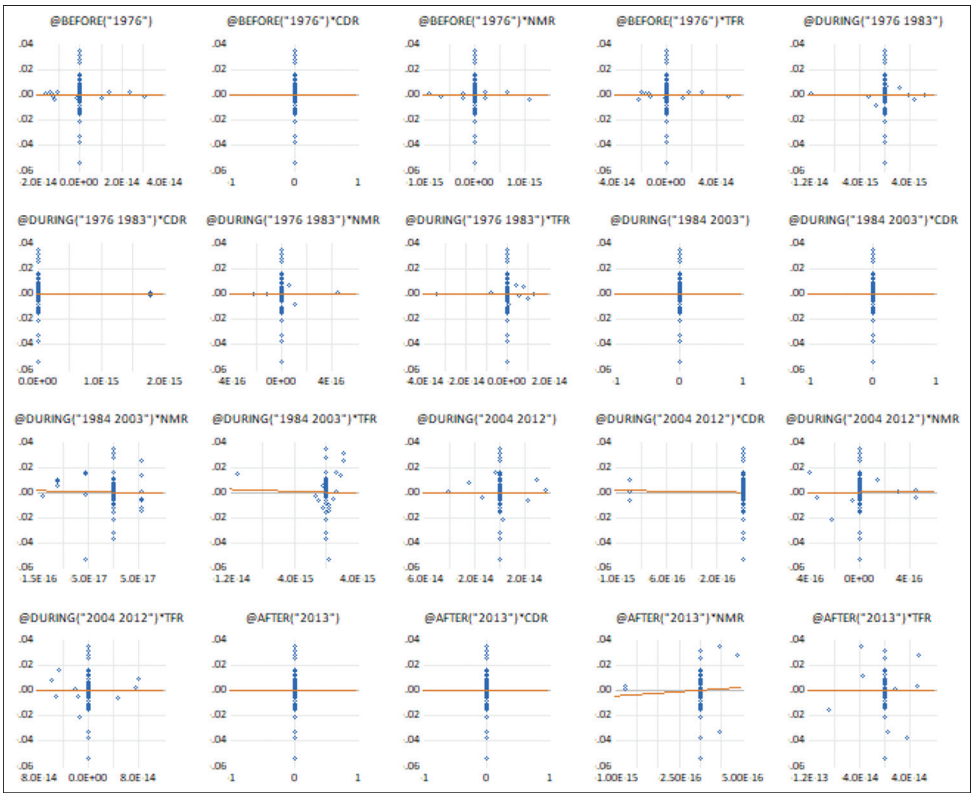

Figure 2. Leverage plots: Log(POPG) versus variables (partial led on regressors). Source: Author's design based on real data.

(Figure 3) are showing that observations of 1979 – 1981, 2000 – 2001, and from 2017 until 2021 are outliers. According to COVRATIO's plot (Figure 3), it can be seen that only the observations of 1979 – 1981 have very huge outliers.

Casual check of the residuals suggests that our model is a very good one and that there is no need to be improved with the additional breakpoints. The corresponding actual, fitted, and residual plot is given in Figure 4:

4. Discussion

Population policies of Türkiye may be analyzed in two periods; the pronatalist period from 1923 – 1960 and antinatalist periods from 1960 to 2000 (Yüksel, 2015; Yüceşahin, Adalı, and Türkyılmaz, 2016). In the middle of 1950s, population policy has been questioned as a result of the fast and not planned urbanization, illegal and harmful to health abortions, as well as lack of public investment for the new cohorts. After the 1960 military takeover, the newly established State Planning Organization and the Turkish Ministry of Health were involved in creating antinatalist policies. Current planning in Türkiye has its origin in the 1961 Constitution, since when planning for social and economic development has been defined as the responsibility of the state (Baran, 1971). The State Planning Organization (SPO) is a government organization having an obligation for drawing up the 5-year plans as well as the annual programs. Since its establishment, the 5-year plans have been drawn up in Türkiye. Furthermore, the duty of the SPO has also to follow up the implementation of the plans and to counsel the government on ongoing economic policy issues (Baran, 1971). The first development plan including antinatalist policies was legalized by the Turkish Parliament in 1965 and the "557 numbered Population Planning Law" was enacted (Yüksel, 2015). Thus, the beginning of the 1960s is accepted as the breaking point for policy change. The 1960s indicate the beginning of the "planned era" in Türkiye, where 5-year development plans have been preparing to assess the current social, economic, and demographic situations and put related goals (Yüceşahin, Adalı, and Türkyılmaz, 2016). Afterward, almost all consequently 5-year development plans between 1965 and 2007 (total eight) are engaged with the population and development relationship and have been indicating the need for controlling the POPG (Yüksel, 2015). As Yüceşahin, Adalı, and Türkyılmaz (2016) emphasize, as from 2008 onward, a new-third pronatalist policy period came into the Turkish scene. A first sign of a new pronatalist policy was given in 2008 by the then-prime minister and current president Recep Tayyip Erdoğan proposing that families should have at least three children (Yüceşahin, Adalı, and Türkyılmaz, 2016). Further signs of the new pro-natalist policy include debates on restrictions on induced abortion and cesarean sections, as well as initiatives for longer maternity leave, early retirement schemes for mothers, and one-time child benefit payments.

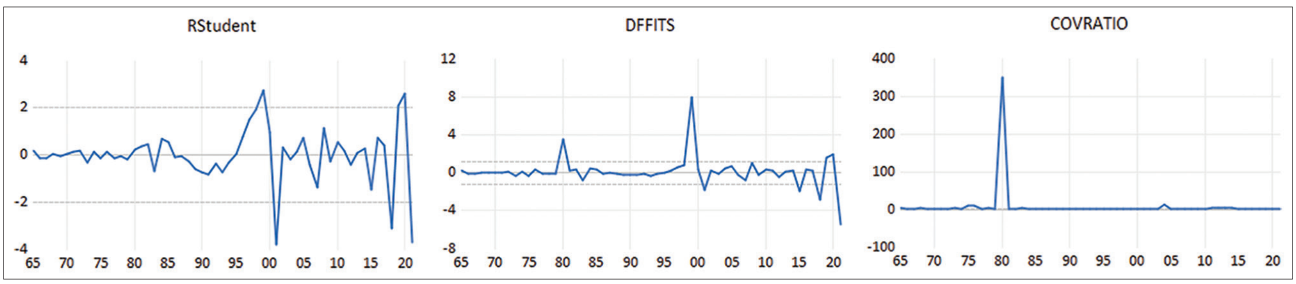

Figure 3. Influence statistics: Breakpoint model for population growth in Türkiye, 1965 – 2021. Source: Author's design based on real data.

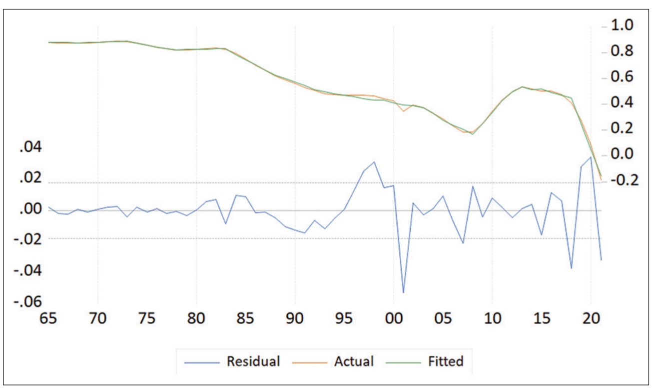

Figure 4. Residual plots: Breakpoint model for population growth in Türkiye, 1965 – 2021. Source: Author's design based on real data.

Our main goal was to convey a deeper understanding by quantifying how much the change in POPG does vary as a result of observations of included parameters of the breakpoint model for Türkiye in the period of 1965 – 2021. The robust least square breakpoint regression using sequential methodology and white standard errors confirms the presence of persistent differences in the impact over POPG in Türkiye during the mentioned period. As mentioned in the previous section, four statistically significant breaks at 1994, 2001, 2010, and 2014 and consequently five regimes have been determined using the Bai-Perron tests of sequentially determined breaks. This indicates that circumstances affecting the mortality, migrations, and fertility in terms of the number of live births and deaths as well as migration trends in the country before and after these indicated years in Türkiye have been largely influenced by the different dynamics of the socioeconomic conditions and different contexts in Turkish society (Lee, 2015; Willekens, 2015; Lesthaeghe, 2014). In this regard, Willekens (2015) states that the processes that are the basis of demographic transitions are interacted with science and technology, the economy, cultural change, and social and political changes. Furthermore, Lesthaeghe (2011) explains more clearly that the theory of the second demographic transition completely recognizes the effects of both structural changes at the macrolevel and economic calculations at the microlevel. The point is that SDT does not consider these explanations as "sufficient," but merely as "necessary" or "non-redundant" (Lesthaeghe, 2011). Moreover, the SDT theory does not consider cultural change as an internal cause of any economic model, but as a necessary additional force with its own external, that is, exogenous effects on demographic outcomes.

It is frequently discussed that the demographic transition in Türkiye is not so advanced (Caarls and de Valk, 2018). However, Türkiye has undergone crucial socioeconomic changes in recent decades and this also has had an impact on the transitions of family life. Herewith, Caarls and de Valk (2018) emphasize that these changes are attributed to the processes of modernization, exposure to Western values, as well as socioeconomic changes. Moreover, as these scholars have mentioned, what also makes Türkiye an interesting illustration is the huge regional variation: There are significant differences between regions both in terms of both economic development and to the extension of more modern values to family life. In view of TFRs, for example, in some regions, these rates are close to those of European countries, while in other regions, the TFR remained very high. In addition, the effects of demographic changes on later POPG can have wider interpretations. Horiuchi (1995) pointed out that demographic changes have an impact on POPG and age distribution in later years, which, in turn, has an impact on future POPG. In any analysis of the current POPG, it is of great importance to take into account the past events of the population. In addition, Horiuchi (1995) showed that not only events that occurred in the recent past but also events that occurred several decades earlier could have significant effects on the current growth rate. These effects are indirect and its impact works through changes in the age structure. The most glaring example is the baby boom generations. These empirical results show clear evidence that in the past 57 years, that is, from 1965 to 2021, the POPG rate in Türkiye is characterized by a different trend and that it has a different effect of the key variables (TFR, CDR, and NMR) on the rate of POPG. From the results in Table 1, it is obvious that the changes in fertility, mortality, and migration trends have notably different impacts on POPG rate in Türkiye. However, it is also argued that life expectancy at birth (e0), TFR, and NMR may be also a good set for modeling since e0 takes age composition into account, while CDR is affected by the age structure of a population of a given year. The conclusion will be likely different if different demographic variables are used in the Bai-Perron approach (Appendix, Table A).

The effect of mortality on POPG gradually increased except for the last regime (2013 – 2021) when fluctuations were noticed. This effect is not the result of an accelerated decline in mortality, as the effect of changes in mortality over the entire period of almost 50 years has remained relatively constant with a steady decline as confirmed by the period data. This effect may be attributed to the accumulation of the reduced mortality. Thus, since 1965, several decades of improved mortality have accumulated. These patterns are consistent with trends in life expectancy in Türkiye which show an acceleration of life expectancy growth in the same period (Bakar, Oymak, and Maral, 2017; World Bank, 2022b; OECD, 2011). The model of the contribution of mortality to POPG has changed during these 57 years and was negative for the first regime (1965 – 1975) and the last regime (2013 – 2021). The impact of mortality on POPG was positive during 1976 – 2012. It is not surprising to claim that a constant infant and child deaths during the first decade or regime of our research study (1965 – 1975) have contributed to reducing the desired number of children, which, as a consequence, had the impact of declining POPG. For a long time, the decreasing infant and child mortality determined the tendency in the death rate (Willekens, 2015). Thus, cumulated improvement in infant and child mortality during the past 57 years as well as the reduction in adult mortality during the whole period contributed the effect of crude death to significantly positive, especially during the second and fourth regimes, that is, (1976 – 1983) and (2004 – 2012), respectively. It is supposed that the mortality effect was positive on POPG during this period mainly as a result of the accumulation of several years of infant and child mortality reduction. It is evident that infant and child mortality decline was very rapid in the remote past compared to the recent past. A lot of literature discusses great improvements of these events in Türkiye during this period (Özen, 2018; Dumont, 2011; Seçkin, 2009). In addition, the decline of the mortality rate in Türkiye from the middle of the 2000s according to Durmus (2022) may be a result of several factors that could explain this phenomenon, such as the reforms in the health system in Türkiye, introducing to a significant improvements in healthcare organization, resource management, and health service delivery to be provided equitable access to quality health services for all since the middle of the 2000s.

The effect of total fertility was positive on POPG in Türkiye throughout the entire period simply because of the high fertility levels. The strongest positive effect of fertility on POPG is considered to be during the third regime (1984 – 2003). Figure 1 indicates a steady and gradually downward trend of the fertility decline during the entire period as well as due to the baby boom. Fertility rates in Türkiye have gradually declined mainly from the early 1970s with about 5.5 births per woman to 2.3 births until early 2000s, that is, the TFR more than halved within these three decades (Ergöçmen and Özdemir, 2005). It is believed that the fertility behavior in Türkiye is mostly affected by social and economic circumstances and that the effects of population policies were quite small (Yüksel, 2015). Thus, Yüksel (2015) mentions that there were some calculations in which the effects of population policies from 1965 to 1980 on fertility were <10 percentages. In addition, Yüceşahin, Adalı, and Türkyılmaz (2016) also stressed out that although Turkish governments implemented antinatalist policies and more liberal regulations toward reproductive health after 1965, it is considered that the fertility decline in Türkiye has followed a course that is much rather independent from these measures. In the study of Bongaarts from 1993 of the impact of policies, it was found that only 31% of fertility decline in Türkiye could be attributed to family planning programs (Yüceşahin, Adalı, and Türkyılmaz, 2016). As stated by these scholars, the fertility transition in Türkiye has mainly carried on as a result of socioeconomic developments and the society's transformation. In addition, education reforms became a national objective for Türkiye, increasing mandatory education from 5 to 8 years in 1997 to improve the levels of educational attainment of the native workforce (Kilic and Biffi, 2021). Furthermore, although Türkiye has gone through major socioeconomic transformation, Yüceşahin, Adalı, and Türkyılmaz (2016) emphasize that Turkish society has still preserved its patriarchal foundation, as it is the case with many developing countries. Since labor force participation among women is low in the country (under 28% within paid employment), therefore, it may be acknowledged that a population policy could at least partially succeed. During the first regime (1965 – 1975), the trajectory of the total effect of fertility on POPG was significantly positive reflecting the fertility increase during the previous period. Horiuchi (1995) calls this "duration-specific effect." The fertility effect on POPG was positively significant also during the third (1984 – 2003) and fourth (2004 – 2012) regime with a duration of <20 years with positive effect probably mainly because of the baby boom. After 2000, fertility rates and the future of Türkiye's population have been discussed at large by scholars, political parties, and policy makers as well from public media. For the 1st time in the history of the Turkish nation in 2005, the age structure of primary school population has been decreased and after 2010 TFR has declined below replacement level (Yüksel, 2015). However, the overall effect remained positive, as the accumulation of previous persistent fertility declines was less pronounced and the compensation for the positive impact of the baby boom.

The results of the effect of NMR on POPG in Türkiye have been explained within this paragraph. Since 1960, international migration has become a global phenomenon. Employers in Europe and in other regions started to recruit immigrant workers, so called – guest workers because of a lack of domestic labor supplies (Willekens, 2015). Thus, labor migration was recruited mainly from South Europe to North and West Europe. The strongest negative effect of the net migration on POPG in Türkiye was noticed during the first regime (1965 – 1975) mostly as a result of migration of a large number of Turks mostly to Germany first as guest workers and later as immigrant workers. During 1963 – 1978, Türkiye was involved in labor recruitment agreements with many European countries (Kilic and Biffi, 2021). Controlled emigration to European countries was officially organized by the Turkish employment agency in collaboration with the public employment agencies of countries with whom Türkiye stipulated into bilateral labor recruitment agreements. The first great and important bilateral labor agreement was with Germany in 1961, and then followed with Austria, the Netherlands, and Belgium in 1964, France 1965, and Sweden and Australia in 1967 (Kilic and Biffi, 2021). In addition, the rapid development of rich countries with oil in the Middle East-North Africa region attracted Türkiye by an agreement with Libya in 1975. At this time, the main characteristics for Türkiye were the lack of political stability and not solved economic, social issues, and a lot of poverty. Türkiye agreed the policy to send unskilled labor for at least two reasons: To lessen unemployment as well as to receive remittances from the migrants and consequently lost more skilled workers in the emigration process than any other Mediterranean countries (Kilic and Biffi, 2021). The positive net migration effect on POPG from 1976 to 1983 onward may be due to the restriction of immigration policies in many European countries that started during 1975 – 1980 (Ergöçmen and Özdemir, 2005). Since 1976, the effect of migration has changed the sign from negative to positive, reflecting the increase in net flow in the country. During the third regime (1984 – 2004), the NMR did not turn to have positive signs but still remained with smaller negative signs, that is, during this whole period emigration to certain extent exceeded immigration. The effect of changes in NMR on POPG during this regime (1984 – 2003) was slightly positive but statistically insignificant. The intensity of diaspora policies and the positive economic development of Türkiye from the 1980s onward, which was driven by enlarged trade with Europe, foreign investment, and privatization, have increased the process of industrialization of the Turkish economy (Kilic and Biffi, 2021). According to these authors, Türkiye experienced a persistent brain drain during this period not as the result of foreign worker recruitment by the prime European destination countries, but much rather a result of family reunion, but to a certain extent also to the political instability in Türkiye. Political instability has been the most significant factor behind the lack of success of Turkish governments to carry out structural reforms (Murat, 2005). Thus, Murat (2005) has shown that there have been several structural causes of the macroeconomic crises in Türkiye, which also have been strongly connected to the major features of the Turkish political economy. As a result of several factors, the liberal efforts in the Turkish economy underwent sporadic difficulties in 1982, 1988, 1994, 1997, 1998, 2000, and 2001. Hence, the populist policies, the public deficits, inflation, a weak financial system, and increasing public debt were among the leading topics that have been used in explaining economic trends and causal relationships in the Turkish economy for this time (Murat, 2005). The impact of the net migration on POPG during the fourth regime (2004 – 2012) as well as fifth regime (2013 – 2021) remained positive and statistically significant. Thus, during the period of 2001 – 2023, the focus of Turkish migration policy turned to highly skilled immigration. This was an established policy course of many developed as well as developing economies for some time and Türkiye joined this group of countries and implemented numerous policy instruments to attract highly skilled migrants deemed productive for the development of Türkiye (Kilic and Biffi, 2021). Therefore, immigration of high-profile educated people was initiated as a new policy matter. In addition, during this period, the return of skilled Turkish origin diaspora stands on the agenda as well (Kilic and Biffi, 2021). In other words, Türkiye started with the promotion of the policy challenge of return migration of highly skilled Turkish (origin) migrants. As a consequence, and because of successful economic development since the 2000s onward (Mihai, 2009), Türkiye experienced a lowering in population outflows and an increase in population inflows, as migration transition theory would claim. In addition, it is argued that the most important historical development which paved the way of Türkiye for a modernization as well as more enhanced state-society relations in the 2000s can be directly linked with the EU membership process (Burak, 2011). It is well known that the adoption and the implementation of the social, political, and economic policies of the EU are crucial and the basic requirement for the candidate countries to become a full member. As claimed by Burak (2011) during the 2000s, Turkish society went through rapid social-cultural, economic, and political changes.

The last ninth 5-year development plan written for the period 2007 – 2013, highlighted that changes in demographic structure of Türkiye, fertility level, and age structure had started to be similar to those of developed countries (Yüceşahin, Adalı, and Türkyılmaz, 2016). This plan is pointing to the need to re-examine policies on education, health, employment, and social security and setting the stage for a new pronatalist approach. Given the latest values of the death rates and fertility rates for Türkiye, in the near future, the number of deaths is expected to increase, and fertility is expected to remain at a lower level than it is now. TFR in Türkiye reached a replacement level of 2.1 children per woman in 2016 – 2017. The tenth 5-year development plan was prepared in 2013. This plan specified a need to “increase the fertility rate through population policies” and put forward the need for such a policy (Yüceşahin, Adalı, and Türkyılmaz, 2016). To meet this requirement, the Turkish Ministry of Family and Social Policies coordinated an action plan in January 2015 called the “Action Plan to Preserve the Family and the Dynamic Structure of the Population.” One of the clearly stated targets of the plan was to remain TFR above the replacement level. Nevertheless, a further steady decreasing trend of POPG will be inevitable for Türkiye. As the population grows, a sudden or steady decline in fertility to replacement level does not mean that there will be an immediate cessation of growth. In general, the growing populations have a tendency to continue to grow because they have large cohorts in the reproductive age and lesser cohorts in the elderly (Schoen, 2018). As mentioned by Horiuchi (1995), the momentum of past demographic events results in steady growth. The experience of actual populations with high fertility usually shows that an increase due to momentum would be of considerable importance. The very interesting question is to what extent POPG may thus depend on the contribution made by immigrants, especially mostly those from Syria and for how long?

Using the Bai-Perron approach, this study has some limitations that future research may address. One such limitation is the lack of exact explanation that could be provided for each of the different regimes of the breakpoint model. However, the author tried as much as he can to cover the regimes with proper socioeconomic policies or population policies specific to Türkiye within the exact period. However, these are different regimes quantified by the breakpoint model and hence the author could not specifically and strictly state a specific policy exactly for each regime of the model but went more to cover partially or completely the period for a given regime from the model. Further studies with this method may be extended to pre-determined breakpoints or to a preferred number of breakpoints that are based on the best knowledge of the author, that is, user specific breakpoints to provide a greater understanding of the breaks in or changes of the time series.

5. Conclusions

The present study aimed to overcome the limitations of the demographic and economic models through the detection of the structural changes in the data series, using the breakpoint test to address the demographic events that led to different regimes of the POPG. The breakpoint model was used because the empirical results provided a large evidence of the major breaks in the POPG series since the sequential procedure selected four breaks. Thus, the breakpoint model was capable of accurately and quantitatively recognizing the key impact of the main demographic events on POPG in Türkiye during six decades now. The results obtained from the breakpoint model are reasonable since the breaks in the POPG somehow coincide with significant economic realities and population dynamics in Türkiye. Consequently, these breaks have fostered to capture the structural changes in Türkiye with regard to its socioeconomic development and population dynamics. Thus, a good exploratory analysis was made based on these breaks and regimes separately from the theoretical knowledge of the four phases of demographic transition process that are specific for Turkish society. In addition, it is observed that within different regimes of the model, the responses in terms of population policies targeting specific demographic aims have lost their popularity and probably, there were replaced by policies focusing on social and economic changes. In today's modern Türkiye, it would be more difficult to implement for instance pronatalist policies that are directly aimed at raising fertility.

The results of this research work provide valuable information on the relationship between migration trends, fertility, and mortality and POPG trends in Türkiye during the period of 57 years, that is, from 1965 to 2021. The empirical results of our research study on Türkiye reflect typical changes in both demographic and epidemiological transitions, such as declining fertility, declining growth rates, declining mortality, and changes in improving longevity. The breakpoint regression analysis confirms the presence of persistent differences in the POPG in Türkiye over the period 1965 – 2021 as a result of the dynamics of key determinants of the POPG. In other words, the relationship between POPG and these determinants is somewhat predictable because POPG is largely directly due to these variables. In addition, for comparison, during the whole period of our research study (1965 – 2021), the POPG rate in Türkiye has more than halved. In other words, from the level of about 2.4% in the late 1960s and the first half of the 1970s in the last years of 2019 – 2020, it reached a level of about 1% and will fall below 1% in 2021. What is interesting is that the Turkish POPG still has positive momentum in comparison to almost all European countries. Furthermore, interesting is the fact that the TFR in Türkiye for the same period (1965 – 2021) has dropped 3-fold. The role ascribed to migration changed from supporting out-migration of mainly low-skilled domestic population in the 1960s to promoting university education abroad from the 1970s until today, and immigration of the highly skilled from 2000 onward. Through this time period of more than 50 years, Türkiye underwent all phases of a migration cycle, beginning as an emigration country and turning into an immigration country. As a result of the complicated process of human migration, it must be pointed out that in Turkish case migration is featured in the context of many policy issues, extending from social and economic policy to demographic, regional, and structural policy, cultural and human resource development, as well as international relations.

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Conflicts of Interest

The author has no conflicts of interest to declare.

Authors' Contributions

Goran Miladinov conceived and designed the paper, analyzed the data, and wrote the paper.

Ethics Statement

Not applicable as this study involves the analysis of secondary data collected by the Macrotrends website.

Availability of Supporting Data

Data utilized to this paper are from secondary sources and available to the public. The data can be freely accessed online from the Macrotrends LLC website: https:////www.macrotrends.net/countries/topic-overview.

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Appendix

Table A. Estimation of breakpoint model for population growth in Türkiye, 1965 – 2021.

Variable	Coefficient	Std. error	t-Statistic	Prob.
1965 – 1977-----13 observations				
C	−0.1613	0.8459	−0.1906	0.8500
Total fertility rate	0.1055	0.0611	1.7278	0.0934
Net migration rate	−0.2531	0.0855	−2.9589	0.0057
Life expectancy at birth	0.0028	0.0105	0.2701	0.7888
1978 – 1985-----8 observations				
C	0.7075	1.7560	0.4029	0.6896
Total fertility rate	0.1900	0.1011	1.8804	0.0689
Net migration rate	0.1591	0.0456	3.4881	0.0014
Life expectancy at birth	−0.0100	0.0224	−0.4478	0.6572
1986 – 1996-----11 observations				
C	−0.0583	1.1753	−0.0496	0.9607
Total fertility rate	0.2457	0.0829	2.9600	0.0057
Net migration rate	0.3998	0.3153	1.2675	0.2138
Life expectancy at birth	1.9905	0.0126	−0.0016	0.9987
1997 – 2004----8 observations				
C	6.5200	2.0890	3.1213	0.0037
Total FERTILITY RATE	−0.6504	0.4931	−1.3184	0.1964
Net migration rate	−0.3558	0.5625	−1.6325	0.5314
Life expectancy at birth	−0.0649	0.0172	−3.7687	0.0006
2005 – 2012-----8 observations				
C	−3.7028	1.7593	−2.1048	0.0430
Total fertility rate	1.2436	0.2983	4.1692	0.0002
Net migration rate	0.1025	0.0052	19.812	0.0000
Life expectancy at birth	0.0156	0.0155	1.0016	0.3238
2013 – 2021-----9 observations				
C	−3.2591	2.0276	−1.6073	0.1175
Total fertility rate	−0.6640	0.6568	−1.0110	0.3194
Net migration rate	0.1588	0.0089	17.875	0.0000
Life expectancy at birth	0.0587	0.0122	4.8285	0.0000
R-squared	0.9979			
Adjusted R-squared	0.9964			
S.E. of regression	0.0152			
Sum squared resid.	0.0077			
Log likelihood	173.19			
F-statistic	669.52			
Prob (F-statistic)	0.0000			
Mean dependent var	0.5729			
S.D. dependent var	0.2529			
Akaike info criterion	−5.2348			
Schwarz criterion	−4.3747			
Hannah-Quinn crit.	−4.9005			
Durbin-Watson stat	2.7321			

***Dependent variable: Log (population growth). Method: Least squares with breaks. **Break type: Bai-Perron tests of L + 1 versus L sequentially determined breaks. Breaks: 1978, 1986, 1997, 2005, and 2013. *Selection: Trimming 0.15, Max breaks 5, Sig. level 0.05. White heteroskedasticity-consistent standard errors and covariances.
Source: Author's calculations