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The Transition of Fertility Rates in the World: Regime Switching Model

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Abstract

In this study, the fertility rates in the world from 1960 to 2021 were analyzed the Switching Regime Model. The reason for modelling with regime switching models is the fact that the fertility rate data in the world experience rigid changes from time to time and the concern that the studies conducted in the literature without considering the regime change give erroneous results because they are not modelled correctly. In this context, fertility rates were modelled as single, double and triple regimes and it was concluded that the most accurate modelling was the triple regime modelling in the period examined. In modelling studies, studies conducted without considering nonlinearity tests (assuming a single regime) give erroneous results. The most obvious one of the rigid changes in fertility rates is 1993. While the world experienced all three regimes until 1993, the low fertility regime was adopted after 1993. The low fertility regime has led to population ageing with increasing life expectancy and thus to changes in many economic variables.

Keywords: Demographic Transition, Fertility Rate, Regime Switching Model

Article Type: Research Article

Dünya'da Doğurganlık Oranlarının Dönüşümü: Rejim Değişim Modeli

Öz

Bu çalışmada 1960'tan 2021'e kadar dünyadaki doğurganlık oranları Rejim Değişim Modeli kullanarak incelenmiştir. Rejim değişim modelleri ile modellemenin sebebi dünyadaki doğurganlık oranları verilerinin zaman zaman rijit değişiklikler yaşaması ve literatürde yapılan çalışmaların rejim değişimini dikkate almadan yaptıkları çalışmaların doğru modellenmediği için hatalı sonuçlar verdiği kaygısıdır. Bu bağlamda doğurganlık oranları tek, çift ve 3 rejim olarak modellenmiş ve en doğru modellemenin incelenen dönemde üç rejim olarak modellemenin olduğu sonucuna varılmıştır. Modelleme yapılan çalışmalarda doğrusal olmama testlerini dikkate almadan yapılan çalışmalar (tek rejim olduğunu varsayar) hatalı sonuçlar verir. Doğurganlık oranlarında yaşanan rijit değişimlerden en barizi 1993 yılıdır. 1993'e kadar dünya her üç rejimi birden yaşarken 1993 yılından sonra düşük doğurganlık rejimine geçilmiştir. Düşük doğurganlık rejimi artan yaşam beklentisiyle birlikte nüfus yaşlanmasına ve dolayısıyla birçok ekonomik değişkende değişime yol açmıştır.

Anahtar Kelimeler: Demografik Dönüşüm, Doğurganlık Oranı, Rejim Değişim Modeli

Makale Türü: Araştırma Makalesi

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1. INTRODUCTION

The world went through a period between 1946 and 1964 when fertility rates were above the replacement level[1] 2.1. One of the reasons for this situation after the Second World War was the economic inequality against young men and young women (Doepke, et al. 2023). The scarcity of labour supply caused young women to be unable to take part in the labour market. Therefore, it was a natural and compulsory choice for young women to have a large family in those years. However, after the 1960s, this situation was reversed with the participation of women in the labour force and fertility rates below replacement level started to be observed first in developed countries and then in developing countries.

In the transition period of low fertility rates (Lesthaeghe, 1995), the transition of young women into the labour market and the postponement of fertility to the 30s caused fertility rates to fall below the replacement level. The fact that women's educational attainment attracted the attention of employers and they joined the labour force, and the change in consumer and gender inequalities in some countries after the 1960s also caused fertility rates to decline (Rindfuss et al. 2016). Due to these and similar factors that cause fertility rates to decline, countries have also changed economically (Herzer et al, 2012; Galor, 2011).

Changes in fertility rates are among the important factors affecting the economic structure. Low fertility rates may lead to population ageing and a decrease in labour supply in an economy. The decline in the productive population may slow down the rate of economic growth and put pressure on social security systems. Moreover, a decline in the number of children may affect consumption demand and cause some sectors to contract. The economic impact of fertility rates is closely related to the demographic structure of a country and is an important factor to be considered in shaping long-term economic policies. Although the easiest and fastest way to eliminate this problem is to meet it by out-migration, this process brings other socio-economic problems.

There are various theories about the reasons for the decline in fertility rates (Mason, 1997). In the classical transition theory of Thompson (1930), known as the father of fertility transition theories, it is stated that the main reason for the fertility decline is the increase in industrialisation and urbanisation. In addition to the classical transition theory, economic modernisation has been attributed to increasing welfare, the desire to have a small family, and the updating of social norms of the fertility decision (Lesthaeghe, 1983, 1995; Schultz, 1983; Cleland and Wilson, 1987). In addition to these theories, there are also neoclassical microeconomic theories. Becker (1960) argued that substitution preferences in the cost of child rearing and the couple's income as determinants of fertility preferences, while Easterlin (1975, 1978) stated that these variables would not be sufficient and that the survival rate of children, the cost of children and the supply of children should be added to these variables.

The study is designed as follows after this section: Chapter 2 is the literature review, Chapter 3 is the data and methodology, Chapter 4 is the interpretation of the results and the last chapter will be concluded with a general evaluation.

2. LITERATURE REVIEW

Individual fertility decisions can be influenced by age, gender, social status (Matysiak et al., 2021) as well as economic conditions. The change in fertility decisions leads to demographic transformation of countries. Demographic transformations are of great importance for the economic

[1] The level of fertility at which a country's population can be replaced by a new one while keeping its numbers the same is called the replacement level. This rate is 2.1 births per woman. The replacement level is 21 births per 10 women.

policies of countries (Ranganathan et al., 2015). In this section, studies in the literature on the relationship between economic policies and fertility will be analysed.

Many countries are experiencing fertility rates below replacement level. In countries where fertility rates have been at replacement level for a long time, this has led to an increase in the old-age dependency ratio, which has raised questions about the sustainability of social security systems. According to population projections, the elderly dependency ratio in Europe is estimated to be 41 per cent in 2064, 46 per cent higher than today. This situation is estimated by Elmeskov (2004) to lead to an average increase of 6-7 per cent in the ratio of GDP to public expenditures in OECD member countries until 2050. The main reason for the increase in public expenditures is estimated to be the pressure on the social security system (Lisenkova et al., 2013).

Adsera and Menendez (2011), found a strong negative relationship between unemployment and fertility since the 1980s, which is associated with the instability in the labour market with the decline in the fertility rate of countries. In this context, studies have proven that uncertainty in labour markets is an important determinant of individuals' fertility decisions (Bernardi et al., 2005; Busetta et al., 2019; Vignoli, et al., 2020).

Fertility rates, which should be considered in shaping economic policies, have varied from year to year. The fact that fertility rates vary means that the policies to be implemented will also change. In this context, studies that determine fertility regimes gain importance in the literature. Strulik and Vollmer (2015) divided the fertility rates in the world into high fertility and low fertility regimes from 1950 to 2005 with a convergence analysis for 184 countries. They stated that after 2005, it is in the low fertility regime. Vignoli, et al. (2020) categorised fertility regimes for European countries into 5 regimes: higher, high, low, very low and lowest-low regimes. However, Rindfuss, et al. (2016), stated that the fertility regime in developed countries is divided into 2 regimes as high and low fertility. Similarly, Berquó and Cavenaghi (2005), who categorised 3 regimes as high, low and below replacement level in developing countries, states that the fertility rate in the high fertility regime is 5 or more. However, it is stated that Brazil has switched to a low fertility regime in recent years, as in every country.

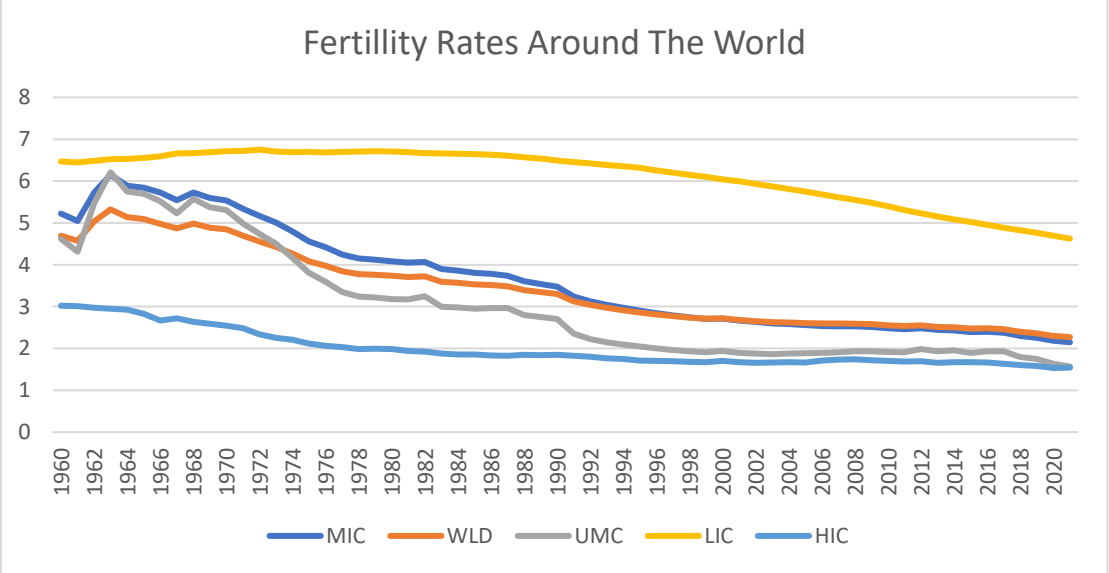
The common feature of these studies is that they have conducted their studies by determining subjective threshold values without using any econometric/statistical techniques, especially regime switching models.

The differentiation of fertility regimes across countries, which is observed in the literature, has been the main motivation of the study. The fact that this change takes place at different times from country to country has raised the problematic of the periods of average change. Fertility rates started to decline first in developed countries and then in developing countries. Although this process started in developed economies in the 1960s, the proportionally small population of developed economies caused the decline in the average to remain limited. However, the momentum has gradually increased.

The number of fertility regime(s) in the world to date is important information for the correct implementation of economic policies. In this context, the research question of the study is how many regimes fertility was divided into between 1960 and 2021, and which characteristics did the separated regimes provide? The main hypothesis that we utilised in reaching the research question is that fertility was divided into two regimes as high fertility and low fertility regimes between 1960-2021 and Strulik and Vollmer (2015) were followed. However, as a result of the analysis, unlike Strulik and Vollmer (2015), this study was conducted against the possibility that there may be more than 2 regimes in the world between 1960-2021.

3. DATA AND METHOD

The demographic transformation of a country is judged by looking at life expectancy, fertility rates and migration variables. When the fertility rate per woman falls below the replacement level - 2.1- continuously, it can be considered that a country will age. In this context, world fertility rates data were used in this study. Fertility rates for 1960-2021 were taken from the World Bank Data Statistics Department.



*MIC: Middle Income Countries, UMC: Upper Middle Countries, LIC: Low Income Countries, HIC: High Income Countries, WLD: World

Figure 1: Fertility Rates Around the World

Source: World Bank Data Statistics Department, date:15/07/2023

When analysed historically, fertility rates per woman in the world are shown in Figure 1. The reason why fertility rates in the world are above the replacement level is that low-income countries have high fertility rates. In this context, it is important which fertility regime the world is currently in. While fertility rates in the world were 4.69 in the 1960s, this rate was 2.27 in 2021. In a period of 60 years, fertility rates have decreased by 52 per cent. Today, world fertility rates are above the replacement level. To see the main reason for this, the fertility rates of countries according to income level are analysed in Table 1. According to Table 1, the high levels of fertility rates in low-income countries and the fact that their populations are higher than other countries cause the world fertility rates to hover above the replacement level.

According to the UN (2022) population projection, the world will reach the population replacement level of 2.1 in 2050. Projections of fertility rates may be inaccurate; in this context, while the actual world fertility rate in 2021 was 2.27, the projection published in UN (2022) estimated the 2021 world fertility rate as 2.32. As the growth rate of the world population decreases, the population replacement level is expected to be realised earlier than the projected 2050.

Since the fluctuations in the fertility rates of the countries and their non-stationarity are similar to non-linear time series, it was deemed appropriate to use the Regime Switching model first applied by Hamilton (1989) in this study.

The Regime Switching Model states that an economic variable exhibits different behaviours in different periods of the economy when time series data are used. Similarly, when fertility rates are

analysed from a historical perspective, it is observed that they are realised at different rates. Regime-Switching models also include multiple structures that can characterise time series behaviour (Hamilton, 1989). The Regime Switching Model allows regime changes in time series to depend on the realisation of a finite number of discrete states of the mean, variance and possibly dynamics of the series (Timmerman, 2000). When the observation values of the data are distributed to the regimes obtained with the help of the Regime Switching Model, the observation values falling into each regime will be linear within itself. In the aforementioned model, it is stated that the regime cannot be observed and only countable regimes are possible; in addition, the models will differ depending on the probabilistic process that derives the regime (Koç and Akgül, 2013). Although regimes cannot be observed, probabilistic explanations can be made about the relative probability of their formation. The Regime Switching Model was introduced to the literature by Hamilton (1989) to determine the contraction and expansion periods of the economy. In the Regime Switching Model, the expansion and contraction periods of the economy are determined according to the state variable s_t,which is a random variable and cannot be directly observed. In regime switching models, the state variable $s_t = (1,2, \dots, N)$is assumed to be a random variable taking integer values. The probability of s_t taking j values depending on the value of s_t can be written as follows:

$$P\{s_t = j/s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j/s_{t-1} = i\} = p_{ij} \quad (1)$$

The above process is defined as an N-state Markov chain with transition probabilities $p_{ij}, j = (1,2, \dots, N)$. p_{ij} transition probability gives the probability of state i following state j and the sum of probabilities for each state is equal to 1:

$$\mathrm{p_{i1}} + \mathrm{p_{i2}} + \cdots + \mathrm{p_{iN}} = 1 \quad (2)$$

In addition, the matrix representation of transition probabilities is as follows:

$$P = \begin{bmatrix} p_{11} & p_{21} & \cdots & p_{N1} \\ p_{12} & p_{22} & \cdots & p_{N2} \\ \vdots & \vdots & \vdots & \vdots \\ p_{1N} & p_{2N} & \cdots & p_{NN} \end{bmatrix}_0^0 \quad (3)$$

The ith column, jth row of the P matrix shows the transition probability p_{ij}. For example, the element in column 1, row 2 shows the probability of state 2 followed by state 1. In the literature on reduced statistical models, structural breaks are sometimes modelled as multiple change points, where s_t can either remain in the current regime or move to the next higher value (Chib, 1998). The Markov regime switching model can be represented as follows:

$$y_t = x_t' \varphi(s_t) + u_t, u_t \sim \text{ i.i.d. } \left(0, \sum(s_t)\right) \quad (4)$$

Where s_t is a first order Markov chain and x_t is a vector containing all exogenous variables and lagged values of the endogenous variable. Maximum likelihood estimates are obtained by maximising the following conditional probability function:

$$\ln\ L(\Theta) = \sum_{t=1}^{T} \ln \sum_{j=1}^{N} \Pr\{s_t = jY_{t-1}, \Theta\} f(y \mid s_t = j, Y_{t-1}, \Theta) \quad (5)$$

4. EMPIRICAL RESULTS AND DISCUSSION

Descriptive statistics are reported in Table 1. Descriptive statistics show that the fertility rate is positive on average. The maximum level is 5.32 and the minimum value is 2.32. The null hypothesis of Jarque-Bera test at 5% and 10% significance level is rejected and fertility rates do not conform to normal distribution.

Table 1: Basic Statistical Information

Mean	3.6438
Medium	3.5100
Maximum	5.3170
Minimum	2.3210
St. Dev.	0.9953
Skewness	0.2489
Kurtosis	1.4739
Jarque-Bera	7.7299 (0.02)*

*p-value

Since Markov regime switching is a non-linear analysis, the fertility rate variable must pass the non-linearity test. Table 2 shows the results of the BDS (Brock, Dechert and Scheinkmantest) test, which is one of the nonlinearity tests.

Table 2: BDS Test Results

Dimension	BDS Statistic	Std. Error	z-Statistic	p-value	
2	0.058281	0.013288	4.386146	0.0000	
3	0.103634	0.015621	6.634422	0.0000	
4	0.124957	0.013791	9.061001	0.0000	
5	0.121147	0.010670	11.35400	0.0000	
6	0.113502	0.007646	14.84431	0.0000	
Dimension	C(m,n)	c(m,n)	C(1,n-(m-1))	c(1,n-(m-1))	c(1,n-(m-1))^k
2	743.0000	0.307660	1206.000	0.499379	0.249379
3	526.0000	0.224211	1159.000	0.494032	0.120578
4	414.0000	0.181738	1112.000	0.488147	0.056781
5	326.0000	0.147445	1068.000	0.483039	0.026297
6	269.0000	0.125408	1025.000	0.477855	0.011906

According to the BDS test results, it is seen that the fertility rate is non-linear and all dimensions

are significant at 5% significance level. The fertility rate variable included in the model should be stationary. Therefore, ADF test was applied to determine the stationarity of the variables. The results are shown in Table 3. The results of the ADF test showed that it is stationary at 5% significance level at first difference.

Table 3: Unit Root Test Results

	t-statistic	p-value
ADF	-0.909313	0.7794
ADF(1)	-7.060024	0.0000

*tau-statistic: %1 (-2,60); %5 (-1,945823); %10 (-1,61)

This study applied Regime Switching Model to investigate how many regimes fertility rates are divided by in the world. Fertility rates are tested to have three regimes against two regimes[2] . The results are given in Appendix 1. Fertility rates in the world between 1960 and 2021 are divided into 3 regimes. The duration of the regime classification, the results are given in Table 4. The estimated transition probabilities are greater than 0.5, indicating that all three regimes are permanent. For example, the probability of remaining in the third regime is 88%, which is higher than both the second regime and the first regime. Similarly, the steady-state probabilities (Table 5) confirm that the third regime has a longer residence period than the other two regimes.

Table 4: Probabilities of Remaining in Regime

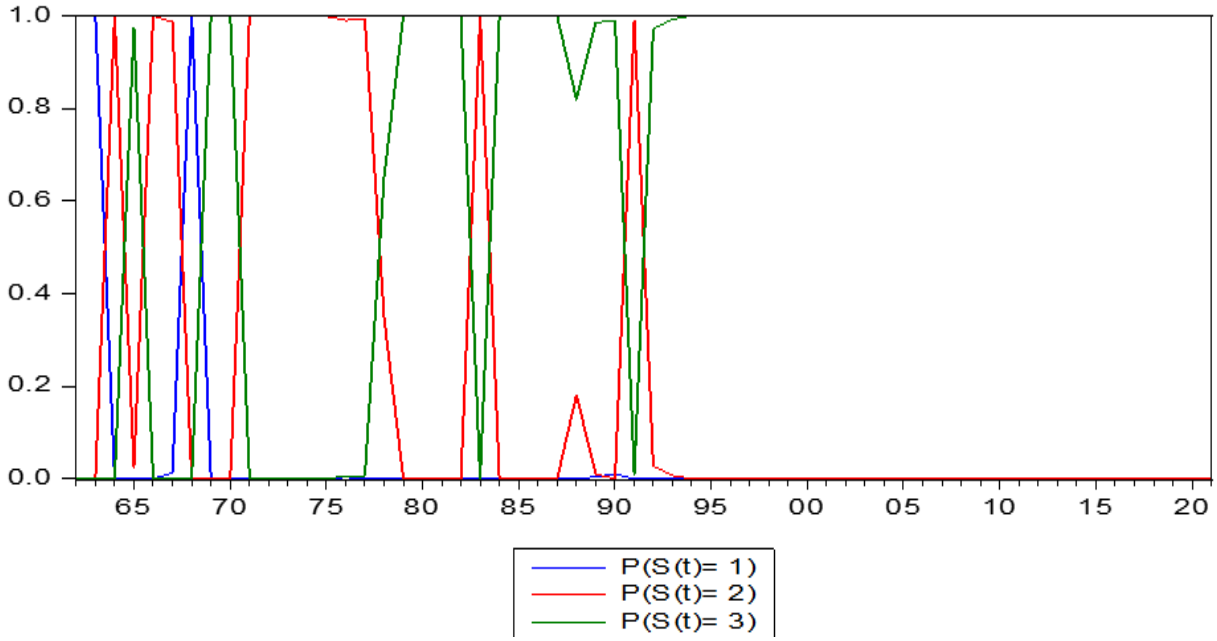
	Regime 1	Regime 2	Regime 3
Regime 1	0.3998	0.3196	0.2805
Regime 2	0.1425	0.5791	0.2783
Regime 3	0,0001	0.1104	0.8895

Table 5*:* Periods of Remaining in Regime

Periods	Regime 1	Regime 2	Regime 3
Duration (Year)	1.6661	2.3761	9.0545

The behaviour of the smoothed probabilities is shown in Figure 2, which also confirms that the smoothed probabilities are persistent in all three regimes.

[2] The number of regimes into which fertility rates are categorised is performed with the LR test. The LR test was used by Akgül, et al. (2015).



* P(S(t)=1, first regime; P(S(t)=2, second regime; P(S(t)=3, third regime.

Figure 2: Markov Switching Smoothed Regime Probabilities

According to the results, the first regime - the high fertility regime - occurred in 1960-1963 and 1968-1969. In this period, fertility rates were realised as 4.91 on average. The most important feature of this period is that the decline in infant mortality rates together with the development of health services led to high fertility rates (Dyson and Murphy, 1985). In addition, the common characteristic of these periods is that they are periods of historical transformation.

The postponement of the fertility age with the return of women to the labour force led to a decline in fertility rates after this period and the world entered the second regime -transition regime-. In the periods 1963-1965; 1966-1968; 1971-1978; 1983-1984; 1990-1993, the fertility rate in the world, which was in the transition regime, decreased to 4.18 on average. It decreased by approximately 17 per cent compared to the high fertility regime. Different views have emerged to explain this decline. Firstly, Harris and Ross (1987) argue that the fact that the majority of the world consists of agriculture-based economies, which causes fertility rates to remain high. However, this situation is still lower than the fertility rate in the first regime. Another claim is that the decline in the economic value of children due to industrialisation limits the fertility decisions of couples. The occupational transformation in the labour market and the rise in per capita income led to a decline in fertility rates (Sanderson and Dubrow, 2000). This is based on Easterlin's (1978; 1989) hypothesis on the low fertility of older generations. According to Easterlin, the decision to have children depends on how large one's potential income is relative to the expected standard of living. A pure increase in income also increases the number of children demanded. However, if this higher income reflects increased wages, then the increased wage may turn out to be an opportunity cost of having children and reduce the number of children demanded through the substitution effect (Guinnane, 2011).

The world entered the third regime - the low regime - after 1993. There was a sharp decline in fertility rates over the period of analysis and a return to high levels. On average, the fertility rate fell to 2.60 during this period. By 2021, the world has not yet fallen below the replacement level, with a fertility rate of 2.27. During this period, the devastating impact of high and persistent unemployment and the persistence of unfavourable economic conditions led to the decline in fertility rates (Adsera, 2006). Most of the countries are developing policies to increase fertility. Empirical evidence is very important in the

policies to be implemented. In this context, the model developed by Becker and Lewis (1973) is pioneering. While the elasticity of fertility with respect to income is positive, it may be zero or negative in recent times (Guinnane, 2011). The preciousness of time for individuals, the indivisibility of wealth, and the increase in the costs of quality education can be counted among the main reasons why fertility is zero or negative with respect to income.

In this study, Becker and Lewis (1973), like its pioneering study, made an important contribution to the literature. After 1993, the transition to a low fertility regime was a turning point and policy makers are advised to take this into account. At the same time, the decline in fertility rates has led to the problem of population ageing in countries with increasing life expectancy.

5. CONCLUSION

In this study, we investigated the world fertility distribution and examined whether fertility rates are in regimes that confirm the literature. Our most important finding was that the world was divided into 3 regimes in the period 1960-2021, and it was shown that it switched to the low fertility regime after 1993 and continues.

When the literature is analysed, it is seen that the fluctuations in fertility rates are divided into regimes based on subjective opinions without an econometric/statistical study (Rignuss et al. 2016; Vignoli et al. 2020). Therefore, in this study, considering the literature, the number of regimes in fertility rates has been analysed with the Markov regime change model. While establishing the hypothesis of the study, Strulik and Vollmer (2015) were followed and it was accepted that fertility rates in the world are divided into 2 regimes. As a result of the analysis, the validity of 2 regimes to 3 regimes was tested. In this context, it was determined that there were 3 regimes in world fertility rates between 1960-2021. While before 1993, all three regimes were observed; after 1993, it is seen that the low fertility regime has been realised and has not changed.

This study differs from the literature in two ways. Firstly, it has been proved by an econometric study that world fertility rates are divided into 3 regimes. Secondly, in the statistical/econometric studies on fertility rates to be conducted in the future, it was found that the structural break occurred in 1993. Therefore, if the data before 1993 are included in the analysis, single regime studies will lead to erroneous results. In this context, researchers are advised to take this into consideration.

Ethical Statement

During the writing and publication of this study, the rules of Research and Publication Ethics were complied with, and no falsification was made in the data obtained for the study. Ethics committee approval is not required for the study.

Contribution Rate Statement

All the authors in the study contributed to all processes of writing and drafting the study and the final version of the study has been read and approved by them.

Conflict Statement

This study has not led to any individual or institutional/organizational conflict of interest.

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APPENDIXES

Appendix 1

$$LR = -2 * LL_{m1} + 2 * LL_{m2}$$

LR: Likelihood Ratio

LL_{m1}: Log likelihood coefficient of 2 regimes

LL_{m2}: 3-regime log likelihood coefficient

$$H_0: \theta = \theta_0$$

$$H_1: \theta = \theta_1$$

The result is compared with the chi-square test statistic

Degree of freedom = Number of parameters with 3 regimes - Number of parameters with 2 regimes

LR= -2* 94.34936+2*105.8997

LR= 23,10068

Degree of freedom 1

Chi-square test statistic: 3,64 (%5). Therefore, MS with Regime 3 is accepted.

Extended Abstract
The Transition of Fertility Rates in the World: Regime Switching Model

Research Purpose: Between 1946 and 1964, the world went through a period of fertility rates above the replacement level of 2.1. The postponement of fertility to the 30s caused fertility rates to fall below the replacement level.
Changes in fertility rates are among the important factors affecting the economic structure. Low fertility rates can lead to aging of the population and a decline in labor supply in an economy. The economic impact of fertility rates is closely related to the demographic structure of a country and is an important factor to be considered in shaping long-term economic policies.
The reason why fertility rates in the world are above replacement level is that low-income countries have high fertility rates. In this context, it is important which fertility regime the world is currently in. While the world fertility rate was 4.69 in the 1960s, it was 2.27 in 2021. In a 60years fertility rates decreased by 52 percent. In this context, since the fluctuations and non-stationarity in the fertility rates of countries are similar to non-linear time series, it was deemed appropriate to use the Regime Shifting model first applied by Hamilton (1989) in this study.

Methodology: A country can be considered to be aging when its fertility rate per woman falls consistently below the replacement threshold of 2.1. In this context, this study uses data on world fertility rates. Fertility rates for 1960-2021 are taken from the World Bank Data Statistics Department.
The Regime Switching Model states that an economic variable exhibits different behaviour in different periods of the economy when time series data are used. Similarly, when fertility rates are analyzed from a historical perspective, it is seen that they are realized at different rates. When the observation values of the data are distributed to the regimes obtained with the help of the Regime Switching Model, the observation values falling into each regime will be linear within itself. Thus, the models will differ depending on the probabilistic process that derives the regime. Regime-Switching models also include multiple structures that can characterise time series behaviour (Hamilton, 1989). The Regime Switching Model allows regime changes in time series to depend on the realisation.

Findings: In this study, the Regime Switching Model was applied to investigate how many regimes fertility rates are divided into in the world. Fertility rates are tested to have three regimes against two regimes. Between 1960-2021, fertility rates in the world are divided into 3 regimes.
The first regime, the high fertility regime, was experienced in 1960-1963 and 1968-1969. In this period, fertility rates averaged 4.91. The most important feature of this period is that the decrease in infant mortality rates due to the development of health services led to high fertility rates.
The postponement of the fertile age with the return of women to the labor force led to a decline in fertility rates after this period and the world entered the second regime - the transition regime. During the period 1963-1965; 1966-1968; 1971-1978; 1983-1984; and, 1990-1993, the fertility rate in the transition regime dropped to 4.18 on average. Compared to the high fertility regime, it decreased by about 17 percent.
After 1993, the world entered the third regime, the low regime. Throughout the analysis period, fertility rates fell sharply and returned to high levels. The average fertility rate fell to 2.60 during this period. By 2021, the world has not yet fallen below the replacement level of 2.27 fertility rates. The devastating impact of high and persistent unemployment and the persistence of unfavourable economic conditions have contributed to the decline in fertility rates.

Conclusions: This study differs from the literature in two aspects. First, it has been proved by an econometric study that world fertility rates are divided into 3 regimes. Secondly, in future statistical/econometric studies on fertility rates, it is determined that the structural break occurred in 1993. Therefore, it is understood that single regime studies will lead to erroneous results if data before 1993 are included in the analysis. In this context, researchers are advised to take this into account.