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FERTILITY, EMPLOYMENT AND CAPITAL ACCUMULATION: A CASE STUDY FOR TURKEY*

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Abstract

In the last two decades Turkish fertility rates have been steadily decreasing. This paper is an attempt to examine the effects of a change in fertility rates on population structure, labor supply, and employment in relation to physical capital stock for the next four decades. This study also evaluates the effects of a possible reversal change in fertility rates on the variables mentioned above. The study is carried out in three stages. In the first stage, population of Turkey is projected with Leslie matrix defined by age-specific fertility rates and survival rates. Projections are repeated for different fertility rates. In the second stage, physical capital stock per employed person is forecasted using time series data. In the third stage, the predictions obtained through the first two stages are combined. Thus, the question of what should be the warranted growth rates of physical capital stock in order to employ labor force projected under different fertility rates is answered. According to the results, increases in fertility rates lead to an increase in labor supply with a 15 year lag, even if fertility rates have remained unchanged in their current level. The physical capital stock growth rate that is necessary for the employment of the extra labor supply emanating from an increase in fertility rates is found to be at least 5 %.

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* Bu çalışmanın ana fikri 2008 yılında Ronald Shone'un Dinamik İktisadi Çözümleme: Faz Diyagramları ve İktisadi Uygulamaları adlı kitabının Türkçe baskısını Merhum Prof. Dr. Muzaffer Sarımeşeli ile birlikte yayına hazırladığımız sırada ortaya çıktı. Kitabın nüfus öngörü modelleri üzerine kurulu on dördüncü bölümünün çevrildiği tarihler aynı zamanda çalışmanın ana eksenini oluşturan doğurganlık oranlarına ilişkin söylemlerin ortaya çıktığı tarihlere karşılık gelir. Çalışmanın ilk bulguları 28-30 Mayıs 2009 tarihinde Erzurum'da Atatürk Üniversitesi Ekonometri Bölümü'nce düzenlenen 10. Ekonometri ve İstatistik Sempozyumu'nda sunulmuştur. Genişletilmiş versiyonu 23 Kasım 2010 tarihinde Ankara Üniversitesi Siyasal Bilgiler Fakültesi İktisat Bölümünce düzenlenen bölüm seminerinde sunulmuştur. Aradan geçen yaklaşık dört yıllık süre içinde çalışma burada yayınlanan son halini almıştır. Bu vesile ile Sayın Editöre, makalenin değerli hakemlerine teşekkürlerimi sunarım. Hayatım boyunca en büyük teşekkürlerim artık aramızda olmasa da Kıymetli Hocam Prof. Dr. Muzaffer Sarımeşeli'ye olacaktır.

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This was higher than the actual growth rate of physical capital stock realized in the last decade which was approximately 4 %.

Keywords: *Matrix population model, Leslie matrix, fertility, employment and physical capital stock.*

JEL Classification*: J11, J21, C02, C22.*

Doğurganlık, İstihdam ve Sermaye Birikimi: Türkiye için Bir Analiz

Özet

Türkiye'de doğurganlık oranları son yirmi yılda istikrarlı bir biçimde azalma göstermiştir. Bu çalışmada doğurganlık oranlarındaki değişmelerin nüfus yapısı, işgücü arzı ve fiziki sermaye stoku çerçevesinde istihdam üzerindeki etkileri önümüzdeki kırk yıl için incelenmiştir. Bu çalışma doğurganlık oranlarında olası tersine bir gelişmenin sözü edilen değişkenler üzerindeki etkisini de incelemektedir. Çalışma üç aşamada gerçekleştirilmiştir. İlk aşamada, Türkiye nüfusu yaş sınıflarına göre doğurganlık oranları ve hayatta kalma oranları ile tanımlanan Leslie matrisi aracılığıyla öngörülmüştür. Öngörüler farklı doğurganlık oranları için tekrarlanmıştır. İkinci aşamada, çalışan başına fiziki sermaye stoku zaman serisi verileri ile öngörülmüştür. Üçüncü aşamada, ilk iki aşamada elde edilen öngörüler birleştirilmiştir. Böylece farklı doğurganlık oranları altında öngörülen işgücü arzını istihdam edebilmek için gerekli sermaye birikimi artış hızı ne olmalıdır sorusu cevaplanmıştır. Analiz sonuçlarına göre doğurganlık oranları mevcut düzeyinde kalsa da istihdam açısından asıl etki yaklaşık on beş yıl sonra ortaya çıkmakta ve artan işgücü arzını istihdam etmek için gerekli sermaye birikimi yıllık ortalama artış hızının en az yüzde 5 düzeyinde olması gerekmektedir. Öngörülen bu değer incelenen dönemde gerçekleşen sermaye birikimi artış hızından (yaklaşık yüzde 4) daha büyüktür.

Anahtar Kelimeler: *Nüfus öngörü modeli, Leslie matrisi, doğurganlık, istihdam ve fiziki sermaye stoku.*

JEL Sınıflaması: *J11, J21, C02, C22.*

1. Introduction

The Turkish economy encountering the 2000s years economic crisis reached high growth rates in the 2002-2008 period; however, these higher growth rates have not brought about increases in employment. In fact, while the average annual growth rate is 5.7%, the average annual growth rate of employment is only 0.9% during this period. The average annual growth rate of non-institutional working age population is 1.5% and this ratio is higher than the rate of increase of employment.

The average annual population growth rate in recent years is 1.03% and topics often emphasized by the authorities are the protection of the young population structure and the employment of the young population. It can be said that these topics are especially emphasized within the framework of the European Union (EU) accession process.

According to the Census 2000, the proportion of population of 0-14 age class to total population is roughly 30%. This ratio is 26.5% in 2009. The World Bank data on EU member countries indicate that the ratio of young population (0-14 age class) to total population is 16.4 % on average, which outlines the fact that Turkey has the youngest population. Within the EU countries, Ireland and Bulgaria has the highest and the lowest young population ratio with 20.2 and 13.8, respectively.[1] Total fertility rate is an important indicator of population dynamics and it is 2.2 per thousand women in Turkey. Turkey is followed by Ireland and France with 2.0 and 1.9 total fertility rates. It is inquired within the context of population dynamics, the total fertility rates for EU countries is 1.4 per thousand women in the period of 2000-2005.[2]

With its high fertility rates and young population ratio, Turkey has a possibility of protect its young population structure in the next decades. At first glance, this appears to be an advantage; however, unemployment and labor force participation rates of Turkey are approximately 10% and 49%, respectively. Labor force participation rate of women is decreasing (it is 26% in 2009 and 23% in 2005). Given the capital intensification nature of the technological changes in our country, population policies such as the protection of the young population structure should be carefully designed.

For example, even if there is not any change in fertility rates, a positive population growth rate will eventually lead to an increase in labor supply. When this situation is taken into consideration, the economy should be directed with the increases in employment arising from increases in labor force supply. This point is important for our economy because of low labor force participation and relatively high unemployment rates. Increases in employment possibilities are closely related

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[1] Worldbank. (2008). *World Development Indicators* [Data File]. Retrieved from http://devdata.worldbank.org/query/default.htm (Access Date: 17.09.2008).

[2] United Nations, Department of Economic and Social Affairs, Population Division. (2008), *World Fertility Patterns 2007*, Retrieved from www.unpopulation.org, Updated version for the web, March 2008.

to economic growth and investments that is main determinant of economic growth. Therefore, policies that incent population growth should also include precautions composing necessary infrastructure in order to employ non-institutional working age population. What kind of precautions should be taken is not fundamental focus of the study; however, capital accumulation will obviously be the main precaution.

Capital accumulation is generally defined as the net addition to capital stock which is in itself requires a certain proportion of national income to be saved. In the long run, the amount of capital determines the amount of output being produced and the amount of output determines the amount of saving and investment, and so the amount of capital being accumulated (Blanchard, 2003). Savings implicitly play a significant role in defining the relationship between capital accumulation and fertility. As pointed out by Correa (1965), the relationship between savings and demographic trends is complicated and high rates of population growth may have a detrimental effect on rates of savings and investments.

According to the life cycle savings model – which connects savings and demographic factors and incorporates effects on the household level and on the aggregate level as well – savings will be highest in the middle of a person's life when saving for retirement takes place. (Tobin, 1967 and Leff, 1969). On micro level, decreasing fertility causes less consumption and an increase of savings at the household level. However, decreased fertility leads to population ageing. Since older households on average have a lower rate of saving, this again brings about reducing in savings. On the other hand, a growing population covers the young and saving households, older and dissaving households. Consequently, a growing population leads to an increase in aggregate savings.

On the macro level, changes in the age structure affect savings because an increase of younger age groups, for instance, increases consumption relative to production. This leads to decline in the level of investment by decreasing the level of savings. Furthermore, according to Faaland (1966), a higher population growth calls for larger investments in social and economic overheads simply to maintain the same basic services and standards for the increased population.[3] Besides, increasing in level of per capita real national income, as indicated by Galenson and Leibenstein (1955), can be synonymous with an increase in per capita investment level. The measure of increasing level of per capita real income depends on increasing in physical capital stock per present labor force.

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[3] For detail explanations about demographic aspects of savings, investments, employment and productivity, see Demeney (1965).

Various studies have been undertaken to examine the relationship among fertility, labor supply and economic growth [see Becker (1960), Becker and Barro (1988), Barro and Becker (1989), Becker, Murphy and Tamura (1990), Wang, Yip and Scotese (1994), Angrist and Evans (1998), Poot and Siegers (2001) and Kalemli-Ozcan (2002). These papers, in general, focus on economic analysis of the linkages between fertility rates and capital accumulation. In general, the quantity, quality and the productivity of labor in itself depend on fertility rates and amount of investment per labor. It is, therefore, important for policy makers to predict future supply of labor and amount of investment that may be required to provide employment for the ever increasing labor supply.

Looking at the same problem from a different angle, capital/labor ratio may be perceived as the average amount of capital that may be required to provide employment for an additional unit labor. The value of this ratio may change in line with changes in factor prices and government policies in relation to technological changes. It is generally accepted that the value of this ratio increases over time as more and more capital intensifying technologies are adopted. However, experiences from developed countries indicate that capital accumulation may exhibit diminishing returns to scale in the long run. Hence, in these countries, governments focus on policies that will improve human capital and research and development activities to keep or to increase their economic growth level. In other words, they directly focus on productivity rise.[4]

This paper is an attempt to examine the effects of a change in fertility rates on population structure, labor supply, and physical capital stock per worker for next four decades. This study also evaluates the effects of a possible increase in fertility rates on labor force, employment and physical capital stock. The main question of the study is "what should be the warranted growth rates of physical capital stock in order to employ labor supply increases due to changes in fertility rates". In other words, the possible consequences of population policies in relation to employment will be investigated by examining relationships among fertility, labor force participation and unemployment rates, and physical capital accumulation.

In the first stage of the present study, an attempt is made to simulate the effects of changes in fertility rates on population structure of Turkey. To put it more succinctly, a Leslie projection matrix with 19 different age groups is used to predict age distribution of the Turkish population for three different fertility levels. The

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[4] In Solow (1956) and Solow (1957), permanent growth only occurs with technological progress. Capital accumulation has diminishing returns to scale without technological progress. On the other hand, continuous progress in technology eliminates diminishing returns of capital accumulation.

predicted age distributions are later used to calculate various dependency ratios that may characterize future Turkish population and the effects of changes in fertility rates on these ratios.

In the second stage of the study, physical capital stock per person employed is forecasted by using time series data. These forecasted values together with age distributions obtained under different fertility rates are then used to calculate warranted capital stock growth rates for the employment of additional labor supply that may stem from population growth. In this respect, two additional parameters, namely participation ratio and unemployment rate are taken into consideration as policy makers may set different objectives.

The rest of the study is organized as follows: Section 2 represents the structure of population, employment and fertility of Turkey. Third section deals with the population projection matrix method. The data set and the Leslie matrix for Turkey are given in Section 4. Forecasts for population and physical capital stock per person employed are summarized under several scenarios in Section 5. General assessments about the results are given in the last section.

2. Population, Employment and Fertility Structure of Turkey

In this section, the detailed information about the population dynamics and the structure of labor force of Turkey are presented. Table 1 and Table 2 give historical developments in demographic parameters such as the non-institutional working age population (15^+), the age dependency ratios and fertility rates. The labor force participation rates and persons employed and unemployed by their age classes, educational status and gender are summarized in Table 3.

Table 1: Population and Age Dependency Ratios between the Period of 1980-2007

Year*	Total Population (000)	Population of 15^+ Age Class (000)	Youth Dependency Ratio	Elderly Dependency Ratio	Total Age Dependency Ratio
1980	44 737	27 136	69.7	8.5	78.1
1985	50 664	31 558	64.6	7.2	71.8
1990	55 294	35 601	57.6	7.1	64.7
2000	66 187	46 211	46.3	8.8	55.1
2007**	68 901	49 994	39.7	10.7	50.4
2008**	69 724	50 772	39.3	10.2	49.5
2009**	70 542	51 686	38.8	10.5	49.3

Source: Turkish Statistical Institute. (2010). *Statistical indicators: 1923-2009*, Publication No. 3493, Ankara: TSI Printing Division.

* Population Censuses was carried out between 1935 and 1990 regularly in years ending with 0 and five. After 1990, population censuses have been decided to be carried out in years ending with 0 by a law and in this regard the 14th Population Census was carried out in the year 2000.

** Data for the years 2007-2009 was computed from Address Based Population Registration System (ABPRS).

As shown in Table 1, total population of Turkey was 44.7 million in 1980 and 70.5 million in 2009. Annual population growth rate within this period was computed as 1.6 %. There was a 2.3 % increase in population of 15 years of age and over (15^+) between the years 1980-2000. Furthermore, the ratio of population of 15^+ to total population is 61% in 1980, this ratio continuously increased and it was observed to reach 70.1% in 2000. In other words, labor supply raised parallel with population growth rate of 15^+ working age class. As it can be seen from Table 1, the ratio of this age class to total population was 73.2% in 2009. Youth dependency ratio decreased from 69.7 to 39.7 through the years 1980-2000 and elderly dependency ratio comparatively exhibited more stable pattern. In fact, while elderly age dependency ratio was 8.5 in the year 1980, there was a very small rise in the year 2000. Moreover, total age and youth dependency ratio exhibit similar tendency because of the high population of 0-14 age class.

Another factor affecting population dynamics are total fertility rate and age-specific fertility rate.[5] Table 2 represents fertility rates in Turkey through the period 1978-2008. As noted in the 2008 Turkey Demographic and Health Survey (TDHS), between 1978 and 2008, there has been a pronounced decrease in the age-specific fertility rates in almost all age classes. Although the age pattern of fertility has not changed remarkably during this period, the fertility for the age class of 25-29 has gradually approximated to that of the age class of 20-24 within the course of time and at the beginning of 2000s, the fertility rates of these two classes have reached almost equal levels. The results of TDHS-2008 indicate that the fertility rate observed for the age class of 25-29 is higher than that of 20-24 for the first time in Turkey. The shift of the highest fertility from 20-24 to 25-29, that is postponement of births, is one of the striking results of fertility transition in Turkey. In line with this finding, when the variation in the age pattern of fertility between 2003 and 2008 is considered, the reduction in the total fertility rates during this period is mainly due to decrease occurred in the fertility rates of early age classes.[6]

Historical developments in labor force, participation rates and unemployment rates in Turkey are presented in Table 3. Over the period 1988-2000, there is an increasing trend with 1.5% annual growth rate in the number of employed people. This pattern is also observed after 2005; however, although the number of employed

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[5] The total fertility rate (TFR) is defined as the total number of children that may be given a birth by a woman during the period in which she is fertile. It is computed as product of sum up fertility rates in accordance with age class with age interval (here it is 5).

[6] Shorter and Macura (1983) and Demeney and Shorter (1968) are two important sources of data and information for readers who are interested in population, mortality and fertility trends of Turkey in the period of 1935-1975.

people has been increased greater than 1%, there is only 0.4% increase in the number of employed people in 2009. The reason behind this decrease is the global financial crisis. The number of unemployed persons is greater than 2 millions after 2000 while it is less then 2 millions before 2000 and the lowest rate of unemployment rate was reached in 2000. Unemployment rate remained approximately 10% level over the period 2005-2008, as a consequence of global crisis it was observed to reach 14% in 2009.

Table 2: Trends in Fertility Rates (per thousand women)

Age Classes	TFS-1978*	TDHS-1988	TDHS -1993	TDHS - 1998	TDHS - 2003	TDHS - 2008
15-19	93	45	56	60	46	35
20-24	259	193	179	163	136	125
25-29	218	183	151	150	134	133
30-34	154	102	94	93	78	90
35-39	101	55	38	42	38	36
40-44	38	19	12	13	12	10
45-49	2	7	0	1	2	1
TFR 15-49	4.33	3.02	2.65	2.61	2.23	2.15

Source: Hacettepe University Institute of Population Studies (2008), Turkey Demographic and Health Survey 2008, Preliminary Report, Retrieved from http://www.hips.hacettepe.edu.tr/tnsa2008/data/TDHS-On-Rapor-eng.pdf.
Note: 1978, 1988 and 1993 rates refer to the year before the survey; 1998, 2003 and 2008 rates refer to the three-year period before the survey. TFS indicates Turkey fertility Survey.

Labor force participation rates indicate the ratio of the labor force to non-institutional working age population. Participation in labor force exhibited a decreasing trend through the years 1988-2009 and it has been less than 50% since the year 2000. While the labor force participation rate had a decreasing trend, total employment exhibited an increasing trend. The negative trend in labor force participation rate may stem from the negative trend in women's participation rates. As is shown in Table 3, there is a slight reduction in this rate from 34.3% to 26% over the period 1988-2009. This pattern is also similar for men's participation. Labor force participation had a negative trend while the number of persons employed had a positive trend during this period.

Table 3: Historical Developments in Labor Force, Participation Rates and Unemployment Rates (per thousands)

	Labor Force		Labor Force Participation Rate			Unemployment Rate		
	Employed	**Unemployed**	**Total**	**Females**	**Males**	**Total**	**Females**	**Males**
1988	17 756	1 639	57.5	34.3	81.2	8.4	10.6	7.5
1990	18 539	1 611	56.6	34.1	79.7	8.0	8.5	7.8
1995	20 586	1 699	54.1	30.9	77.8	7.6	7.3	7.8
2000	21 581	1 497	49.9	26.6	73.7	6.5	6.3	6.6
2005*	20 067 (--)	2 388 (--)	46.4	23.3	70.6	10.6	11.2	10.5
2006*	20 423 (1.8)	2 328 (-2.5)	46.3	23.6	69.9	10.2	11.1	9.9
2007*	20 738 (1.5)	2 376 (2.1)	46.2	23.6	69.8	10.3	11.0	10.0
2008*	21 194 (2.2)	2 611 (9.9)	46.9	24.5	70.1	11.0	11.6	10.7
2009*	21 277 (0.4)	3 471 (32.9)	47.9	26.0	70.5	14.0	14.3	13.9

Source: Turkish Statistical Institute. (2010). *Statistical indicators: 1923-2009*, Publication No. 3493, Ankara: TSI Printing Division.
* Revised data by the new population projections based on Address Based Population Registration System (ABPRS).
(.) denotes annual growth rates.

Table 4 presents the distribution of persons employed and unemployed according to their age classes and educational statutes. As shown in Table 4, 20-54 age class is the main contributor both to employment and unemployment and 35% of non-institutional working age population has been employed. The same table also gives the number of persons employed and unemployed in accordance with their educational statutes. High proportion of employment consists of people who have only primary education. Although through the years the number of persons employed with higher education increased steadily, the ratio of men and women graduated from a university or college to total employment increased sharply from 8.5% to 20.7%. This implies an improvement in human capital which may also contribute to economic growth. Persons classified by their gender strongly indicate that men in Turkey are the main contributor of labor force without depending on their educational level. In fact, although men's participation rates have a decreasing trend, they are roughly as three times as higher than women's participation rates.

In summary, this type of pattern can be explained as the ratio of non-institutional working age population to total population is 73% and the ratio of labor force to non-institutional working age population (participation rate) is 47% on average.

Table 4: Historical Developments in Employment and Unemployment by Educational Statues and Age Classes (per thousands)

	Employed Females by Educational Statues*			Unemployed Females by Educational Statues*		
	Primary School Graduate	High School and Vocational High School Graduate	Higher Education Graduate	Primary School Graduate	High School and Vocational High School Graduate	Higher Education Graduate
1988	2 265	372	214	244	171	46
1990	2 551	409	259	201	165	31
1995	3 027	589	401	169	185	35
2000	2 687	759	632	100	149	64
2005**	1 983	818	818	155	249	134
2006**	1 936	884	912	160	250	136
2007**	1 881	942	982	131	260	158
2008**	1 906	985	1 097	155	256	183
2009**	2 020	944	1 197	210	333	232
	Employed Males by Educational Statues*			**Unemployed Males by Educational Statues***		
	Primary School Graduate	**High School and Vocational High School Graduate**	**Higher Education Graduate**	**Primary School Graduate**	**High School and Vocational High School Graduate**	**Higher Education Graduate**
1988	7 145	1 229	656	525	182	41
1990	7 627	1 323	729	604	175	42
1995	8 397	2 200	923	625	291	55
2000	8 697	2 806	1 263	527	275	80
2005**	6 676	3 389	1 663	737	421	143
2006**	6 548	3 488	1 782	685	402	149
2007**	6 503	3 580	1 902	672	414	153
2008**	6 438	3 583	2 043	716	423	179
2009**	6 231	3 448	2 124	933	558	226
	Employed Persons by Age Classes			**Unemployed Persons by Age Classes**		
	15-19	**20-54**	**55+**	**15-19**	**20-54**	**55+**
1988	2 545	13 167	2 044	521	1 043	73
1990	2 503	13 822	2 212	458	1 095	61
1995	2 368	16 037	2 182	401	1 255	40
2000	2 061	17 317	2 203	247	1 216	35
2005**	1 348	16 896	1 823	299	2 035	54
2006**	1 353	17 267	1 802	285	1 982	61
2007**	1 324	17 603	1 811	325	1 990	61
2008**	1 351	17 941	1 902	330	2 203	78
2009**	1 298	17 957	2 022	401	2 963	107

Source: Turkish Statistical Institute. (2010). *Statistical indicators: 1923-2009*, Publication No. 3493, Ankara: TSI Printing Division.

* Illiterate, literate, literate but no school completed and primary education and junior high school or equivalent vocational school graduates are excluded.

** Revised data by the new population projections based on Address Based Population Registration System (ABPRS).

3. Empirical Methodology

In this study, the population projection matrix called Leslie matrix is used to forecast Turkish population. The Leslie matrix provides more comprehensive investigation in population projection studies. It is possible to investigate changes in total population and population of age classes over time and possible effects of changes in fertility rates with Leslie matrix.

Leslie matrix begins with a model for age-classified population. The continuous variable age is divided into a discrete set of age classes. If, for example, it is assumed that women can bear children to age 45 and there are three class intervals. Then there are three classes such as 0-15, 15-30 and 30-45. In general, if the terminal age is N and there are n-age classes, then N/n indicates the duration of the age class. In given example, it is $45/3 = 15$.

Let b_i denote the birth rate for the ith-age class (i.e., i = 1, 2, 3) and s_{ij} denote the survival rate from class i into class j. In the illustrative example, there are s_{12} and s_{23}. To be in class i = 1 (that is 0-15) means the individuals can be born from a women of any of the three age classes. So, equation (1) can be written as follows.

$$x_1(t+1) = b_1 x_1(t) + b_2 x_2(t) + b_3 x_3(t) \tag{1}$$

where x and $x_i(t)$ indicate the continuous variable age and the population of the ith-age class at time t, respectively. However, the individuals in age classes 2 and 3 at time $(t+1)$ are the survivors of the previous age classes at time t. For this reason, the number of people surviving to the second, third, etc. has to be computed. These computations are given in equation (2).

$$\begin{aligned} x_2(t+1) &= s_{12} x_1(t) \\ x_3(t+1) &= s_{23} x_2(t) \end{aligned} \tag{2}$$

The set of equations (1) and (2) can be written in a matrix form.

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}(t+1) = \begin{bmatrix} b_1 & b_2 & b_3 \\ s_{12} & 0 & 0 \\ 0 & s_{23} & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix}(t)$$

or

$$\mathrm{x}(t+1) = \mathrm{A}\mathrm{x}(t) \tag{3}$$

The matrix **A**, often called Leslie matrix after P. Leslie (1945, 1948) who first introduced it, is described as above. It is clear that projections after time t only require taking tth-order power of the matrix **A**. The solution equation is

$$x(t) = A^t x(0). \quad (4)$$

where **x**(0) shows the vector of the number of individuals in each *i*th-age classes in initial period. The matrix **A** also gives information about population growth rate and the distribution of age classes within the total population. The dominant eigenvalue and its eigenvector of the matrix **A** denote general growth rate of system and limit values of the projections of related age classes.[7]

Within the context of population projection matrix, if **A** is constant, it is assumed that the fertilities and the survival probabilities remain constant over time. As pointed out by Keyfitz and Caswell (2006: 51), this situation can only be accepted for human population, because human population cannot vary conspicuously in time and space without a war, natural disasters, etc. What happens if the entries of **A** are changed? In the present study, it is assumed that while the survival ratios are constant, there is a change in fertility rates in Turkey. Even though the institutions such as Turkish Statistical Institute and United Nations publish population projections for Turkey, we prefer to predict the Turkish population to investigate the effects of increase or decrease in age-specific fertility rates on population dynamics, employment and capital accumulation in Turkey.

For detailed information about population projection models, see Keyfitz and Caswell (2006), Shone (2001), Preston (2001), Caswell (2000), Hinde (1998), Hoppensteadt (1992) and Renshaw (1991).

4. Data Set and Projection Matrix

The variables with their definitions and data sources used in the first and second part study are summarized below. The Leslie population projection matrix is also given in this section.

Fertility rate for each age class is defined as the ratio of the number of live-births to the total women-years lived in the related age class since 36 months prior to the survey data. Turkey Demographic and Health Survey (TDHS) prepared by Hacettepe University Institute of Population Studies and the Ministry of Health are the main sources of the fertility data. The data are classed into seven groups each consisting of five year period.

The survival rate or ratio (${}_nS_x$) is defined as the proportion of the individuals from *i*th-age class to *j*th-age class. Let ${}_nL_x$ denotes the total number of individuals lived the interval between ages x and $x+n$. Values of ${}_nS_x$ are computed using life tables by the following formula.

[7] **Theorem:** If **A** is a Leslie matrix of the form,

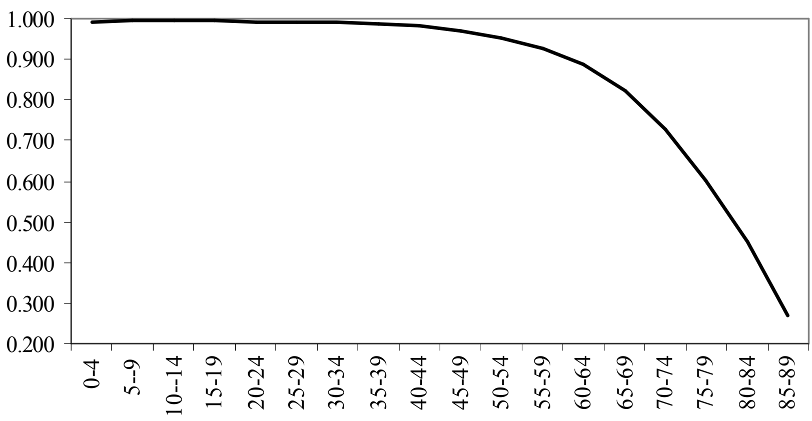
$$\mathbf{A} = \begin{bmatrix} b_1 & b_2 & b_3 \\ s_{12} & 0 & 0 \\ 0 & s_{23} & 0 \end{bmatrix} \qquad \begin{array}{ll} b_i \geq 0 & i = 1,2,3 \\ 0 < s_{i-1,i} \leq 1 & i = 2,3 \end{array}$$

it satisfies the following conditions: *i*) there exist a unique dominant eigenvalue which is positive (λ_d); *ii*) the eigenvector associated with the dominant eigenvalue has positive components, and *iii*) all other eigenvalues, $\lambda_i \neq \lambda_d$, satisfy $|\lambda_i| < \lambda_d$ (Shone 2001).

$$_nS_x = L_{x+n} / L_x \qquad (5)$$

There is no recent data for life tables officially published. However, there are several studies for the life tables of the Turkish population such as Kırkbeşoğlu (2007), Coşkun (2002), Toros (2000) and Lopez et al. (2003). The data used in this study were taken from Kırkbeşoğlu (2007). The author constructed the complete life table which includes each age in interval between 0-100 by using TDHS-2003 survey data. In this recent study, $_nL_x$ values were re-edited for both sexes according to age interval determined by age-specific fertility rates and the survival ratios from one age class to another were computed using these $_nL_x$ values.[8] Figure 1 indicates the tendency of the computed survival ratio according to age classes.
The Leslie matrix for predicting the Turkish population, which is given in Table 5, is determined as 19×19. The values given in this matrix are adjusted by five-year periods. Using this Leslie matrix and the population of the *i*th-age class at time *t* (or initial period) population of Turkey can be projected, for example for every consecutive five year. The elements of the first row of the Leslie matrix consist of fertility rates for each age class. Since, under normal circumstances, there will be no child birth in 0-14 and 50^+ age classes or if so, fertility rates for these age classes were equal to zero. Sub-diagonal elements of the Leslie matrix indicate the survival ratio from age class *i* to *j*.

Figure 1: The Survival Ratios from an age class to another for Turkey



Source: Author's Calculations based on Kırkbeşoğlu (2007).

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[8] First $_nL_x$ values given for female and male were added and then $_nS_x$ values were computed. The terminal age is 90^+. $_nS_x$ values computed for age classs 90-94, 95-99 and age 100 were weighted by the ratio of $_nL_x$ values related each age class to total $_nL_x$ values were computed and then added. Thus, the survival ratio of 90^+ age class was obtained.

In this study, three different population projection matrices were used. The difference among the matrices arises from age-specific fertility rates. Therefore, all population projections were obtained under constant survival ratios because of data constraints.[9]

Table 5 : The Population Projection Matrix (the Leslie Matrix)

	0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**…**	**90+**
0-4	0	0	0	0.094	0.401	0.434	0.269	0.097	0.026	0.003	0	0	0	0		0
5-9	0.991	0	0	0	0	0	0	0	0	0	0	0	0	0		0
10-14	0	0.997	0	0	0	0	0	0	0	0	0	0	0	0		0
15-19	0	0	0.997	0	0	0	0	0	0	0	0	0	0	0		0
20-24	0	0	0	0.995	0	0	0	0	0	0	0	0	0	0		0
25-29	0	0	0	0	0.993	0	0	0	0	0	0	0	0	0		0
30-34	0	0	0	0	0	0.992	0	0	0	0	0	0	0	0		0
35-39	0	0	0	0	0	0	0.991	0	0	0	0	0	0	0	…	0
40-44	0	0	0	0	0	0	0	0.987	0	0	0	0	0	0		0
45-49	0	0	0	0	0	0	0	0	0.981	0	0	0	0	0		0
50-54	0	0	0	0	0	0	0	0	0	0.971	0	0	0	0		0
55-59	0	0	0	0	0	0	0	0	0	0	0.955	0	0	0		0
60-64	0	0	0	0	0	0	0	0	0	0	0	0.928	0	0		0
65-69	0	0	0	0	0	0	0	0	0	0	0	0	0.885	0		0
…	…															
90+	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0

Source: Author's Calculations based on Kırkbeşoğlu (2007) and TDHS-2008..
Notes: First row elements of Leslie matrix are age-specific fertility rates according to TDHS-2008.
Since it is females that give birth, a number of matrix population models consider only the number of females. However, population projections can be made from together with female and male population. In the present paper, population projections cover total population. Therefore, elements different from zero of first row are computed the following way. Population projections are obtained by using total population rather than female population. The first row of the matrix indicate that age-specific fertility rates per thousand women (see Table 4), first are divided with 1000, second 1 were added and then their 5^{th} power were divided 2. Similarly, sub-diagonal elements of the matrix are 5^{th} power of the survival ratios because of intervals of five year.

5. Empirical Results

5.1 Population Projections

According to Theorem 1 (see 5^{th} footnote), Leslie matrix has one dominant eigenvalue and it indicates the growth rate of the population. The dimension of the Leslie matrix defined for the Turkish population (see Table 5) is 19×19 and to

[9] The 2008 Death Statistics of Turkish Statistical Institute support survival ratios computed from life tables used in this present study. Therefore, it can be accepted existing survival ratios will be valid in the near future.

determine the eigenvalues of this matrix is identical to find the roots of equation which is 19th order. The system determined for the Turkish population has one real and 18 complex root.[10]

Table 6 presents the dominant eigenvalues and their normalized values to unit of the projection matrices defined by using fertility rates of TDHS-2008, TDHS-2003. The last column of the table gives the relevant results if there is a reversal change in fertility rates. This value shows that five-year growth rate of the Turkish population is 0.051 ($\lambda_d - 1$). This ratio implies that annual growth rate of the Turkish population is approximately 0.86 %. If age-specific fertility rates increase their values in the year 2003, annual growth rate of the Turkish population would approximately be 1.02 %.

Table 6: Dominant Eigenvalues and Their Eigenvectors of the Leslie Matrices

Age Classes	TDHS-2008		TDHS-2003		An increase in Fertility rates (TDHS-1998)	
	Eigenvector for λ_d = 1.04326	Eigenvector normalized to 1	Eigenvector for λ_d = 1.05112	Eigenvector normalized to 1	Eigenvector for λ_d = 1.08776	Eigenvector normalized to 1
0-4	0.356	0.092	0.369	0.096	0.426	0.117
5-9	0.338	0.087	0.348	0.091	0.388	0.107
10-14	0.323	0.084	0.330	0.086	0.356	0.098
15-19	0.308	0.080	0.313	0.082	0.326	0.090
20-24	0.294	0.076	0.296	0.077	0.298	0.082
25-29	0.280	0.072	0.280	0.073	0.272	0.075
30-34	0.266	0.069	0.264	0.069	0.248	0.068
35-39	0.253	0.065	0.249	0.065	0.226	0.062
40-44	0.239	0.062	0.234	0.061	0.205	0.056
45-49	0.225	0.058	0.218	0.057	0.185	0.051
50-54	0.210	0.054	0.201	0.053	0.165	0.045
55-59	0.192	0.050	0.183	0.048	0.145	0.040
60-64	0.170	0.044	0.161	0.042	0.124	0.034
65-69	0.145	0.037	0.136	0.036	0.101	0.028
70-74	0.114	0.029	0.106	0.028	0.076	0.021
75-79	0.079	0.021	0.074	0.019	0.051	0.014
80-84	0.046	0.012	0.042	0.011	0.028	0.008
85-89	0.020	0.005	0.018	0.005	0.012	0.003
90+	0.005	0.001	0.005	0.001	0.003	0.001

Source: Author's Calculations from Table 5.
Note: The population projections are obtained under three different fertility rates. However, the survival ratios from one age class to another are assumed to be constant because of data constraints.

[10] Other two Leslie matrices were not reported for brevity and available upon request.

Table 7: Age Dependency Ratios and Projections for Growth of Non-institutional Working Age Population

Year	Youth Dependency Ratio	Elderly Dependency Ratio	Age Dependency Ratio	Growth of Non-institutional Working Age Population
			TDSH-2008	
2007	39.7	10.7	50.4	-
2012	40.8	10.3	51.0	7.1
2017	42.2	10.8	53.0	6.3
2022	46.0	12.3	58.3	4.3
2027	43.3	13.3	56.6	7.7
2032	41.3	14.5	55.7	6.6
2037	40.8	15.4	56.1	5.7
2042	42.1	16.4	58.5	4.7
2047	44.5	17.8	62.3	4.0
2052	45.2	17.9	63.2	4.4
				Annual growth rate = 1.10
			TDSH-2003	
2007	39.7	10.7	50.4	-
2012	40.1	10.3	50.4	7.1
2017	41.1	10.8	51.9	6.3
2022	44.3	12.2	56.5	4.3
2027	42.0	13.3	55.3	7.2
2032	40.0	14.6	54.6	6.2
2037	39.3	15.6	54.8	5.2
2042	40.2	16.7	56.9	4.3
2047	42.3	18.2	60.5	3.6
2052	43.2	18.5	61.7	3.8
				Annual growth rate = 1.04
			TDSH-1998	
2007	39.7	10.7	50.4	-
2012	44.3	10.3	54.6	7.1
2017	49.0	10.8	59.8	6.3
2022	55.9	12.2	68.1	4.3
2027	51.1	12.9	64.0	10.6
2032	47.8	13.7	61.5	9.1
2037	48.1	14.2	62.3	7.8
2042	51.5	14.8	66.4	6.6
2047	55.8	15.7	71.5	6.1
2052	56.2	15.3	71.4	7.6
				Annual growth rate = 1.41

Source : Table 2, 3 and 4 in Appendix.
Note: The values belong to the year 2007 are computed according to ABPRS.

The case an increase in fertility rates were investigated by using fertility rates observed with TDHS-1998. In this situation, annual growth rate was roughly computed 1.76%. When different population growth rates computed from three different Leslie matrices are compared with each other, 1% increase in fertility rates lead to 0.94 and 1.03 % in population growth rates.

The eigenvector associated with the dominant eigenvalue allows a computation of the proportion to which each class stabilizes. The normalized eigenvector gives the limiting values of these proportions in the long-term. The normalized values given in first and second columns of Table 6 shows that there is a minimal decline in the proportion of 0-4, 5-9 and 10-14 age classes population to total population. However, if the fertility rates in 1998 were valid, these proportions would be greater than those in 2003 and 2007. It is possible to say that the reason for this situation is changes in the age structure of fertility in Turkey.

The total population of Turkey was projected as 76, 82, 87, 92 and 117 million for the years 2012, 2017, 2022, 2027 and 2052, respectively when the fertility rates associated with TDHS-2008 were used. For the same forecast periods, it was projected as 76, 81, 86, 91 and 113 million when TDHS-2003 fertility rates were used. The total population of Turkey is projected as 78, 85, 92, 99 and 145 million when TDHS-1998 fertility rates were used. Under the assumption that the survival ratios remain unchanged, the population projections change after the year 2032 in each case (see Table 1*a*, 2*a* and 3*a* given in Appendix).

The forecasts of age dependency ratios and growth rates of the non-institutional working age population from three different projection matrices are presented in Table 7. Suppose that the fertility rates do not change (e.g. their values in 2050 are their values in 2003). Even if both youth and total age dependency ratios remain unchanged, the forecast values of those in 2052 will be greater than their values in 2007. Similar results were observed when the TDHS-2008 fertility rates were used in the Leslie matrix. The forecasts for non-institutional working population indicate that there will be a decreasing trend in working population in the future. But if there is a reversal change in fertility rates, annual growth rate of working population will approximately be 1.4 % over the next decades.

5.2 Forecasts of Physical Capital Stock per Unit Person Employed

The physical capital stock data were taken from Saygili and Cihan (2008). The data were calculated by the authors using gross capital investments defined as 1998 prices in domestic currency. The employment data for 15^+ age class were obtained from Bulutay (1995) and Turkish Statistical Institute database. The data cover the quarterly period of 1987.1-2007:4. In this study, we assumed that constant returns to scale will prevail through out the period that is considered.

Figure 2: Physical Capital Stock per unit employed labor force

Source: Saygili and Cihan (2008), Bulutay (1995) and Turkish Statistical Institute database

Let KL_t denote the physical capital stock per unit employment. The logarithmic values of the seasonally adjusted KL_t series for the 1987-2007 period are presented in Figure 2. Before forecasting the KL_t values, its time series properties were investigated in terms of unit root tests and outlier effects. The stationarity of the series were tested using the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979), the generalized least squares detrended Dickey-Fuller (DF-GLS) test (Elliot, Rothenberg, and Stock, 1996) and Kwiatkowski- Phillips-Schmidt-Shin (KPSS) test (Kwiatkowski, Phillips, Schmidt, and Shin, 1992). In order to check the effect of structural changes on the unit root test results we use the test developed by Zivot and Andrews (1992). Perron (1989) and Zivot and Andrews (1992) suggested that the conventional unit root tests are biased towards the non-rejection of the unit-root null in the case of a structural change. Developing a variation of Perron's (1989) original test, Zivot and Andrews (1992) emphasized that the date of the break point should be endogenously estimated. In the method of Zivot and Andrews (1992), the null hypothesis of a unit-root without an exogenous structural break is tested against the alternative that the series is trend-stationary with a one-time break. The unit root tests results are given in Table 8.

Table 8: Unit Root Test Results

Series	without break(s)											
	ADF [a]		ADF [b]		DF-GLS [a]		DF-GLS [b]		KPSS[a]		KPSS[b]	
	k	*t*-ist	*k*	*t*-ist	*k*	*t*-ist	*k*	*t*-ist	*k*	*LM-stat.*	*k*	*LM-stat.*
$\ln KL_t$	2	-0.685	0	-3.555^{**}	1	1.811	2	-2.745	1	600.741	2	1.505
$\Delta \ln KL_t$	0	-8.225^{***}	0	-8.176^{***}	8	-1.777^{*}	0	-8.154^{***}	0	0.511♣	0	0.027♣
	with one Endogenous Break											
	ZA[c]			ZA[d]				ZA[e]				
Series	*k*	Min *t*-stat.	*TB*	*k*	Min *t*-stat.	*TB*		*k*	Min *t*-stat.	*TB*		
$\ln KL_t$	2	-4.533	1993:Q1	2	-3.604	1993:Q4		1	-4.593	1993:Q1		

[a] The regression includes an intercept but no trend.
[b] The regression includes an intercept and a linear trend variable.
The lag orders *k* is chosen according to Schwarz Bayesian Information Criterion (SIC).
*** and ** indicate the unit root hypothesis is rejected at the 1% and 5% level, respectively.
[c] Break in both intercept and trend; the critical values are -5.57 and -5.08 for 1% and 5% levels, respectively.
[d] Break in trend; the critical values are -4.93 and -4.42 for 1% and 5% levels, respectively.
[e] Break in intercept; the critical values are -5.34 and -4.80 for 1% and 5% levels, respectively.
TB stands for time break.
***, ** and * indicate the rejection of the unit-root hypothesis at 1, 5 and 10% levels, respectively.
♣ are used for the KPSS test results and indicates the series is stationary at the 1% level.

The unit root test results without break indicate that the series of the logarithm of physical capital stock per employed person, $lnKL_t$, is non-stationary series. The ZA test results show that it is non-stationary when structural breaks (in the form of a break in the intercept, break in the trend or a break in both intercept and trend) are taken into account. The time of the structural break (TB) for each variable is shown in Table 8.

Table 9: Descriptive Statistics

Series	No of Obs.	Mean (μ)	Standard Error (σ)	Skewness
ΔKL_t	83	0.008	0.018	0.133
	Kurtosis	**Minimum Value**	**Maximum value**	***JB*-stat.**
	1.384	-0.053	0.058	6.868 (0.032)

Note: Descriptive statistics are based on the first-difference series.
* shows that the data are not normally distributed at the all traditional significance level.

The descriptive statistics for the first-difference of the series are given in Table 9. It shows positive skewness and kurtosis; however, the series has normal distribution at the 1% significance level. -0.053 and 0.058 minimum and maximum values of the series correspond to the first quarter of the year 1993 and 1994, respectively. Forecasts for the series KL_t were obtained using ARIMA models.[11]

Numerous ARIMA (*p*,*d*,*q*) models to fit the data were estimated. The measures root mean square error (RMSE), mean absolute error (MAE) and mean absolute percentage error (MAPE) computed on one-step ahead forecast were used to test forecasting accuracy. Forecasting accuracy was tested both the estimation and validation periods (i.e., ex-post and ex-ante). The validation period was determined five years (20 quarters) after the 2001 crisis. Furthermore, the randomness of the residuals of each model was tested using Box-Pierce *Q* statistic based on the sum of squares of the autocorrelation coefficients.

Table 10: Parameter Estimates

Parameter	**Estimate**	**Std. Error**	***t*-stat.**	***p*-value**
AR(1)	0.463	0.149	3.090	0.002
MA(1)	0.335	0.124	2.703	0.008
MA(2)	0.608	0.116	5.258	0.000
Constant	0.008	0.008	0.008	0.008

Box-Pierce *Q*-stat. = 16.732 (with 0.727 *p*-value)
Box-Pierce *Q*-stat tests the hypothesis that the residuals are random.

The autoregressive integrated moving average ARIMA (1,1,2) with constant model has been selected. This model assumes that the best forecast for future data is given by a parametric model relating the most recent data value to previous data values and previous noise.[12] The *p*-values for the AR(1), MA(1), MA(2) and constant terms are less than 0.01, so they are significantly different from zero.

[11] Univariate Box-Jenkins models are sophisticated extrapolation methods, using only past values of the variable being forecast to generate forecasts. As noted in Kennedy (2003:367), when using the Box-Jenkins methodology to forecast a constructed variable, for example (K_t/L_t), it is not clear whether it is better to forecast K_t and L_t separately to produce the forecast, or to forecast (K_t/L_t) directly. Kang (1986) and Allen and Fildes (2001) suggest the former approach is better. The latter approach was preferred in line with the basic objective of the study.

[12] In a model with one order of differencing, a constant term should be included if the series has a non-zero average trend.

5.3 Forecasts of Warranted Physical Capital Stock to Employ the Increase in the Supply of Labor Force due to an Increase in Fertility Rates

Using both forecasts of physical capital stock per unit employed and population projections, with simple algebra, physical capital stock values can be forecasted or accounted until the year 2052.

Population projection matrices are useful to predict non-institutional working age population (which is defined as the population 15 years age and over within the non-institutional civilian population). However, to forecast the number of people that will be employed in the future requires several assumptions on labor force participation and unemployment rates. Within the context of the study, in order to predict the number of people that will be employed four different scenarios were taken into consideration.[13]

Table 11: Warranted Physical Capital Stock versus Target Labor Force Participation Rate and Target Unemployment Rate

	Total Fertility Rate	**Target Labor Force Participation Rate**	**Target Unemployment Rate**	**Warranted Physical Capital Stock Growth Rate (%)**
TDHS-2008	2.15	47	10.5	4.2
		47	6.4	4.5
		70	10.5	5.3
		70	6.4	5.5
TDHS-2003	2.23	47	10.5	4.2
		47	6.4	4.6
		70	10.5	5.4
		70	6.4	5.6
An increase in Fertility Rates (TDHS-1998)	2.61	47	10.5	4.6
		47	6.4	4.9
		70	10.5	5.7
		70	6.4	5.9

Notes:

1. Total fertility rates are only given here. Changes in total fertility rate means changes inn age-specific fertility rates.
2. Annual growth rate of physical capital stock is approximately 4.3 % on average in thee period of 1980-2007.

[13] Even though percentage unemployment may be specified as is a function of total investment within the country, then prediction of physical capital requirement may itself require predictions about total investment. Therefore, predictions were obtained under the assumption that warranted capital stock for the determined unemployment rate will be undertaken.

Scenario 1: During the forecast period labor force participation and unemployment rates remain unchanged. The rates are determined as the average values for the 2002-2007 period (respective values are approximately 47% and 10.5%).[14]

Scenario 2: Constant labor force participation rate, a 5 % unemployment rate at the end of 2052 with a constant percentage decrease per year.

Scenario 3: Constant unemployment rate, a 70 % labor force participation rate at the end of 2052 with a constant percentage increase per year.[15]

Scenario 4: Unemployment rate decreases to 5 % and labor force participation rate increases to 70 % with constant percentage change per year until 2052.

Three different fertility rates were taken into consideration, namely the fertility rates related to the years 1998, 2003 and 2008. The first fertility rates were taken by reason of investigating the effects of an increase in fertility rates on warranted physical capital stock or its growth rates. Table 11 indicates warranted physical capital stock growth rates corresponding to target labor force participation and unemployment rates. Under the assumption of the 2008 the fertility rates will be valid in the coming decades, the warranted physical capital stock growth rates were estimated between approximately 4.2% and 5.5%. The results related to the year 2003 fertility rates are similar to in that warranted physical capital stock growth rates change between 4.2% and 5.6%. There is only a 0.46 point decrease the total fertility rates in 2008 than those in 1998 and this implies that the physical capital stock per employed person should increase yearly between 4.6-5.9% in order to raise employment opportunities.

If we look at the predicted warranted physical capital stock values, a change from 2.15 to 2.61 in total fertility rates implies a change in physical capital stock which ranges between 2.6% and 14.7% especially after the year 2027. In this case, it should be pointed out that the effects of increase in fertility rates will be seen after fifteen years.

5. Conclusion

This paper is an attempt to examine the effects of a reversal change in fertility rates on population growth, labor supply, and employment in relation to physical

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[14] The years 2008 and 2009 are the global crisis years and the values of these years are excluded from the scenarios.

[15] Approximately 70% labor force participation rate corresponds to average rate for EU countries for the year 2007.

capital stock for next four decades. In the last two decades Turkish fertility rates have been steadily decreasing. This study assesses and evaluates a reversal change in fertility rates on the variables mentioned above.

The study was carried out in three stages. In the first stage, the population of Turkey is projected using the age-classified matrix (the Leslie matrix) model. The main population projections were obtained by using 2008 fertility rates. The population projections were repeated by increasing fertility rates related to the years 1998 and 2003. In the second stage, the physical capital stock per person employed for the next four decades was forecasted by using Box-Jenkins analysis. In the third stage, the warranted growth rates of physical capital stock required for the employment of increases in labor supply due to fertility rate increases was calculated.

All population projections were obtained under constant survival ratios because of data constraints. Annual growth rate of the Turkish population was approximately computed 0.86 % according to the Leslie matrix constructed with 2008 age-specific fertility rates. If 2003 and 1998 age-specific fertility rates can catch, annual growth rate of the Turkish population will roughly be 1.02 and 1.76 %, respectively. If recently observed age-specific fertility rates may preserve over the next decades, the proportion of 0-14 age group population to total population will increase until the years of 2030s and then decrease its present value (26.5 %). However, the proportions of 15-64 and 65^+ age group populations to total population will be 62.3 and 11.2 %, respectively at the end of the forecast period. These projection results imply that decreasing tendency in the age-specific fertility rates might negatively affect population dynamics of Turkey.[16] Although Turkish fertility rates and population growth rates have been steadily decreasing, in comparison with the European Union countries, Turkey will probably preserve her young population structure during the next decades.

These population predictions were used to find the answer of the question of if there is a reversal change in the fertility rates that are getting lower in Turkey, what should be the physical capital stock warranted growth rate to employ non-institutional working age population that will most probably be increased under this reversal change. According to the calculations under four different scenarios, 1 point

[16] Population projections were also repeated by age-specific fertility rates that have been decreased/increased by using percentage changes from TDHS-2008 to TDHS-2003. According to population projections, the proportion of 0-14, 15-64, 65^+ age group populations to total population were almost predicted the same as their values obtained from TDHS-2008, except for 0-14 age group. The projection results indicate that the proportion of youngest population to total population will be 25.4 % in the year 2052.

increase in the fertility rates requires approximately 0.85 point increase in physical capital stock for the warranted growth rates. This result does not seem to be dramatic at first sight. Under the assumption that present fertility rates will preserve over the next years, total population will reach 112 million and during that time the level of employment was forecasted between 36 and 52 million people. To create these jobs the warranted physical capital stock should be at least 1.5 and 2 trillion TL (with the 1998 prices). In other words, over the 45 years period average annual growth rate of quantity of people available for work will probably be between 1 and 1.9 % and of physical capital stock warranted growth rate should increase to at least 4 % in every year in response to this reversal change in fertility rates. Under the assumption that Turkey reaches the fertility rates observed in 1998, the warranted physical capital stock should be 1.7 and 2.5 trillion TL. Under this circumstance, the percentage changes for employment and capital were predicted as 1.4-2.3 % and 4.4-5.3 %, respectively.

Under the assumption of a 1.76% average annual population growth rate (yearly population growth rate projected by fertility rates in 1998), governments are obliged to adjust their economic policies in line with the education, housing, and employment requirements. Although a decreasing tendency in age-specific fertility rates is observed in Turkey, estimated physical capital stock warranted for the growth rates implies that a reversal change in fertility rates will be required a change in physical capital stock which ranges between 2.6 and 14.7 % especially after 2027. In this case, it should be pointed out that the effects of increase in fertility rates will be seen after fifteen years.

After 2001 crisis, the proportion of real domestic savings to real GDP ranged between 18 and 24 % and annual average growth rate in real domestic savings was 9 %. The data indicate that even in the period of higher economic growth rates were registered after the year 2001, physical capital stock has not increased over 4.3 %.

In conclusion, if policy makers adopt the population policies that will provide a reversal change in fertility rates getting lower in Turkey, they should plan (i) social and productive investments in the near future and (ii) financing of investment decisions (foreign direct investments, privatization and green field investments) in order to increase physical capital stock compensating the increase in labor supply.

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Table 1*a*. Age Class Projections when 2008 Fertility Rates are used: Numbers

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+	Total Population
2 007	5 794	6 437	6 412	6 157	6 241	6 513	5 728	5 072	4 726	4 085	3 566	2 789	2 068	1 699	1 373	1 070	579	182	97	70 586
2 012	8 400	5 742	6 419	6 389	6 123	6 198	6 463	5 674	5 008	4 637	3 967	3 404	2 587	1 831	1 395	998	643	260	49	76 189
2 017	8 480	8 324	5 726	6 397	6 354	6 082	6 150	6 402	5 602	4 914	4 504	3 787	3 158	2 291	1 503	1 014	600	289	70	81 648
2 022	8 556	8 403	8 302	5 706	6 362	6 311	6 035	6 093	6 321	5 497	4 773	4 299	3 513	2 796	1 881	1 093	610	270	78	86 898
2 027	8 539	8 479	8 381	8 273	5 675	6 319	6 262	5 978	6 015	6 202	5 339	4 556	3 989	3 111	2 296	1 368	657	274	72	91 785
2 032	8 594	8 462	8 456	8 351	8 227	5 636	6 270	6 203	5 902	5 903	6 024	5 096	4 227	3 532	2 555	1 669	822	295	74	96 299
2 037	9 464	8 517	8 440	8 426	8 305	8 171	5 593	6 211	6 125	5 792	5 733	5 750	4 728	3 743	2 900	1 857	1 004	370	79	101 207
2 042	10 470	9 378	8 494	8 410	8 380	8 249	8 108	5 540	6 132	6 010	5 625	5 472	5 335	4 187	3 073	2 109	1 117	451	99	106 639
2 047	11 041	10 376	9 353	8 464	8 364	8 323	8 185	8 032	5 470	6 017	5 837	5 370	5 077	4 724	3 438	2 235	1 268	502	121	112 195
2 052	11 326	10 941	10 348	9 320	8 418	8 307	8 259	8 108	7 930	5 368	5 844	5 572	4 981	4 496	3 879	2 499	1 344	570	135	117 644

Source: Author's Calculations from Table 5 and data for physical capital stock per unit employed labor force obrained from the cited sources in the text.

Table 1*b*. %

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+
2 007	0.082	0.091	0.091	0.087	0.088	0.092	0.081	0.072	0.067	0.058	0.051	0.040	0.029	0.024	0.019	0.015	0.008	0.003	0.001
2 012	0.110	0.075	0.084	0.084	0.080	0.081	0.085	0.074	0.066	0.061	0.052	0.045	0.034	0.024	0.018	0.013	0.008	0.003	0.001
2 017	0.104	0.102	0.070	0.078	0.078	0.074	0.075	0.078	0.069	0.060	0.055	0.046	0.039	0.028	0.018	0.012	0.007	0.004	0.001
2 022	0.098	0.097	0.096	0.066	0.073	0.073	0.069	0.070	0.073	0.063	0.055	0.049	0.040	0.032	0.022	0.013	0.007	0.003	0.001
2 027	0.093	0.092	0.091	0.090	0.062	0.069	0.068	0.065	0.066	0.068	0.058	0.050	0.043	0.034	0.025	0.015	0.007	0.003	0.001
2 032	0.089	0.088	0.088	0.087	0.085	0.059	0.065	0.064	0.061	0.061	0.063	0.053	0.044	0.037	0.027	0.017	0.009	0.003	0.001
2 037	0.094	0.084	0.083	0.083	0.082	0.081	0.055	0.061	0.061	0.057	0.057	0.057	0.047	0.037	0.029	0.018	0.010	0.004	0.001
2 042	0.098	0.088	0.080	0.079	0.079	0.077	0.076	0.052	0.058	0.056	0.053	0.051	0.050	0.039	0.029	0.020	0.010	0.004	0.001
2 047	0.098	0.092	0.083	0.075	0.075	0.074	0.073	0.072	0.049	0.054	0.052	0.048	0.045	0.042	0.031	0.020	0.011	0.004	0.001
2 052	0.096	0.093	0.088	0.079	0.072	0.071	0.070	0.069	0.067	0.046	0.050	0.047	0.042	0.038	0.033	0.021	0.011	0.005	0.001

Source: Table 1a.

Table 2*a*. Age Class Projections when 2003 Fertility Rates are used: Numbers

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+	Total Population
2 007	5 794	6 437	6 412	6 157	6 241	6 513	5 728	5 072	4 726	4 085	3 566	2 789	2 068	1 699	1 373	1 070	579	182	97	70 586
2 012	8 076	5 742	6 418	6 392	6 126	6 197	6 461	5 676	5 006	4 636	3 967	3 405	2 588	1 830	1 395	998	643	260	49	75 865
2 017	8 180	8 003	5 725	6 398	6 360	6 083	6 147	6 403	5 602	4 911	4 502	3 788	3 160	2 290	1 502	1 014	600	289	70	81 028
2 022	8 227	8 106	7 979	5 707	6 366	6 316	6 035	6 092	6 319	5 496	4 769	4 299	3 515	2 797	1 880	1 092	609	270	78	85 953
2 027	8 226	8 153	8 082	7 955	5 679	6 322	6 265	5 980	6 013	6 199	5 337	4 554	3 989	3 111	2 296	1 367	656	274	72	90 531
2 032	8 209	8 152	8 129	8 057	7 915	5 639	6 271	6 209	5 903	5 899	6 020	5 096	4 226	3 531	2 554	1 669	822	295	73	94 669
2 037	8 839	8 135	8 127	8 104	8 017	7 860	5 594	6 215	6 128	5 790	5 727	5 749	4 729	3 740	2 899	1 857	1 003	370	79	98 964
2 042	9 672	8 760	8 111	8 103	8 064	7 961	7 797	5 544	6 134	6 012	5 623	5 470	5 335	4 186	3 071	2 107	1 116	451	99	103 614
2 047	10 263	9 585	8 733	8 086	8 062	8 007	7 897	7 727	5 472	6 017	5 838	5 370	5 076	4 721	3 436	2 233	1 267	502	121	108 413
2 052	10 502	10 171	9 556	8 707	8 046	8 006	7 943	7 826	7 626	5 368	5 843	5 575	4 983	4 492	3 876	2 498	1 342	570	135	113 065

Source: Author’s Calculations from Table 5(changed version by using TDHS-2003 fertility rates) and data for physical capital stock per unit employed labor force obrained from the cited sources in the text.

Table 2*b*. %

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+
2 007	0.082	0.091	0.091	0.087	0.088	0.092	0.081	0.072	0.067	0.058	0.051	0.040	0.029	0.024	0.019	0.015	0.008	0.003	0.001
2 012	0.106	0.076	0.085	0.084	0.081	0.082	0.085	0.075	0.066	0.061	0.052	0.045	0.034	0.024	0.018	0.013	0.008	0.003	0.001
2 017	0.101	0.099	0.071	0.079	0.078	0.075	0.076	0.079	0.069	0.061	0.056	0.047	0.039	0.028	0.019	0.013	0.007	0.004	0.001
2 022	0.096	0.094	0.093	0.066	0.074	0.073	0.070	0.071	0.074	0.064	0.055	0.050	0.041	0.033	0.022	0.013	0.007	0.003	0.001
2 027	0.091	0.090	0.089	0.088	0.063	0.070	0.069	0.066	0.066	0.068	0.059	0.050	0.044	0.034	0.025	0.015	0.007	0.003	0.001
2 032	0.087	0.086	0.086	0.085	0.084	0.060	0.066	0.066	0.062	0.062	0.064	0.054	0.045	0.037	0.027	0.018	0.009	0.003	0.001
2 037	0.089	0.082	0.082	0.082	0.081	0.079	0.057	0.063	0.062	0.059	0.058	0.058	0.048	0.038	0.029	0.019	0.010	0.004	0.001
2 042	0.093	0.085	0.078	0.078	0.078	0.077	0.075	0.054	0.059	0.058	0.054	0.053	0.051	0.040	0.030	0.020	0.011	0.004	0.001
2 047	0.095	0.088	0.081	0.075	0.074	0.074	0.073	0.071	0.050	0.056	0.054	0.050	0.047	0.044	0.032	0.021	0.012	0.005	0.001
2 052	0.093	0.090	0.085	0.077	0.071	0.071	0.070	0.069	0.067	0.047	0.052	0.049	0.044	0.040	0.034	0.022	0.012	0.005	0.001

Source: Table 2a.

Table 3*a*. Age Class Projections when 1998 Fertility Rates are used: Numbers

	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89	90+	Total Population
2 007	5 794	6 437	6 412	6 157	6 241	6 513	5 728	5 072	4 726	4 085	3 566	2 789	2 068	1 699	1 373	1 070	579	182	97	70 586
2 012	10 206	5 742	6 418	6 392	6 126	6 197	6 461	5 676	5 006	4 636	3 967	3 405	2 588	1 830	1 395	998	643	260	49	77 995
2 017	10 306	10 114	5 725	6 398	6 360	6 083	6 147	6 403	5 602	4 911	4 502	3 788	3 160	2 290	1 502	1 014	600	289	70	85 266
2 022	10 398	10 214	10 084	5 707	6 366	6 316	6 035	6 092	6 319	5 496	4 769	4 299	3 515	2 797	1 880	1 092	609	270	78	92 336
2 027	10 360	10 304	10 183	10 053	5 679	6 322	6 265	5 980	6 013	6 199	5 337	4 554	3 989	3 111	2 296	1 367	656	274	72	99 017
2 032	10 754	10 267	10 273	10 152	10 003	5 639	6 271	6 209	5 903	5 899	6 020	5 096	4 226	3 531	2 554	1 669	822	295	73	105 657
2 037	12 887	10 657	10 236	10 242	10 102	9 933	5 594	6 215	6 128	5 790	5 727	5 749	4 729	3 740	2 899	1 857	1 003	370	79	113 939
2 042	14 949	12 771	10 625	10 205	10 191	10 031	9 854	5 544	6 134	6 012	5 623	5 470	5 335	4 186	3 071	2 107	1 116	451	99	123 773
2 047	16 160	14 814	12 733	10 593	10 154	10 120	9 951	9 765	5 472	6 017	5 838	5 370	5 076	4 721	3 436	2 233	1 267	502	121	134 342
2 052	16 736	16 014	14 770	12 695	10 540	10 083	10 039	9 861	9 638	5 368	5 843	5 575	4 983	4 492	3 876	2 498	1 342	570	135	145 057

Source: Author’s Calculations from Table 5(changed version by using TDHS-1998 fertility rates) and data for physical capital stock per unit employed labor force obrained from the cited sources in the text.

Table 3*b*. %

	0-4	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85-89**	**90+**
2 007	0.082	0.091	0.091	0.087	0.088	0.092	0.081	0.072	0.067	0.058	0.051	0.040	0.029	0.024	0.019	0.015	0.008	0.003	0.001
2 012	0.131	0.074	0.082	0.082	0.079	0.079	0.083	0.073	0.064	0.059	0.051	0.044	0.033	0.023	0.018	0.013	0.008	0.003	0.001
2 017	0.121	0.119	0.067	0.075	0.075	0.071	0.072	0.075	0.066	0.058	0.053	0.044	0.037	0.027	0.018	0.012	0.007	0.003	0.001
2 022	0.113	0.111	0.109	0.062	0.069	0.068	0.065	0.066	0.068	0.060	0.052	0.047	0.038	0.030	0.020	0.012	0.007	0.003	0.001
2 027	0.105	0.104	0.103	0.102	0.057	0.064	0.063	0.060	0.061	0.063	0.054	0.046	0.040	0.031	0.023	0.014	0.007	0.003	0.001
2 032	0.102	0.097	0.097	0.096	0.095	0.053	0.059	0.059	0.056	0.056	0.057	0.048	0.040	0.033	0.024	0.016	0.008	0.003	0.001
2 037	0.113	0.094	0.090	0.090	0.089	0.087	0.049	0.055	0.054	0.051	0.050	0.050	0.042	0.033	0.025	0.016	0.009	0.003	0.001
2 042	0.121	0.103	0.086	0.082	0.082	0.081	0.080	0.045	0.050	0.049	0.045	0.044	0.043	0.034	0.025	0.017	0.009	0.004	0.001
2 047	0.120	0.110	0.095	0.079	0.076	0.075	0.074	0.073	0.041	0.045	0.043	0.040	0.038	0.035	0.026	0.017	0.009	0.004	0.001
2 052	0.115	0.110	0.102	0.088	0.073	0.070	0.069	0.068	0.066	0.037	0.040	0.038	0.034	0.031	0.027	0.017	0.009	0.004	0.001

Source:Table 3a.

Table 4. Non-Intuitional Working Age, Employment and Physical Capital Stock (Thousands and Thousand TL)

TNSA-2008; TDO = 2.15									
Year	**Non-instutional Working Age**	**Employment [a]**	**Physical Capital Stock[a]**	**Employment [b]**	**Physical Capital Stock[b]**	**Employment [c]**	**Physical Capital Stock[c]**	**Employment [d]**	**Physical Capital Stock[d]**
2012	55 627	20 304	285 300 580	20 766	291 786 504	21 442	301 288 819	21 903	307 774 743
2017	59 118	21 578	360 289 686	22 520	376 023 804	24 049	401 549 645	24 991	417 283 763
2022	61 637	22 498	446 371 609	23 914	474 472 152	26 447	524 728 902	27 863	552 829 445
2027	66 058	24 111	568 456 098	26 057	614 337 284	29 879	704 443 534	31 825	750 324 720
2032	70 156	25 607	717 381 689	28 093	787 015 917	33 434	936 666 222	35 920	1 006 300 450
2037	73 824	26 946	897 014 612	29 967	997 596 830	37 051	1 233 409 858	40 072	1 333 992 076
2042	77 018	28 111	1 112 008 010	31 654	1 252 123 664	40 688	1 609 495 165	44 230	1 749 610 819
2047	79 761	29 113	1 368 569 662	33 153	1 558 497 711	44 335	2 084 177 410	48 376	2 274 105 459
2052	82 744	30 202	1 687 058 463	34 748	1 941 036 636	49 233	2 750 136 398	53 780	3 004 114 572
TNSA-2003; TDO = 2.23									
Year	**Non-instutional Working Age**	**Employment [a]**	**Physical Capital Stock[a]**	**Employment [b]**	**Physical Capital Stock[b]**	**Employment [c]**	**Physical Capital Stock[c]**	**Employment [d]**	**Physical Capital Stock[d]**
2012	55 627	20 304	285 300 580	20 766	291 786 504	21 442	301 288 819	21 903	307 774 743
2017	59 118	21 578	360 289 686	22 520	376 023 804	24 049	401 549 645	24 991	417 283 763
2022	61 637	22 498	446 371 609	23 914	474 472 152	26 447	524 728 902	27 863	552 829 445
2027	66 386	24 231	571 277 103	26 187	617 385 977	30 028	707 939 386	31 983	754 048 261
2032	70 787	25 837	723 834 321	28 345	794 094 888	33 735	945 091 252	36 243	1 015 351 819
2037	74 787	27 297	908 712 760	30 358	1 010 606 690	37 534	1 249 495 003	40 595	1 351 388 934
2042	78 297	28 578	1 130 479 390	32 179	1 272 922 482	41 364	1 636 230 222	44 965	1 778 673 314
2047	81 426	29 720	1 397 133 907	33 845	1 591 026 059	45 261	2 127 677 537	49 385	2 321 569 689
2052	85 029	31 036	1 733 640 722	35 708	1 994 631 621	50 592	2 826 071 862	55 264	3 087 062 761

TNSA-1998; TDO = 2.61									
Year	**Non-instutional Working Age**	**Employment [a]**	**Physical Capital Stock[a]**	**Employment [b]**	**Physical Capital Stock[b]**	**Employment [c]**	**Physical Capital Stock[c]**	**Employment [d]**	**Physical Capital Stock[d]**
2012	55 630	20 305	285 313 154	20 767	291 799 364	21 443	301 302 098	21 904	307 788 308
2017	59 121	21 579	360 310 467	22 522	376 045 493	24 050	401 572 806	24 993	417 307 832
2022	61 641	22 499	446 399 112	23 915	474 501 386	26 448	524 761 233	27 865	552 863 507
2027	68 169	24 882	586 623 323	26 890	633 970 820	30 834	726 956 766	32 842	774 304 264
2032	74 363	27 142	760 400 301	29 777	834 210 226	35 439	992 834 482	38 074	1 066 644 406
2037	80 158	29 258	973 978 071	32 538	1 083 190 199	40 230	1 339 235 880	43 511	1 448 448 008
2042	85 428	31 181	1 233 436 523	35 110	1 388 852 459	45 131	1 785 248 040	49 060	1 940 663 976
2047	90 635	33 082	1 555 145 274	37 673	1 770 966 007	50 380	2 368 311 048	54 971	2 584 131 781
2052	97 537	35 601	1 988 669 222	40 961	2 288 053 379	58 035	3 241 803 252	63 394	3 541 187 410

[a] Scenario 1. [b] Scenario 2. [c] Scenario 3. [d] Scenario 4.

Source: Author's Calculations from Table 5(and its changed version by using TDHS-1998 and TDHS-2003 fertility rates) and data for physical capital stock per unit employed labor force obrained from the cited sources in the text.