# Population with immigration: Turkey and the EU. Does a young population remedy to the aged?

Özdemir, Durmuş and Rosch, Angi

Istanbul Bilgi University, FOM University of Applied Sciences

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# Populations with immigration: Turkey and the EU. Does a young population remedy to the aged?

Angi Rösch*
FOM University of Applied Sciences
Munich, Germany

Durmuş Özdemir†
Istanbul Bilgi University
Istanbul, Turkey

**Abstract**

Annual population growth rate in Turkey is as high as 1.1 per cent, while many EU countries have shrinking, and hence ageing, populations. In this paper we consider an age-structured population that consists of female natives and Turkish immigrants into the EU. Immigrants' fertility and mortality schedule may differ from that of EU natives, their children may adopt it. We apply a discrete-time Leslie-type model which allows for immigration and the study of its long-run effects. We examine the contribution of EU natives and Turkish immigrants to the EU population in terms of age-specific reproductive values which measure the value of one female of a given age as a seed for future population growth. Genealogies are derived in terms of the realisations of a corresponding Markov chain running backward in time.

**Key words**: Turkey and the EU; ageing populations; immigration; stochastic demography; stable populations; discrete-time Leslie-type model; age-specific reproductive values; Markov chain; genealogy

## 1 Introduction

Europe is facing the loss of its "demographic motor". Figures in the Green Paper on Demographic Change launched by the European Commision in March 2005 [5] show, that the EU's population is set to increase just sligthly until 2025, before it is starting to shrink: 458 million in 2005, 469.5 million in 2025, then 468.7 million in 2030. It would be the result of continuing low birth rates as presumed by Eurostat's baseline scenario.

The scenario indicates a major impact on the whole of society: From now until 2030, the EU will lack 20.8 million people (−6.8 per cent) of working age (15 to 65). The demographic dependency ratio will rise from 49 to 66 per cent which means that roughly three active persons, as compared to four in 2005, will have to take care of two inactive people. However, there will be additional 40 million (+52.3 per cent) elderly people (aged 65+), whereas the number of children (aged 0 to 14) will fall by 8.8 million (−11.8 per cent). As a consequence, the potential support ratio will drop to around 2.3 people of working age for one elderly person by 2030.

The ageing of populations is a universal trend and will affect all parts of the world over this century, sooner or later, this is what the UN Population Division communicated in 2000 [10], and what the EU Commission confirmed in March 2005 [5].

Demographic decline in Europe is already visible: Around one third of the EU-25 regions already witnessed a fall in populations during the late 1990's. Almost everywhere in Europe fertility is below replacement level. In many EU member states it has even fallen below 1.5 children per woman. Yet 2 children per woman are not enough. In 2002, the annual natural increase in the EU-25's population was just 0.02 per cent. Net migration accounted for more than 84 per cent of its total population growth of 0.19 per cent. Immigration has become vital to mitigate the impact of falling birth rates and to offset the loss of working-age people.

*e-mail: angi.r@t-online.de
†e-mail: dozdemir@bilgi.edu.tr

The populations of the neighbouring regions in Europe, Africa, and the Middle East are younger on the average, they are supposed to start to age later. The demographic contrasts in Europe, however, can be illustrated through Eurostat's forecasts for the present EU candidate countries: Between 2005 and 2030, populations in Bulgaria, Romania and Croatia are expected to fall (−21, −11, and −19 per cent respectively), due to natural decline and net emigration. By contrast, the population in Turkey is set to increase by more than 19 million people (+25 per cent), though even perceptible decline in fertility. Presently, annual natural increase in Turkey's population is as high as 1.1 per cent.

How these challenges of demography could be met is the focus of ongoing discussions at national and international levels. Immigration from outside the EU, from young populations, could be a remedy to the aged populations in Europe, not only intended to supply manpower, though in the absence of migration the size of the working-age population tends to decline faster than the population. This was shown in the 2000 UN report on replacement migration [10]. But issues of effective and transparent admission mechanisms, free labour mobility, and proactive integration need to be adressed. In [5] the European Commission predicts that ever larger immigrant flows may be needed.

To estimate the eventual immigration from Turkey to the EU when Turkey becomes a full member was the purpose of a recent study by Erzan et al. [2]. Currently, the EU receives around 70 000 immigrants per annum from Turkey, with a net migration of about half of this figure. Erzan et al.'s econometric forecast model assumed free labour mobility as early as 2015, and it inflated projections of the Turkish immigrant flow into Germany to the EU-15 region. Using various scenarios, some refering to experiences in Greece, Portugal and Spain, "non-sensational" magnitudes of 0.9 to 2.1 million Turkish immigrants between 2004 and 2030 were implied. Forecasts in a preceding study by the EU Commission [4] had ranged from 0.5 to 4.4 million. However, if Turkey loses the membership perspective, Erzan et al. concluded, the EU may end up with having even more, namely 2.7 million Turkish migrants until 2030.

As general insights into populations' dynamics contribute to the evaluation of immigration policies, the analysis of the effect of immigration on a population is an important topic in stochastic demography.

Espenshade et al. [3] used a continuous-time approach and prove a basic property concerning the long-term effect of immigration: A constant stream of immigrants into a population whose fertility is below replacement will lead to a stationary population even if the immigrants' children will adopt native fertility. This population, other than life-table populations, will be stationary through immigration. For a discrete-time model Feichtinger and Steinmann [6] found similar results. Schmidbauer and Rösch [8] took this up and developed a homogeneous Leslie-type model which permits the simultaneous discussion of the age-specific reproductive behaviour of natives and immigrants. In view of findings by Demetrius [1] and Tuljapurkar [9], on population entropy and on the convergence of populations to stability concerning populations which are closed to immigration, they transformed their model into a Markov chain and derived genealogies, i.e. life histories of individuals in a population with immigration.

The goal of this paper is to measure the contribution of EU natives and Turkish immigrants to the EU population on an age-specific and individual basis. We apply the Leslie-type model developed by Schmidbauer and Rösch [8] to the situation of Turkey and the EU-25. Age-specific reproductive values of EU natives and Turkish immigrants are provided and discussed. The transformation of the model into a Markov chain allows to answer the following question: How long, on the average, must an individual's ancestry be traced back until an Turkish immigrant can be met? All computations are carried out in R [7].

# 2 Stable populations with immigration: The model used in the present study

Our approach is largely based on the model developed by Schmidbauer and Rösch [8].

This model deals with populations of native and immigrant females. There is a constant stream of immigrants per period of time and time proceeds in steps of 5 years in our application. Accordingly, the populations are structured by ten 5-year intervals of age covering reproductive ages 0 to 49. The age-specific fertility and mortality patterns are assumed to be constant through time. The immigrants' patterns may differ from those of the natives, while second generation immigrants are assumed to behave like natives with this respect, and they are counted as natives actually.

The starting point is a Leslie model which governs the dynamics of a closed population, representing the population of natives without immigration. Denote by $f_i$ the average number of girls per period of time born to a female in age class $i$, and surviving to the next age class, and by $p_i$ the probability that a female now in age class $i$ will survive to be in $i+1$ the next period of time, then the Leslie matrix is

$$\mathbf{M} = \begin{pmatrix} f_1 & f_2 & \dots & f_9 & f_{10} \\ p_1 & 0 & \dots & 0 & 0 \\ 0 & p_2 & \dots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & p_9 & 0 \end{pmatrix}. \tag{1}$$

The matrix projection equation reads

$$\vec{n}_t = \mathbf{M} \cdot \vec{n}_{t-1}, \tag{2}$$

where $\vec{n}_t = (n_{1,t}, \dots, n_{10,t})'$ denotes the age-structured population vector of natives.

If $\mathbf{M}$ is primitive (irreducible in consequence), in the long run, there will be a stable population whose age distribution is given by the right eigenvector of $\mathbf{M}$ corresponding to its dominant eigenvalue $\lambda$. Then, $\lambda$ is the asymptotic growth rate and related to the intrinsic rate of growth $r$ in the continuous-time approach by the equation $\lambda = \mathrm{e}^{5\,r}$. A value of $\lambda$ less than 1 indicates that the population has fertility below replacement level and will die out in the long run. If $\lambda$ equals 1, the population will finally become stationary. The left eigenvector of $\mathbf{M}$ corresponding to $\lambda$ gives the age-specific "reproductive values" which respectively measure the value of one female of a given age as a seed for future population growth.

Schmidbauer and Rösch showed that the dynamics of a population with constant immigration through time can be cast into a single homogeneous projection equation

$$\begin{pmatrix} \vec{n}_t \\ \vec{n}^*_t \\ R \end{pmatrix} = \mathbf{M}_I \cdot \begin{pmatrix} \vec{n}_{t-1} \\ \vec{n}^*_{t-1} \\ R \end{pmatrix}, \tag{3}$$

with Leslie-type projection matrix

$$\mathbf{M}_I = \begin{pmatrix} f_1 & \dots & f_9 & f_{10} & f^*_1 & \dots & f^*_9 & f^*_{10} & 0 \\ p_1 & \dots & 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & \dots & p_9 & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & \dots & 0 & 0 & 0 & \dots & 0 & 0 & r_1 \\ 0 & \dots & 0 & 0 & p^*_1 & \dots & 0 & 0 & r_2 \\ \vdots & \ddots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots \\ 0 & \dots & 0 & 0 & 0 & \dots & p^*_9 & 0 & r_{10} \\ 0 & \dots & 0 & 0 & 0 & \dots & 0 & 0 & 1 \end{pmatrix}. \tag{4}$$

A superscript $*$ indicates immigrants' vital rates, as well as the age-structured population vector of immigrants.

The immigrants' $f^*_i$'s are positioned in the first row of $\mathbf{M}_I$ to meet the assumption that immigrants' children behave like natives with respect to fertility and mortality patterns and are counted as natives actually. Present immigrants do not give birth to further immigrants, but they will retain their fertility and mortality patterns throughout life.

Note that $\vec{n}^*_t = (n^*_{1,t}, \dots, n^*_{10,t})'$ refers to immigrants that arrived in the past and survived to time period $t$. However, the number of new immigrants arriving in each period of time equals $R$, and $\vec{r} = (r_1, \dots, r_{10})'$ is their age distribution ($r_i \geq 0$, $\sum r_i = 1$).

The homogeneous nature of the projection equation reveals several advantages as shown by Schmidbauer and Rösch: It is true that the projection matrix $\mathbf{M_I}$ is not primitive as $\mathbf{M}$ is, but some relations carry over. The long-run development of the population with immigration may be studied in terms of the properties of the matrix $\mathbf{M}_I$. It gives the stable age distribution in equilibrium, allows for a simultaneous discussion of the reproductive values of natives and immigrants, and it permits to translate the model into a Markov chain in order to develop a concept of genealogy incorporating immigration. We give a brief outline, but confine ourselves to the case of native populations with fertility below replacement, i.e. $\lambda < 1$, as this is the present situation in the EU.

**Stable age distribution**

Since a low-fertility population incorporating constant immigration will become stationary in the long run, the age-specific numbers of the population in equilibrium are determined by the right eigenvector $\vec{u} = (u_1, \ldots, u_{21})'$ of $\mathbf{M}_I$ which belongs to the eigenvalue 1:

$$\mathbf{M}_I \cdot \vec{u} = \vec{u},$$

with the setting $u_{21} := R$. In full:

$$\begin{aligned}
u_1 &= f_1 u_1 + \ldots + f_{10} u_{10} + f_1^* u_{11} + \ldots + f_{10}^* u_{20}, \\
u_2 &= p_1 u_1, \\
&\vdots \\
u_{10} &= p_9 u_9, \\
u_{11} &= r_1 R, \\
u_{12} &= (p_1^* r_1 + r_2) R, \\
&\vdots \\
u_{20} &= (p_9^* \ldots p_1^* r_1 + \ldots + p_9^* r_9 + r_{10}) R, \\
u_{21} &= R.
\end{aligned}$$

**Reproductive, respectively "productive" values**

A left eigenvector $\vec{\nu} = (\nu_1, \ldots, \nu_{21})'$ of $\mathbf{M_I}$ which belongs to the dominant eigenvalue $\lambda$ of $\mathbf{M}$ must satisfy the relation

$$\vec{\nu}' \cdot \mathbf{M}_I = \lambda \cdot \vec{\nu}'.$$

Formulae of the vectors' components are:

$$\begin{aligned}
\nu_1 &= f_1 \lambda^{-1} + p_1 f_2 \lambda^{-2} + p_1 p_2 f_3 \lambda^{-3} + \ldots + p_1 \ldots p_9 f_{10} \lambda^{-10} = 1, \\
\nu_2 &= f_2 \lambda^{-1} + p_2 f_3 \lambda^{-2} + \ldots + p_2 \ldots p_9 f_{10} \lambda^{-10}, \\
&\vdots \\
\nu_{10} &= f_{10} \lambda^{-1}, \\
\nu_{11} &= f_1^* \lambda^{-1} + p_1^* f_2^* \lambda^{-2} + p_1^* p_2^* f_3^* \lambda^{-3} + \ldots + p_1^* \ldots p_9^* f_{10}^* \lambda^{-10}, \\
\nu_{12} &= f_2^* \lambda^{-1} + p_2^* f_3^* \lambda^{-2} + \ldots + p_2^* \ldots p_9^* f_{10}^* \lambda^{-10}, \\
&\vdots \\
\nu_{20} &= f_3^* \lambda^{-1}, \\
\nu_{21} &= (r_1 \nu_{11} + \ldots + r_{10} \nu_{20})(\lambda - 1)^{-1}.
\end{aligned}$$

The first ten components are identical to the ten age-specific reproductive values within the population of natives. The second ten components permit the interpretation as an immigrant's contribution to the native population, and may be called age-specific "productive values": $\nu_i^*$ is the number of daughters that an immigrant now in age-class $i$ will "produce" in the future, discounted with the rate $\lambda$ to the present value of her daughters' future contribution to the population of natives. (If $\lambda < 1$, the last component $\nu_{21}$ lacks an interpretation, but if $\lambda > 1$, it may be called "productive potential" of all future immigrants, as it gives their discounted total "productive value".)

**Transformation into a Markov chain — a concept of genealogy**

A Markov chain can be used as a basis for a sequential state description of an individuals' genealogy. A genealogy may be represented in terms of a sequence of numbers from the set $\{1, \ldots, 10, 11, \ldots, 20, 21\}$. It specifies the state (age-class and status: native or immigrant) and descent of every ancestor; 21 denotes a state of immigration potential yet to come. A realization of a genealogy is a realization of the Markov chain.

If $\lambda < 1$, a stochastic matrix describing an individual's life history can be obtained from $\mathbf{M}_I$ by means of "backward" transformation only. This means that it specifies the origin of the individual, i.e. describes the line of descent running backward in time:

$$\mathbf{P}_B = \mathbf{U}^{-1}\mathbf{M}_I\mathbf{U}, \tag{5}$$

where $\mathbf{U}$ is the diagonal matrix with components from the right eigenvector $\vec{u}$ of $\mathbf{M}_I$ which belongs to the eigenvalue 1.

A Markov chain with transition matrix $\mathbf{P}_B$ has the absorbing state 21. It means that every person will finally have an ancestor who is an immigrant, as with $\lambda < 1$ the original population of natives will finally die out. The average time to absorption can be interpreted as the average number of time periods (here: 5 years) one has to trace back in the line of descent of an individual until an immigrant can be found, when the population is in equilibrium. Age-specific times can be calculated from the row sums of the matrix $(\mathbf{E} - \mathbf{Q})^{-1}$, where $\mathbf{Q}$ is the submatrix of $\mathbf{P}_B$ concerning the transient states, i.e. every state except state 21.

# 3 The input data to the model

Our analysis is based on data downloaded from online data bases of two different sources: Eurostat[1], and the U.S. Census Bureau, International Data Base[2].

We do not examine the situation of the EU-25 member countries separately, but treat the EU-25 as if it were a single country. Since the latest available joint life table for the EU-25 region refered to 2002, we chose this year as our study's year of reference. The demographic profiles of Turkey and the EU-25 region in 2002 may be summarized as follows:

| | EU-25 | Turkey |
|---|---|---|
| midyear population numbers | | |
| total | 453 747 403 | 67 308 928 |
| female | 231 904 218 | 33 290 122 |
| male | 221 843 185 | 34 018 806 |
| sex ratio (females per males) | 1.05 | 0.98 |
| median age (years, both sexes) | 38.9 | 26.4 |
| dependency ratio (per cent) | | |
| both sexes | 48.9 | 51.7 |
| females only | 53.1 | 52.5 |
| potential support ratio | | |
| both sexes | 4.1 | 10.5 |
| females only | 3.5 | 9.6 |
| births | 10.3 | 17.9 |
| deaths | 9.9 | 5.9 |
| net number of migrants | 1.6 | 0.0 |
| (per 1 000 population) | | |
| total fertility rate | 1.46 | 2.07 |
| (per female aged 15-49) | | |
| rate of natural increase (per cent) | 0.04 | 1.20 |
| growth rate (per cent) | 0.19 | 1.20 |

As compared to the EU-25 the median age of the Turkish population was more than 12 years less. Turkey and the EU-25 both showed dependency ratios of around 50 per cent, which means that two active people (aged 15-64) had to take care of one inactive person (aged 0-14 or 65+). Regarding the potential support ratio, however, there were roughly ten active people for each elderly person in Turkey, and just four in the EU-25. Higher female life expectancy makes these proportions worse when confined to females only.

The total fertility rate in Turkey was above the important level of 2 children per female of reproductive age. But it was even below 1.5 in the EU-25, and the process of population ageing, which is being brought about by below replacement fertility and increased longevity, accounted for numbers of deaths almost reaching up to the level of births. It was net migration which essentially contributed to a slight

[1] http://www.eds-destatis.de/de/database/estatonline.php

[2] http://www.census.gov/ipc/www/idbnew.html

population growth in the EU-25. In Turkey, immigration and emigration flows were balanced and the growth of population was due to its natural increase actually.

We focus on the contribution of immigration from Turkey to encounter population ageing and decline in the EU-25. Currently, the annual gross inflow of Turkish people into the EU is estimated as high as 70 000 (the return flow is about half this figure), and the EU is reported to accommodate a Turkish migrant community of about 3 million (see, e.g. [2]).

To isolate the effect of Turkish immigration we assume zero net migration from other countries and count Non-Turkish migrants as natives actually. The issue of emigration fom the EU-25 region remains to be adressed, as it is not incorporated in the matrix projection model 4 explicitly. The restriction to net migration streams per period may compensate for re-emigration of Turkish immigrants. Emigration, particularly native emigration, may also be covered in an extended notion of "mortality", respectively "survival". Because of missing emigration numbers, the present study has to dispense with this latter option.

The approach used in this study deals with female populations of natives and immigrants, its demographic variables are related to females and are age-specific. Age-specific vital rates of native and immigrant females are essential, but as far as female immigrants from Turkey or immigrants per se are concerned, non-available. The same goes for female immigrants' age distribution and numbers. As an alternative, our study incorporates data based on the following assumptions:

- Turkish immigrants retain their homeland fertility, but are subjected to EU mortality.
- The structure of Turkish migration flows into the EU-25 is the average age and sex structure of migrants into the United States, Canada and Australia, which are the three major traditional countries of immigration. Herein, we apply the United Nations's model pattern of net migration streams constituted in its 2000 report on migration [10].

Taking as a base the 2002 populations by sex and 5-year age groups, observed life tables, estimated age-specific fertility rates and sex ratios at birth, measures are derived meeting the needs of the model:

| age-class | female midyear population | survival probability of females | avg. no. of girls surviving to age 5 per female, during 5 years | | shares female migrants aged 0-49 |
|---|---|---|---|---|---|
| | EU-25[2] | EU-25[1] | EU-25[1] | Turkey[2] | UN model pattern |
| | $n_{i,2002} + n^*_{i,2002}$ | $p_i = p^*_i$ | $f_i$ | $f^*_i$ | $r_i$ |
| 0-4 | 11 507 869 | 0.99471 | 0.00000 | 0.00000 | 0.09 |
| 5-9 | 12 056 957 | 0.99941 | 0.00000 | 0.00000 | 0.10 |
| 10-14 | 13 152 171 | 0.99934 | 0.01418 | 0.00000 | 0.09 |
| 15-19 | 13 614 255 | 0.99872 | 0.03411 | 0.06478 | 0.09 |
| 20-24 | 14 514 384 | 0.99852 | 0.13095 | 0.25693 | 0.15 |
| 25-29 | 15 482 028 | 0.99832 | 0.22858 | 0.32000 | 0.19 |
| 30-34 | 16 833 649 | 0.99762 | 0.20976 | 0.23533 | 0.13 |
| 35-39 | 17 542 477 | 0.99621 | 0.08833 | 0.09389 | 0.08 |
| 40-44 | 16 799 792 | 0.99375 | 0.01558 | 0.03105 | 0.05 |
| 45-49 | 15 838 223 | 0.98971 | 0.00077 | 0.00315 | 0.03 |

Hence, we apply the UN model pattern of migration to the estimated net number of Turkish migrants, assuming 52.60 per cent females of around 35 000 migrants, 88.90 per cent of them aged 49 or below. This gives an estimated (net) number $R$ of female migrants of reproductive ages which is roughly as high as 82 000 per five years.

The study of long-term effects from immigration manages without prerequisite of population numbers, unlike short to medium term population projections. In order to examine the impact on dependency and potential support ratios, at least as far as the female population is concerned, information on non-reproductive ages need to be supplemented:

| age-class | female midyear population<br><br><br>EU-25[2] | survival probability of females<br><br><br>EU-25[1] | shares female migrants aged 50+<br><br>UN model pattern |
|---|---|---|---|
| 50-54 | 15 280 144 | 0.98461 | 0.25 |
| 55-59 | 13 149 569 | 0.97709 | 0.23 |
| 60-64 | 12 429 560 | 0.96620 | 0.21 |
| 65-69 | 11 563 725 | 0.94585 | 0.16 |
| 70-74 | 10 780 514 | 0.90712 | 0.08 |
| 75-79 | 9 384 928 | 0.83828 | 0.06 |
| 80+ | 11 973 973 | 0.00000 | 0.00 |

According to calculations on the basis of the UN model of migration, the (net) number of female Turkish migrants aged 50 or above roughly comes to 10 000 per five years.

# 4 Results concerning immigration from Turkey into the EU

Europe's population has fertility below replacement. This is confirmed by the dominant eigenvalue of matrix $\mathbf{M}$ in (1) when the population is studied as a closed one:

$$\lambda = 0.9478.$$

The asymptotic growth rate per 5 years is less than 1, saying that this population, if its original fertility and mortality pattern is retained, will die out in the long run.

In the model incorporating immigration, the fertility and mortality schedule of EU-25 natives is not affected, but immigration saves the whole population from extinction in the long run: Immigrants and their descendants, which are counted as EU natives actually, will ultimately dominate the population.

The left eigenvector of the matrix $\mathbf{M}_I$ in (4) which belongs to $\lambda = 0.9478$ shows the reproductive, respectively "productive" values of one female by age and status (EU-25 native or Turkish immigrant) and enables a comparison of long-term contributions to the EU population:

| | age-class<br>0-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 |
|---|---|---|---|---|---|---|---|---|---|---|
| status | | | | | | | | | | |
| native | 1.0000 | 0.9528 | 0.9035 | 0.8497 | 0.7802 | 0.6190 | 0.3672 | 0.1282 | 0.0218 | 0.0011 |
| immigrant | 1.3866 | 1.3211 | 1.2528 | 1.1881 | 1.0626 | 0.7513 | 0.3927 | 0.1372 | 0.0363 | 0.0033 |

By definition the reproductive value of an EU native aged between 0 and 4 equals 1. It is the highest reproductive value of natives as well, which is true for the situation of any closed below-replacement population. A native female now aged 20-24 for example has a reproductive value of 0.8497. It can be interpreted as her average number of daughters in the future, discounted with the growth rate $\lambda = 0.9478$ to the value of a native's future contribution to the EU's population when aged between 0 and 4. However, the highest value at all is found in the first age-class of immigrants: An immigrant now aged between 0 and 4 will contribute about 1.39 daughters to the population of EU natives, discounted with the rate 0.9478 to the value 1 of her daughters' future contribution at birth.

The translation of the model into a Markov chain leads to genealogies, which are lines of descent running backward in time. The corresponding transition matrix $\mathbf{P}_B$ in (5) specifies the origin of females, when the population is in equilibrium. In particular, the first-row entries of this matrix give the probabilities that a EU native aged 0-4 was born by a mother of given status and age:

| mother was | age-class<br>0-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 |
|---|---|---|---|---|---|---|---|---|---|---|
| native | 0 | 0 | 0.0072 | 0.0259 | 0.1203 | 0.2181 | 0.2177 | 0.0985 | 0.0192 | 0.0010 |
| immigrant | 0 | 0 | 0 | 0.0100 | 0.0558 | 0.0946 | 0.0822 | 0.0358 | 0.0124 | 0.0013 |

The probability that her mother is native sums up to 70.8 per cent.

As the original population of natives will die out in the long run, every individual will finally have an ancestor who is an immigrant. The average times to absorption of this Markov chain can be interpreted as average numbers of time periods an individual of given status and age-class has to trace back to find an immigrant being on the point of arrival. The results are:

| | age class | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 0-4 | 5-9 | 10-14 | 15-19 | 20-24 | 25-29 | 30-34 | 35-39 | 40-44 | 45-49 |
| status | | | | | | | | | | |
| native | 19.87 | 20.87 | 21.87 | 22.87 | 23.87 | 24.87 | 25.87 | 26.87 | 27.87 | 28.87 |
| immigrant | 1.00 | 1.48 | 2.02 | 2.51 | 2.77 | 3.03 | 3.56 | 4.25 | 5.04 | 5.88 |

The first figure in the above table means that in equilibrium an EU native aged from 0 to 4 has to go back 99.4 years (19.87 times 5 years) on the average until meeting an ancestor in process of immigration. The relation to the second and further figures in this row indicates that a native of higher age has to be traced back to birth first. Immigrants aged from 0 to 4, however, must have immigrated one time period ago, as daughters of immigrants are considered native by naturalization. Thus, absorption times for immigrants do not depend on fertility, they just depend on mortality and inflow patterns.

Reproductive and "productive" values, probabilities of origin, and the length of traces backward in time until an immigrant is found are irrespective of the level of the immigration stream. These measures characterize proportions of the equilibrium population provided by the matrix projection equation (4) and confined to reproductive ages. The level of immigration does not affect the population's dependency ratio and ratio of potential support either, as long as the age distribution of the migrant flow is assumed constant. As a prerequisite to calculation, the stationary population covering ages 50 and above can be received by applying the corresponding survival probability pattern to both the stationary number of population members aged between 45 and 49 and the stream of elderly immigrants. The results are:

| | |
|---|---|
| dependency ratio (per cent) | 68.1 |
| potential support ratio | 2.3 |
| (females only) | |

Therefore, in the long run the model reproduces the ratio figures of Eurostat's baseline scenario by 2030 ([5]), however relating to the whole population. Thus, long term proportions for females slightly improve with immigration.

Of course, the level of immigration is a decisive factor of influence to population numbers in equilibrium. The presumed stream of 82 000 plus 10 000 elderly female migrants per five years implies a total female population number which is as high as 4.4 million only. The level of migration needed to maintain the EU-25's 2002 female population number in the long run is of substantially larger magnitude, almost 4.9 million per five years. It may me interpreted as the extent of total immigration to the EU-25, not just fom Turkey.

Unlike the number of immigrants, fertility, mortality, and the immigrants' age distribution naturally do have effects on proportions in equilibrium, and on population numbers as well. The following table shows how measures vary when the natives' fertility and mortality is changed:

| | natives' fertility | | | | mortality |
|---|---|---|---|---|---|
| | changes by | | | equals | changes by |
| | −10% | +10% | +20% | 95% of immigrants' fertility | −2% |
| $\lambda$ | 0.9325 | 0.9618 | 0.9749 | 0.9909 | 0.9638 |
| highest "productive" value (immigrants aged 0-4) | 1.53 | 1.27 | 1.16 | 1.05 | 1.25 |
| probability of native origin (per cent) | 63.7 | 77.9 | 85.0 | 94.6 | 78.8 |
| years backward to meet an immigrant (natives aged 0-4) | 78.0 | 134.4 | 202.5 | 554.9 | 141.7 |
| dependency ratio (per cent) | 67.6 | 68.7 | 69.4 | 70.5 | 67.8 |
| potential support ratio (females only) | 2.3 | 2.3 | 2.4 | 2.4 | 2.2 |
| female population (million) | 3.7 | 5.4 | 7.5 | 18.7 | 6.6 |

When $\lambda$ is close to 1 the natives' fertility is nearly at replacement level and the "productive" values of immigrants which can be considered as contributions to the future population growth diminish. Then, in the long run a line of descent must be traced back hundreds of years on the average until an immigrant is found on the point of arrival. Nevertheless, the potential support ratio does not rise substantially. In the long run it will be at most 2.5, unless the native population actually exceeds replacement level. Of course, increases in longevity put fertility levels in relative terms.

# 5 Summary and conclusions

The EU's population is ageing. It witnesses the effect of continuing low birth rates and the arrival at below-replacement fertility. Immigration from countries with young populations, e.g. Turkey, are due to mitigate the impact on the whole society.

The demographic profiles of Turkey and the EU-25 were used to investigate the long-term effect of immigration on a population with below-replacement fertility. Turkish immigrants into the EU are supposed to retain their homeland fertility in the first generation, they adopt European patterns in the second. The study confined to female populations and a constant (net) stream of immigrants into the EU-25 per period of time.

Stable population theory shows that in the long run immigration saves the population from extinction. The contributions of natives and migrants to future population growth can be measured in terms of age-specific reproductive values. These measures can be interpreted as average numbers of daughters in the future discounted with the asymptotic growth rate to the reproductive value of a native aged between 0 and 4. Thanks to higher fertility, the highest reproductive, respectively "productive" values can be observed for immigrants aged from 0 to 4. The average time to trace back a single line of descent until an immigrant as ancestor is met can be calculated. The constant annual level of roughly 970 000 net migrants, which is found necessary to maintain the present female population number in the EU-25 under scenario conditions, takes on the extent of total immigration, of course, not just from Turkey.

Continuing ageing, actually was not found to be remedied through immigration in the long run study of the model. There is only limited offset of a dramatic decline in the potential support ratio, to the extent which was predicted by Eurostat for 2030. The long term age structures will not improve visibly as long as descendants of immigrants are assumed to adopt EU natives' fertility, or respectively, EU natives to maintain their fertility below replacement. Immigration rather seems to exhibit a short to medium term impact on ageing. A concept of an immigration generated population momentum may help study the mitigating effect on current age structures.

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