Project 2006/S 100-106607/EN, LOT 2

Modelling of statistical data on migration and migrant populations

MIMOSA

Estimation of population stocks by broad group of citizenship, sex and age for 1st January 2002–2008

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TABLE OF CONTENTS

1. Introduction

This report constitutes a part of the outcomes of the research project MIMOSA (*Modelling of statistical data on migration and migrant populations*), funded by the Eurostat (Contract No. 2006/S 100-106607/EN, LOT 2) and executed in the years 2007–2009 by a consortium led by the Netherlands Interdisciplinary Demographic Institute (NIDI). The aim of the report is to present the final methods for estimation of annual population stocks by sex, age and broad groups of citizenship for the period from 1 January 2002 to 1 January 2008, alongside with the resulting estimates. The study covers 31 European countries, of which 27 belong to the European Union (as of 1st January 2007), and further four – to the EFTA (Iceland, Liechtenstein, Norway and Switzerland). The three groups of citizenships considered in the estimation are: nationals (*N*), EU citizens resident in another Member State (*EU* or EU27), and non-EU citizens (*nEU* or non-EU27). The age groups are five-year, with the last, open-ended category being 85 years or more.

The study is based chiefly on data available in the Eurostat databases, supplemented by additional information from respective National Statistical Institutes, whenever required and feasible. Detailed information on the availability and reliability of data are assessed for each country under study. In the methodological part, standard demographic and algebraic techniques are discussed and the references to scientific literature are provided. Throughout the report, the abbreviation 'NSI' is used to denote the National Statistical Institute of a respective country, 'JMQ' stands for the Joint Questionnaire on International Migration Statistics (Joint Migration Questionnaire) of Eurostat, UN Statistical Division (UNSD), UN Economic Commission for Europe (UNECE), the Council of Europe and International Labour Office (ILO). 'LFS' depicts the Labour Force Survey.

The proposed estimation methods aim to combine data from different sources (population census, vital statistics, data on acquisition of citizenship, specific surveys, etc.), taking into account different definitions in use in various countries, as well as the effects of various legal regulations in place, possible regularisations programmes, etc. In this project, the data that are already available were not modified (for example, in order to harmonise definitions, or for any other reason), unless in the case of inconsistencies between the sources. In the latter cases, the demographic data of Eurostat (from the DEMO domain) were given priority. With respect to data issues, this report is based on another MIMOSA report, authored by Kupiszewska and Wiśniowski (2009).

The report is structured in five sections. Firstly, in Section 1, current national practices in estimating population stocks by citizenship are briefly discussed. In Section 2, the proposed methods of estimating population stocks by sex, age groups and citizenship are discussed. This methodological section presents such methods, as estimation of data in single years of age from 5-year age-groups, cohort-wise interpolation of population stocks, cohort-wise shares propagation, cohort-component projections, proportional fitting, as well as other auxiliary methods. Subsequently, Section 3 contains a detailed overview of data sources and methods ultimately applied for the estimation of population stocks in individual countries, which are listed in the official order in use in the Eurostat (see Annex for details). The procedures are summarised in a tabular form in Section 4. Finally, the report also contains an Annex, which presents selected results of the estimations in the form of age pyramids for all 31 countries under study.

2. Proposed methods of estimating population stocks by citizenship, sex and age

The current section presents a theoretical background of methods proposed for the calculations of missing elements in the population stocks by sex, age group and citizenship group. After a brief summary of the notation used, the following methods are subsequently discussed: interpolation of 5-year into 1-year age groups, regarded as a data preparatory method (Section 2.2), followed by cohort-wise interpolation of population stocks (2.3), cohort-component projections traditionally-used in demography (2.4) and cohort-wise shares propagation (2.5). Further, Section 2.6 describes selected proportional fitting methods, which category encompasses three approaches, depending on the availability of information, namely, the proportional adjustment, direct proportional fitting and iterative proportional fitting. Section 2 concludes by presenting some auxiliary methods for dealing with the *Unknown* categories, and estimation of missing elements of age distributions (2.7).

2.1. Notation and basic concepts

Throughout the report, the notation used for population variables follows a common convention presented below. In all cases, the superscript n indicates one of the three broad groups of citizenship: nationals, EU foreigners or non-EU foreigners, abbreviated as *N*, *EU* and *nEU*, respectively, where EU refers to 27 countries, thus to the composition of the European Union as of 1st January 2007. The non-EU group includes stateless persons. An abbreviation FOR is used for all foreign population (EU and non-EU together). For the transparency of presentation, the country index is skipped, as all calculations presented in the report are always country-specific. The variables in question are as follows:

Stock variables:

$P^n(x, t)$ - Population in broad citizenship group n, in the age of x years on 1st January, year t.

$P^n(x, c)$ - Population in broad citizenship group n, in the age of x years at the census date c.

Event variables:

$B^n(t)$ - Births during calendar year t in citizenship group n;

$D^n(x, t)$ - Deaths of persons aged x years, belonging to citizenship group n, during calendar year t;

$I^n(x, t)$ - Registered immigration of persons from citizenship group n, aged x years, during calendar year t, regardless of the country of origin;

$E^n(x, t)$ - Registered emigration of persons from citizenship group n, aged x years, during calendar year t, regardless of the country of destination;

$R^n(x, t)$ - Outcome of the regularisation of the status of formerly irregular residents aged x, in year t, by definition referring only to foreigners, $n \in \{EU, nEU\}$, thus with $R^N(x, t) \equiv 0$;

$S^n(x, t)$ - Statistical adjustment (official correction) concerning the size of population aged x, in year t, due to other reasons than regularisations;

$A^n(x, t)$ - Acquisitions of citizenship by the population aged x, in year t, by definition referring only to foreigners, $n \in \{EU, nEU\}$, thus with $A^N(x, t) \equiv 0$.

In all cases, unless noted otherwise, age is reported in years *reached* during a given calendar year, and thus the *events* in question (deaths, migrations, citizenship changes, etc.) correspond to parallelograms with vertical sides on the Lexis diagram. An illustration of the relevant concepts on a Lexis plane is shown in Figure 2, in Section 2.4.

Whenever necessary, the index denoting sex is added as an additional subscript $g \in \{m, f\}$ for males and females, respectively, e.g. $P_f^n(x, t)$ refers to female population stock, and $D_m^n(x, t)$ to deaths among males. In order to distinguish five-year age groups, an additional left-hand side subscript '5' is added. For example, ${}_5P_m^n(x, t)$ refers to male population belonging to broad citizenship group n, which was in the age of $[x, x+5)$ years on 1st January of year t. The same principle applies to almost all event variables (D, I, E, R, S and A), with a clear exception of B.

In some instances, for clarity of presentation, the summation of a particular variable over a given index is indicated by an asterisk in a respective place, eg. $A^{nEU}(*, t) = \Sigma_x A^{nEU}(x, t)$ refers to all acquisitions of citizenship by non-EU foreigners in year t, regardless of age. Similarly, $I^*(x, t) = \Sigma_n I^n(x, t)$ denotes all immigrants aged x, in year t, irrespective of their citizenship, and $D^*(*, t) = \Sigma_n \Sigma_x D^n(x, t)$ to all deaths registered in year t, without respect to nationality or age. It has to be noted that in several cases the summation over n involves only two components, e.g. $n \in \{EU, nEU\}$ for $R^n(x, t)$ and $A^n(x, t)$.

2.2. Interpolation of 5-year into 1-year age groups

Among the preparatory steps for the estimation of missing data, the most frequent problem concerns disaggregation of five-year age groups of population (or events) into single years. This has to be performed in order to enable cohort-wise interpolations or cohort-component projections with yearly steps, as described in Sections 2.3 and 2.4.

If auxiliary information is available from a different source (e.g., from a census, from the previous or next year, etc.), the population size or the number of events can be disaggregated using a 'Prorating' method (Shryock *et al.*, 1993: 5-61), whereby the relative distribution from the auxiliary source is imposed on the data in question. The obtained distribution might need to be further adjusted to marginal totals, by means of proportional fitting procedures, described in Section 2.5.

If the data on population stocks by sex, broad citizenship group and 5-year age group ${}_5P^n(x, t)$ are available and the stocks by sex and 1-year age group $P^*(x, t)$ are also known, then, assuming no other information about the distribution by single years, we can estimate the missing distributions for particular citizenship groups proportionally, that is as: $P^n(x+i, t) = {}_5P^n(x, t) \cdot P^*(x+i, t) / {}_5P^*(x, t)$. This is an example of the application of the direct proportional fitting method described in Section 2.5.2.

If none of the above information is available, the proposed methodology can use the well-known interpolative four-term third-difference solution of Karup and King (Shryock *et al*., 1993: 5-65). For each five-year group, the disaggregation into fifths is done via applying multiplicative coefficients to the global value of this group and the neighbouring ones. Different multipliers are used for the first group, the middle groups and the last group, as set forth in Table 1. For example, if we want to split a middle five-year group with population N_i into five single-year groups n_1, n_2, n_3, n_4, n_5, then:
$n_1 = 0.064\ N_{i-1} + 0.152\ N_i - 0.016\ N_{i+1}$, $n_2 = 0.008\ N_{i-1} + 0.224\ N_i - 0.032\ N_{i+1}$, etc.
When Karup-King multipliers are used, the condition $N_i = n_1 + n_2 + n_3 + n_4 + n_5$ is automatically fulfilled.

As an alternative to the Karup-King interpolation, the six-term fifth-difference interpolative formulae of Sprague or Beers can be applied, which however use information from more surrounding groups. Methodological details can be found in Shryock *et al*. (1993: 5-65–5-71). In our case, the Karup-King interpolation is recommended for the sake of simplicity.

Table 1. Coefficients for the Karup-King interpolation formula

	First group, N_0			Middle groups, N_i			Last group, N_K		
	N_0	N_1	N_2	N_{i-1}	N_i	N_{i+1}	N_{K-2}	N_{K-1}	N_K
First fifth	+0.344	–0.208	+0.064	+0.064	+0.152	–0.016	–0.016	+0.112	+0.104
Second fifth	+0.248	–0.056	+0.008	+0.008	+0.224	–0.032	–0.032	+0.104	+0.128
Third fifth	+0.176	+0.048	–0.024	–0.024	+0.248	–0.024	–0.024	+0.048	+0.176
Fourth fifth	+0.128	+0.104	–0.032	–0.032	+0.224	+0.008	+0.008	–0.056	+0.248
Last fifth	+0.104	+0.112	–0.016	–0.016	+0.152	+0.064	+0.064	–0.208	+0.344

Source: Shryock et al. (1993: Table C-1, p. 5-69).

For variables depicting non-vital events, in particular for migration, the estimates for particular **cohorts** can be obtained from two neighbouring period-age estimates yielded by the Karup-King formula, split equally by half. For the first cohort, we can assume that a half of such events concern the cohort born during a given year *t*, while for the last, open-ended cohort, we can add up the period-age estimate for the open-ended group and a half of the events concerning the age group immediately preceding the last one. The underlying rationale is an assumption that non-vital events for the members of a given cohort are equally spread throughout the calendar year (see also Figure 2 in Section 2.4). In any case, the estimates for the eldest cohorts would be anyway close to zero for all practical migration-related applications.

Regardless of the method, if the disaggregation is performed on data broken down by sex or citizenship, the final estimate might need to be obtained by proportional fitting methods (described in Section 2.5), in order to ensure the summation to available marginal totals.

2.3. Interpolation of population stocks

2.3.1. Cohort-wise interpolation

Given information on the age structures of the population for two non-adjacent moments of time, a simple idea to obtain the missing figures for in-between moments would be to apply interpolation techniques. In this case, we propose cohort-wise interpolation for all cohorts apart from the youngest and oldest one, which are discussed separately. Overall, this method requires much less information on input than the cohort-component projections presented in the next section, but it requires information about population both before and after the moment for which the estimates are to be done. The interpolative approach is recommended for the cases where (a) the span between two points with available data is not wide (say, two-three years), and (b) no information on the distribution of vital and migratory events by citizenship is available.

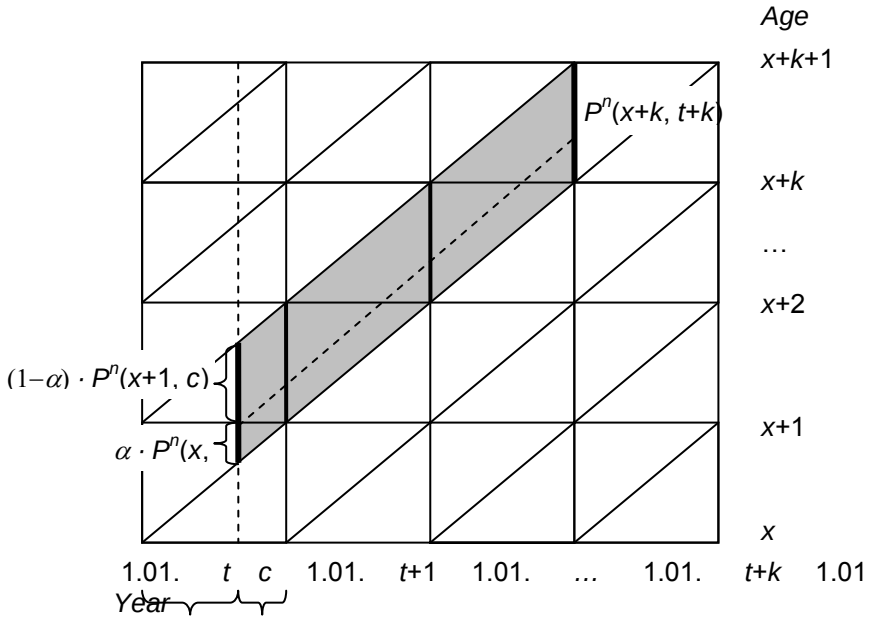
In practical applications listed further in Section 4, the situation is very often such that data are available for year $\underline{t}$ from the census conducted at time c ($t \leq c < t+1$), and for the 1st January of the year $t+k$, not immediately following the census. Such situations can be put in a general framework illustrated on a Lexis diagram in Figure 1, where α denotes the fraction of a year remaining after the census until 31st December. Figure 1 and the methodology proposed below cover also the situations when data come from other sources than the census, and the situations when the reference date of the data for year *t* is 1 January. In the latter case it suffices to set $\alpha = 1$.

For cohorts already existent at the census date *c*, the interpolation can follow various patterns, but an arithmetic and geometric pattern of growth (Rowland, 2003: 46–64; Calot

and Sardon, 2003: 23–32) will be the most frequent choices. As noted by Rowland (2006: 50), "under arithmetic growth, successive population totals differ from one another by a constant amount [, while] under geometric growth they differ by a constant ratio". For short-period interpolations, both approaches should yield similar results, although this is an empirical issue, and there is no convincing argument in favour of either of them. Hence, a selection of appropriate methods should rely on case-specific judgements.

It has to be noted that the cohort aged *x* completed years on 1 January *t*+*k* was split at the census date between two cohorts: the younger one (aged *x* completed years) and the older (aged *x*+*1*), as shown in Figure 1. Therefore, the interpolative estimate of $P^n(x, t+i)$ depends on $P^n(x, c)$, $P^n(x+1, c)$ and $P^n(x, t+k)$.

Figure 1. Cohort-wise interpolation of population stocks: a general idea



Source: Own elaboration.

Given the above, the formula for an interpolative estimate of population sizes belonging to a particular age group *x*+*i* and citizenship group *n,* assuming linear pattern of change, is as follows:

$$P^n(x+i, t+i) = (k-i) / (k-1+\alpha) \cdot [\alpha \cdot P^n(x, c) + (1-\alpha) \cdot P^n(x+1, c)] + \\ + (i-1+\alpha) / (k-1+\alpha) \cdot P^n(x+k, t+k), \quad (1a)$$

while for the geometric change:

$$P^n(x+i, t+i) = \{[\alpha \cdot P^n(x, c) + (1-\alpha) \cdot P^n(x+1, c)]^{k-i} \cdot P^n(x+k, t+k)^{i-1+\alpha}\}^{1 / (k-1+\alpha)}. \quad (1b)$$

In order to ensure consistency of the results and summation of the age-specific estimates to the marginal totals by sex or citizenship group, whenever available, the estimates have to be adjusted by the means of iterative proportional fitting, presented in Section 2.5.

For the youngest and oldest cohorts, the interpolation as proposed above is not possible due to reaching either minimum (zero) age towards the beginning, or maximum age towards the end of the interpolation period. In such cases we suggest to assume the country of birth structure of these cohorts as available from the later date for the youngest cohort(s) and from the earlier date for the oldest cohort(s).

The framework presented above can be easily generalised to a much less frequent situation with interpolation between two censuses – in such case, a fraction β of a year between the 1st January of the year of the second census and the second census date, *c*', should be additionally accounted for.

It should be noted that an identical solution as shown above in (1a), or in (1b) can be used for extrapolating cohort sizes *beyond* the available data points, in whichever direction. In either case, it would suffice to put an appropriate integer $i \leq 0$ for the backward extrapolation (in particular, following the example from Figure 1, set $i = 0$ to obtain values for the beginning of the census year), or $i > k$ for the forward extrapolation.

Noteworthy, the methods discussed above resemble to some extent the ones presented in the *Human Mortality Database Methods Protocol* (Wilmoth *et al*., 2005: 15–32), with the exception of the oldest age groups, where the quoted study suggests more sophisticated extinct cohort and survivor ratios approaches. Direct application of the methods proposed by Wilmoth *et al.* would be, however, difficult. This is not because of computational reasons, but rather due to the lack of yearly estimates of deaths, births and migratory events broken down by citizenship groups, which has been listed as a pre-condition for selecting cohort-wise interpolation method at the very beginning of the current section.

2.3.2. Period-wise interpolation

As an alternative to the cohort-wise interpolation, a similar period-wise method can be proposed, especially for those age groups (in principle, the youngest ones, as shown further in Section 2.6.1), for which such methodology can yield age structures being closer to reality than the ones produced by the cohort-wise method. This feature is primarily attributable to the presence of highly age-selective migration flows in several (especially younger productive) age groups.

In the period-wise approach, interpolation is done across the calendar years, thus "horizontally" in the convention of Figure 1. The interpolation formulas (1a) and (1b) then become:

$$P^n(x, t+i) = (k-i) / (k-1+\alpha) \cdot P^n(x, c) + (i-1+\alpha) / (k-1+\alpha) \cdot P^n(x, t+k), \text{ or} \quad (2a)$$

$$P^n(x, t+i) = [P^n(x, c)^{k-i} \cdot P^n(x, t+k)^{i-1+\alpha}]^{1 / (k-1+\alpha)}, \quad (2b)$$

assuming respectively arithmetic or geometric pattern of change. Again, to ensure consistency of the resulting estimates with the marginal totals by sex or country of birth group, whenever available, the figures obtained from (2a) and (2b) need to be adjusted, for example using the iterative proportional fitting, described in Section 2.5.

2.4. Cohort-component projections

Let us denote by $X^n(x, t)$ a sum of all event variables *not* related to the natural change of population stocks (ie. all but births and deaths), thus:

$$X^n(x, t) = I^n(x, t) - E^n(x, t) + S^n(x, t) + \Sigma_{k \in \{EU,\, nEU\}} A^k(x, t), \text{ for } n = N; \quad (3a)$$

$$X^n(x, t) = I^n(x, t) - E^n(x, t) + S^n(x, t) + R^n(x, t) - A^n(x, t), \text{ for } n \neq N. \quad (3b)$$

Given (3a) and (3b), the population accounting equations for each broad citizenship groups *n* are:

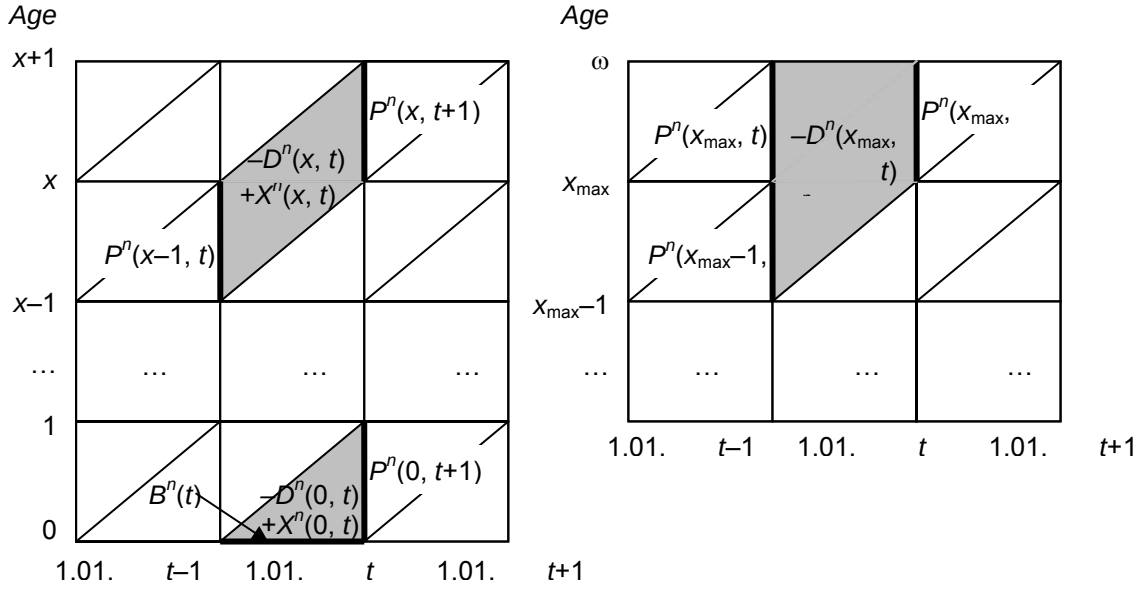
$$P^n(0, t+1) = B^n(t) - D^n(0, t) + X^n(0, t); \quad (4a)$$

$$P^n(x, t+1) = P^n(x-1, t) - D^n(x, t) + X^n(x, t), \text{ for } x \in \{1, 2, ..., x_{max}-1\}; \quad (4b)$$

$$P^n(x_{max}, t+1) = [P^n(x_{max}-1, t) + P^n(x_{max}, t)] - D^n(x_{max}, t) + X^n(x_{max}, t). \quad (4c)$$

In (4c), x_{max} stands for the highest (open-ended) age group for which information is available. Note also that deaths and other event variables in age group x_{max} refer to the trapezoid on the Lexis diagram rather than to a parallelogram, while for age group 0 – to a right triangle (see Figure 2). Under the assumptions presented above, the projection is made following the equations (4a), (4b) and (4c) for consecutive years, on the basis of information available for single-year age groups, decomposed from the five-year groups, if needed.

Figure 2. Relationships between population stocks P^n, and events B^n, D^n and X^n on a Lexis diagram



Source: own elaboration

Note that the default citizenship of a newborn child differs between the countries, either following a *ius soli* principle, whereby a child acquires the citizenship of the country of birth, or *ius sanguinis*, according to which a child inherits the citizenship of its parent(s), or finally a mixture of those two, for example differentiating between the generations of migrants, taking into account the length of stay in the country, etc. Details are discussed wherever applicable (i.e. if the cohort-component projection is recommended) on the country-by-country basis in Section 4. The general rules are as follows:

a) *Ius sanguinis*
If the child gets citizenship of any of the parents, then $B^n(t)$ in equation (3a) may be assumed to be roughly proportional to $P^n(t)$. If the child gets citizenship of the mother and we have no separate estimate of fertility for nationals and foreigners, then $B^n(t)$ may be assumed to be roughly proportional to $P_f^n(t)$. If estimates of fertility by broad citizenship and age of mother exist then a better estimate may be obtained using the formula:

$$B^n(t) = B^*(t)\, f^n(x)\, P_f{}^n(x, t) \,/ \Sigma_k f^k(x)\, P_f{}^k(x, t), \quad (5)$$

where $f^n(x)$ denotes age-specific fertility rates for women in age group x, belonging to the group of citizenship n.

b) *Ius soli*
If the child automatically acquires the citizenship of a given country, then the balance equation for the youngest age group, (3a), becomes, depending on the citizenship in question:

$$P^{N}(0, t+1) = B^{*}(t) - D^{N}(0, t) + X^{N}(0, t), \text{ for } n = N; \quad (4a')$$
$$P^{n}(0, t+1) = X^{n}(0, t) - D^{n}(0, t), \text{ for } n \neq N. \quad (4a'')$$

In mixed cases, it is recommended to project one part of births according to formulas for *ius soli* and another part according to the *ius sanguinis* principle.

Note also that losses of citizenship are not accounted for, as they in most instances concern persons in reality either already living abroad, or emigrating (and counted in *E*). For acquisitions of citizenship, we assume that non-nationals fall in the category of nationals upon naturalisation, in order to count the same people only once, regardless of the number of citizenships they have.

If the breakdown by citizenship group of all variables referring to vital and migratory events can be assumed proportional to the citizenship structure of the population at the beginning of each year, then the projection methodology can be *de facto* simplified to proportional adjustment / decomposition, whereby the citizenship distribution of the considered cohort in the previous year would directly apply to all cohorts except the first and the last one in each year. In particular, this situation applies if the following three conditions hold.

1. We may assume that the distribution of deaths and migration flows by broad citizenship is the same as the citizenship composition of the population;
2. Acquisitions of citizenship may be ignored;
3. There was no regularisation, or it may be ignored.

In such cases, the projection equation (4b) simplifies to a proportional decomposition of $P^{*}(x, t+1)$ by citizenship group, described in Section 2.5.1. The estimations can be performed using the formulas:

$${}_5P^{n}(x, t) = {}^{\text{DEMO}}{}_5P^{*}(x, t) \cdot {}_5P^{n}(x, c) / {}_5P^{*}(x, c), \text{ if } t \text{ is the census year, or:} \quad (6a)$$
$${}_5P^{n}(x, t) = {}^{\text{DEMO}}{}_5P^{*}(x, t) \cdot {}_5P^{n}(x-1, t-1) / {}_5P^{*}(x-1, t-1) \text{ for subsequent years.} \quad (6b)$$

The first and the last cohort may be disaggregated using the citizenship composition of the first and last age group in the previous year or at the census date. In such cases, the following formulas apply:

$${}_5P^{n}(0, t) = {}^{\text{DEMO}}{}_5P^{*}(0, t) \cdot {}_5P^{n}(0, c) / {}_5P^{*}(0, c), \text{ or:} \quad (7a)$$
$${}_5P^{n}(x_{\max}, t) = {}^{\text{DEMO}}{}_5P^{*}(x_{\max}, t) \cdot {}_5P^{n}(x_{\max}, c) / {}_5P^{*}(x_{\max}, c). \quad (7b)$$

2.5. Proportional fitting methods

The general task is to estimate $P_g^{n}(x, t)$, i.e. the elements of a three-dimensional cube (with the dimensions being sex, age and citizenship). The choice of a particular proportional fitting method depends on which marginal information (cube's edges or faces) is known and if an initial estimate of the cube elements are available. Below, the examples of possible situations are given. The formulas have been given for population by single years of age but the analogical formulas apply to population by 5-year age group. For more information on multi-proportional techniques see for example the studies of Willekens (1977, 1982), Willekens *et al*. (1981), Rees (1994) and Norman (1999). Note that proportional fitting methods presented below are known under various names in the scientific literature.

In addition to a potential application as the main estimation method, proportional fitting may be used, in almost all the countries for which estimations are needed, as the final stage of the estimation procedure, in order to adjust the initial estimates to known aggregates or marginal totals. The initial estimate might be obtained for example using interpolation or

projection, or assumed to be the same as at some different time (e.g. the same as at the census date). Such an initial estimate has to be subsequently adjusted for example to the known total population size by age and sex.

2.5.1. Proportional adjustment / decomposition

Among the proportional methods, the simplest one can be applied to situations, when a population can be directly disaggregated by a variable (sex, age or citizenship), according to the pattern observed in an auxiliary source. In general, the idea is the same as in the case of the Prorating' method (Shryock *et al*., 1993: 5-61), mentioned in Section 2.2.

For example, if the aggregates $P^*(x, t)$ and an initial estimate of the citizenship structure $P'^n(x, t)$ are known, then the final estimate $P''^n_g(x, t)$ may be obtained using the formula:

$$P''^n_g(x, t) = P'^n_g(x, t) \cdot P^*_g(x, t) / P'^*_g(x, t). \quad (8)$$

In particular, if one wants to estimate the breakdown by citizenship using the citizenship structure from the census, $P^n_g(x, c)$, then the formula (8) becomes: $P^n_g(x, t) = P^*_g(x, t) \cdot P^n_g(x, c) / P^*_g(x, c)$.

If information about the citizenship structures is available from the census only (or from some earlier year) and total population by sex and age is also available, then the proportional adjustment/decomposition method might be considered as an alternative to projection, with the shares calculated using one of the three shares propagation method described in Section 2.6.

2.5.2. Direct proportional fitting

The estimation problem becomes slightly more complicated, if one wants to estimate $P^n_g(x, t)$, but does not have any initial estimate of it. One possible situation is that at least some parts of the data cube (faces and/or edges) are available and provide coherent information (sum up to the same totals). In such cases, the most straightforward solution is provided by a direct proportional fitting method, whereby the missing elements (i.e. the inside of the cube) can be obtained by taking simple proportions to all available marginal totals.

For example, let the available data consist of known $P^*_g(x, t)$ and $P^n_{\bullet}(*, t)$, i.e. the age-sex face and the citizenship edge of the age-sex-nationality cube. Then, the sought-for $P^n_g(x, t)$ can be estimated as:

$$P^n_g(x, t) = P^*_g(x, t) \cdot P^n_{\bullet}(*, t) / P^*_{\bullet}(*, t) \quad (9)$$

In practical applications discussed in Section 4, this option will be used rather infrequently, because there usually are some initial estimates of the population structures, for example from the census. Willekens *et al.* (1981: 97) noted that general formulae of a form akin to (9) for a one face – one edge problem, as well as similar closed-form solutions for the three edges or two faces problems are solutions of the entropy-maximisation problems in research tasks aimed at reconstructing the elements of a three-dimensional arrays, given the available marginal sums.

2.5.3. Iterative proportional fitting

In a general case, a closed-form solution (9) may not exist due to possible incoherence between the data at hand. Such problems call for a multi-step iterative proportional fitting (IPF) method, whereby the solutions are sought step-wise, through iterative adjustments of the consecutive approximations to marginal totals available from the faces or edges of the data cube. In particular, the method can be used for adjusting the existing joint preliminary distributions to known marginal distributions.

For example, let the initial estimate of the citizenship structure $P_{g'}^{n}(x, t)$ be known, so as the sex-age face and the citizenship edge of the data cube, respectively $P_{g}^{*}(x, t)$ and $P_{\bullet}^{n}(*, t)$. By the IPF algorithm, the initial estimates are iteratively corrected by proportional adjustment. An additional superscript (k) in $P_{g}^{(k)\,n}(x, t)$ denotes the iteration step (for $k \geq 1$). The starting value $k = 1$ defines also the initial estimate of the joint sex-age-citizenship distribution, $P_{g}^{(1)\,n}(x, t) = P_{g'}^{n}(x, t)$).

$$P_{g}^{(2k)\,n}(x, t) = P_{g}^{(2k-1)\,n}(x, t) \cdot P_{g}^{*}(x, t) / P_{g}^{(2k-1)\,*}(x, t); \quad (10a)$$
$$P_{g}^{(2k+1)\,n}(x, t) = P_{g}^{(2k)\,n}(x, t) \cdot P_{\bullet}^{*}(*, t) / P_{\bullet}^{(2k)\,n}(*, t). \quad (10b)$$

The procedure defined by (10a) and (10b) is repeated iteratively till some convergence criterion is achieved. For example, the estimates yielded by subsequent steps should differ by no more than by an arbitrarily-selected small number ε. More details of the method have been discussed by Willekens (1982: 69–71), Willekens *et al*. (1981), Rees (1994) and Norman (1999).

Although the IPF method is purely mechanical, its main advantage is that it does not require any additional information (such as data on vital events or migration) or excessive labour resources, and the obtained results (in terms of joint distributions by all variables under study) are automatically coherent with marginal distributions of particular variables. Moreover, under some not very strong assumptions, the IPF estimates can be interpreted from a statistical viewpoint as joint probability distributions obtained using the maximum likelihood or entropy maximisation methods (Bishop, Fienberg and Holland, 1975: 83–97; after: Willekens, 1982: 70–71 and Norman, 1999: 2).

2.6. Shares propagation methods

In some cases, too much information on the age-sex-citizenship distribution of the components of population change is missing, which renders projections too dubious with respect to the number of assumptions that need to be made. In practice, in such instances the only reliable information comes from the population census and from annual population stocks available in the DEMO database. Three alternative procedures are proposed, described in detail in Sections 2.6.1 – 2.6.3.

2.6.1. Period-wise shares propagation

The period-wise shares propagation is the simplest of the three proposed shares propagation methods. It is expected that it might be superior to the cohort-wise shares propagation in the situations when population structures are highly influenced by short term migration flows of foreigners concentrating in selected age groups. In such cases, the breakdown of population by citizenship can be estimated using formula (8) and the country of birth structure from the from the previous year (or from the census). Formula (8) then becomes:

$${}_5P_{g}^{n}(x, t) = {}_5P_{g}^{*}(x, t) \cdot {}_5P_{g}^{n}(x, c) / {}_5P_{g}^{*}(x, c), \text{ if } t \text{ is the census year}; \quad (11a)$$
$${}_5P_{g}^{n}(x, t) = {}_5P_{g}^{*}(x, t) \cdot {}_5P_{g}^{n}(x, t-1) / {}_5P_{g}^{*}(x, t-1), \text{ for subsequent years}, \quad (11b)$$

or simply:

$${}_5P_{g}^{n}(x, t) = {}_5P_{g}^{*}(x, t) \cdot {}_5P_{g}^{n}(x, c) / {}_5P_{g}^{*}(x, c), \text{ for all years}. \quad (11)$$

The estimates are automatically consistent with the aggregated population by sex and age, so no further adjustment is necessary. Unlike in the cohort-shares propagation and weighted shares method, the estimates are directly made for 5-year age groups.

2.6.2. Cohort-wise shares propagation

For the cohort-wise propagation of shares, the proposed algorithm is as follows:

1. For the census population, apply the structure by citizenship, taken from each five-year age group, to the respective single-year age groups (i.e. from age group 0–4 to single ages 0, 1, …, 4; from 5–9 to 5, 6, …, 9 etc.). Let $w^n(x, c) = P^n(x, c) / P(x, c)$ denote the age-specific shares of citizenship group n in the census.

2. Further, set α as a fraction of the calendar year before the census date. It is implicitly assumed that the census population in single-year age groups can be divided between 'older' and 'younger' cohorts using the α and $(1-\alpha)$ partition.

3. For the census date, use the following formula to calculate the share of citizenship group n in the cohort that was aged x years on 1st January of the census year:

$$w^n(x+\alpha, c)=[(1-\alpha)\, P^n(x, c) + \alpha\, P^n(x+1, c)] / [(1-\alpha)\, P^*(x,c) + \alpha \cdot P^*(x+1,c)], \text{ for } x<x_{max}; \quad (12a)$$

$$w^n(x_{max}+\alpha, c) = P^n(x_{max}, c) / P^*(x_{max}, c). \quad (12b)$$

4. For the 1st January of the census year assume:

$$w^n(x, t) = w^n(x+\alpha, c). \quad (13)$$

5. For the 1st January of the year following the census year ($t > c$), assume in turn:

$$w^n(x, t) = w^n(x-1+\alpha, c), \text{ for } 0 < x <x_{max}; \quad (14a)$$

$$w^n(x_{max}, t) = [P^n(x_{max}-1, c)\,(1-\alpha) + P^n(x_{max}, c)] / [P^*(x_{max}-1, c)\,(1-\alpha) + P^*(x_{max}, c)], \text{ and} \quad (14b)$$

$$w^n(0, t) = w^n(0, c) \text{ for the youngest age group.} \quad (14c)$$

6. For subsequent years calculate:

$$w^n(x, t) = w^n(x-1, t-1), \text{ for } x = 1, \ldots, x_{max}-1; \quad (15a)$$

$$w^n(x_{max}, t) = [P^n(x_{max}-1, t-1) + P^n(x_{max}, t-1)] / [P^*(x_{max}-1, t-1) + P^*(x_{max}, t-1)]; \quad (15b)$$

$$w^n(0, t) = w^n(0, t-1). \quad (15c)$$

7. Calculate populations for all years using the above shares and total populations (available e.g. from DEMO), as:

$$P^n(x, t) = P^*(x, t)\, w^n(x, t). \quad (16)$$

Finally, aggregate single-year age groups into five-year ones.

2.6.3. Mixed solutions

Given the empirical distributions of population by citizenship and age groups, such as the ones presented in Section 2.6.1, one option to combine the advantages of the two approaches would be to apply the period-wise propagation (11) for younger age groups ($x < x^o$), and the cohort-wise propagation (12) – (16) thereafter (for $x \geq x^o$). Selection of the division point, x^o would be country-specific, although in principle it would most likely be below the most mobile age groups.

Another theoretical possibility would be to perform a 'weighted' propagation of shares, with age-specific weights $\delta(x)$ given to the cohort-wise method and $1 - \delta(x)$ to the period-wise

approach, for all age groups except the youngest one. Using notation from the previous section, this would yield an iterative procedure for subsequent post-census years, $t > c$:[1]

$$w^n(x, t) = \delta(x) \cdot w^n(x–1, t–1) + [1 – \delta(x)] \cdot w^n(x, t–1), \text{ and} \quad (17a)$$
$$w^n(0, t) = w^n(0, t–1). \quad (17b)$$

Ultimately, the procedure would end with an (iterative) proportional adjustment to all marginal totals, in order to ensure the internal consistency of the outcome.

The 'weighted' solution, however, although more general than the previous one, requires very strong judgmental assumptions about the shape of the weighting function, $\delta(x)$. Its estimation may be not straightforward. The distances between the observed patterns and the 'propagated' ones (under various metrics), and the 'correction factors' to be applied to the "old" shares, do not seem to have any universal, general form, even defined in very rough terms. For further evaluation of the method see Section 5.

To conclude, the search for an 'optimal' functional form of $\delta(x)$ still remains a research challenge. For the purpose of MIMOSA, it is recommended to use a simplified solution proposed before, thus, assuming a step-wise $\delta(x) = 0$ for $x < x^o$ and $\delta(x) = 1$ for $x \geq x^o$.

2.7. Auxiliary methods

Among the auxiliary methods, the foremost one is the decomposition of the *Unknown* category wherever it appears (i.e., with respect to age, citizenship, or even sex, as in the case of Greece in 2005). The universal solution proposed in such cases is a proportional disaggregation: population belonging to the *Unknown* category is broken down proportionally to the existing, well defined categories (citizenship groups, age groups, etc.) and the resulting parts are attached to these categories. For example, if total population P consists of n well-defined groups P_1, …, P_n, and the *Unknown* category, P_{unk}, such that $P = \Sigma_i P_i + P_{unk}$, where $i = 1, \ldots, n$, then the following corrections apply:

$$P'_j = P_j + P_{unk} \cdot P_j / \Sigma_i P_i = P_j (1 + P_{unk} / \Sigma_i P_i) \text{ , for all } j, \text{ with } i = 1, \ldots, n. \quad (18)$$

If some elements of age structures are missing (e.g., tails of respective age distributions, or breakdown into five-year groups given the availability of broader ones), we may either use a structure from a different year or fit a mathematical function to available data. For example, we can assume that foreign population stocks are a double-exponential function of age, as originally proposed for the intensity of migration flows by A. Rogers and L. J. Castro (Rogers and Castro, 1981; Castro and Rogers, 1983). The number of foreign population aged x, $\phi(x)$, would then be given by the following equation:

$$\phi(x) = c + a_1 \cdot \exp(–\alpha_1 \cdot x) + a_2 \cdot \exp\{–\alpha_2 \cdot (x – \mu_2) – \exp[–\lambda_2 \cdot (x – \mu_2)]\}. \quad (19)$$

The parameters c, a_1, α_1, a_2, α_2, λ_2 and μ_2 can be estimated separately for each sex, for example using the ordinary least squares method (OLS) on the basis of the data for the available age groups (for example, below 65 years of age). Technically, the calculations can be done in a spreadsheet (e.g. MS Excel) using a solver-like tool, controlling for sensitivity to the choice of initial input values of the algorithm. Based on the obtained parameter estimates, formula (19) yields approximations of $\phi(x)$ for the remaining age groups. The last, open-ended group (85+) can be obtained by subtraction of all other figures from the total. To

[1] The census year modifications, omitted here for the sake of transparency, would be analogous to the ones presented in Sections 2.6.2 and 2.6.3.

avoid negative numbers in the 85+ category, appropriate constraints should be set during the estimation procedure.

In either case, when adjustment to broader age groups is needed in order to ensure summation to respective totals (e.g. for functional age groups), it can be done via a proportional fitting method presented in Section 2.5.

3. Overview of methods applied for particular countries

The current section offers an overview of methods and data sources used for the estimation of population stocks by sex, age and broad citizenship group for 31 European countries (EU-27, followed by four EFTA countries). The outline is the result of the verification and extension up to 2008 of the methodology suggested earlier in the MIMOSA project. This section therefore presents only these options, which have been ultimately applied in the calculations, together with other issues that came out during the implementation phase. A more detailed description of particular data sources mentioned in this section may be found in the report of Kupiszewska and Wiśniowski (2009). The order of the countries follows the official one in use in Eurostat.

3.1. Belgium

The Joint Migration Questionnaire data and the NSI data together provided a complete set of data on population stocks by age, sex and citizenship in Belgium for the period 2002–2006. The data on population by age and sex are consistent between the JMQ/NSI and the Eurostat DEMO database except for 2002. Belgian data on population stock by citizenship, sex and age were directly aggregated into the three citizenship categories of interest (Nationals, EU27 foreigners, non-EU27 foreigners) from the JMQ/NSI. The stateless population (around 300 per year) was allocated to the non-EU27 foreigners. The population with unknown citizenship, ranging from 12,200 in 2003 to 16,500 in 2006, was distributed proportionally among EU27 and non-EU27 categories.

The estimates for 2002–2006 were calculated earlier by NIDI. For 2007 data disaggregated by sex, age and citizenship were provided by courtesy of Statistics Belgium. For 2008 the data were provided in the JMQ. According to the recommendation received from the Belgian NSI the 'Unknown' category comprises of the non-EU27 foreigners and thus it was added to the non-EU27 category for all years of interest 2002–2008.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	JMQ 2003	JMQ 2004 / NSI	JMQ 2005 / NSI	JMQ 2006 / NSI	DEMO/NSI	JMQ2008
Total population by sex and age	NSI	JMQ 2003	JMQ 2004 / NSI	JMQ 2005 / NSI	JMQ 2006 / NSI	DEMO/NSI	JMQ2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004 / NSI	JMQ 2005 / NSI	JMQ 2006 / NSI	NSI	JMQ2008

Summary of used estimations methods

Year	Method
2002	Aggregation from NSI; proportionally adjusted to DEMO population by age group and sex; "Unknown citizenship" category distributed among EU27 and non-EU27 categories
2003 – 2006	Direct aggregation from JMQ and NSI; "Unknown citizenship" category added to non-EU27 categories
2007	Data Provided by Belgian NSI
2008	Direct aggregation, 'Unknown' category added to non-EU27

3.2. Bulgaria

The estimations for Bulgaria were produced using the cohort-wise interpolation method between Census of 1 March 2001 and 2008 data directly aggregated from the JMQ. When estimating the shares of broad citizenship groups in the Census, the "Other" category was distributed proportionally between nationals, EU27 and non-EU27 foreigners.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2008
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2008
Population by citizenship, sex and age	DEMO Census2001 JMQ2008	DEMO Census2001 JMQ2008	DEMO Census2001 JMQ2008	DEMO Census2001 JMQ2008	DEMO Census2001 JMQ2008	DEMO Census2001 JMQ2008	JMQ2008

Summary of used estimations methods

Year	Method
2002 – 2007	Total population by age and sex taken from DEMO. Population by citizenship, sex and age estimated using cohort-wise interpolation between the 2001 Census and 2008 data.
2008	Direct aggregation of the JMQ data.

3.3. Czech Republic

For all years (2002–2008), the calculations were based on the data from the relevant validated JMQs. The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). After consultation with the NSI, the "Unknown" category, present in the data for 2005 and 2006, was identified to include foreigners. It was distributed proportionally among EU27 and non-EU27 categories.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories (2005 and 2006 only).

3.4. Denmark

The Joint Migration Questionnaire data on population stocks by age, sex and citizenship in Denmark for the period 2002–2006 are complete. For 2007-2008 the JMQ data are inconsistent with DEMO. These data were obtained from the NSI webpage (and ensured that they are consistent with DEMO): http://www.statbank.dk/statbank5a/default.asp?w=1024.

Danish data on population stocks by citizenship, sex and age were directly aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*) from the JMQ. The stateless population, ranging from 5,200 in 2002 to 3,600 in 2006, was allocated to the non-EU27 foreigners. The population with unknown citizenship (around 95 per year) was distributed proportionally among EU27 and non-EU27 categories. The estimates for 2002–2006 were computed earlier by NIDI.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2006	Direct aggregation from JMQ; "Unknown citizenship" category distributed among EU27 and non-EU27 categories
2007 – 2008	Direct aggregation from NSI data; "Unknown citizenship" category distributed among EU27 and non-EU27 categories

3.5. Germany

The estimations for Germany were produced using two types of data, following the methodology used by the German NSI.

1. Data on total foreigners and total German nationals (in each case by sex and age), produced using the component method (*Bevölkerungsfortschreibung*) based on the census of 25th May 1987.
2. Data on foreigners by citizenship, sex and age from the Central Register of Foreigners (CRF).

The required *Bevölkerungsfortschreibung* data were received from the NSI for 2002–2004 and taken from the JMQ for 2005–2006. As for the data from the Central Register of Foreigners, the following data (by sex and age) were provided by the NSI for 2002–2005: total foreigners, citizens of each EU27 country and persons of unknown citizenship. For 2006, the CRF data were available from the JMQ. For 2007 and 2008 the adjusted data were provided in the JMQ and they were directly aggregated.

The estimation of the number of nationals and foreigners and their sex and age structure were taken directly from the *Bevölkerungsfortschreibung* data. The distribution of foreigners into EU27 and non-EU27 foreigners was done in proportion to their shares in respective age groups according to the data from the Central Register of Foreigners. The Unknown citizenship category was distributed proportionally among EU27 and non-EU27 categories.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	Provided by NSI (BF)	Provided by NSI (BF)	Provided by NSI (BF)	JMQ 2005 (BF)	JMQ 2006 (BF)	JMQ 2007	JMQ 2008
Nationals by sex and age	Provided by NSI (BF)	Provided by NSI (BF)	Provided by NSI (BF)	JMQ 2005 (BF)	JMQ 2006 (BF)	JMQ 2007	JMQ 2008
Foreigners by sex and age	Provided by NSI (BF)	Provided by NSI (BF)	Provided by NSI (BF)	JMQ 2005 (BF)	JMQ 2006 (BF)	JMQ 2007	JMQ 2008
Foreigners by citizenship	Provided by NSI (CRF)	Provided by NSI (CRF)	Provided by NSI (CRF)	Provided by NSI (CRF)	JMQ 2006 (CRF)	JMQ 2007	JMQ 2008

BF = *Bevölkerungsfortschreibung;* CRF = Central Register of Foreigners.

Summary of used estimations methods

Year	Method
2002 – 2006	Total nationals and foreigners by age and sex taken directly from BF Foreigners disaggregated into EU27 and non-EU27 according to the shares in CRF; "Unknown citizenship" category distributed among EU27 and non-EU27 categories
2007 – 2008	Direct aggregation of the JMQ data; "Unknown citizenship" category distributed among EU27 and non-EU27 categories

BF = *Bevölkerungsfortschreibung;* CRF = Central Register of Foreigners.

3.6. Estonia

Annual data on population by citizenship, sex and age are not available for Estonia. The only data available come from the census (as of 31st March 2000), and annual data on population by age and sex are available from the Eurostat DEMO database. Annual population estimates are prepared by the NSI using the cohort-component method, based on the figures from the 2000 census and annual vital and internal migration statistics. International migration is not taken into account due to the poor quality of data. Given that, the projection method, as described in Section 2.4, could not be applied here.

The method used to estimate the population by broad group of citizenship, sex and age consists thus in the propagation of shares from the 2000 Census using 1-year groups from Census and DEMO, followed by re-aggregation to 5-year groups. Categories "Unknown age" and "Unknown citizenship" were distributed proportionally, respectively among the well-defined age groups, and among Nationals, EU27 and non-EU27 citizens. The citizenship distribution of the considered cohort in the previous year was directly applied to all cohorts except the first and the last one in each year starting from the year 2000. Since the census date, already offset from the beginning of the estimation period by 1¾ year, is close to 1st January 2000 the distribution of the census population by age groups, sex and citizenship is assumed to be representative for 1st January 2000.

In the calculations, an assumption of equal distributions by citizenship for all single-year age groups within a relevant five-year one was kept. However, as mentioned above, the current computations were directly based on the data for five-year age groups. The main rationale for this simplification is a small population size of Estonia. The first and the last cohort are disaggregated using the citizenship composition of the first and last age group in the previous year or at the census date.

The census data on population by citizenship, age and sex was obtained from the NSI website, at:
http://pub.stat.ee/px-eb.2001/I_Databas/Population_census/03Citizenship/03Citizenship.asp

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	DEMO estimates for 2001	DEMO estimates for 2002	DEMO estimates for 2003	DEMO estimates for 2004	DEMO estimates for 2005	DEMO estimates for 2006	DEMO estimates for 2007

All population estimates based on the census of 31st March 2000.

Summary of used estimations methods

Year	Method
2002 – 2008	Simplified cohort-wise weights propagation method using 5-year age groups from the census 2000 and DEMO; "Unknown age" and "Unknown citizenship" distributed proportionally, respectively among the well-defined age groups, as well as among the Nationals, EU27 and non-EU27 categories

3.7. Ireland

Data on the population of Ireland by citizenship, sex and age are available from the censuses in 2002 and 2006, by five-year age groups and sex in DEMO, and by sex and broad group of citizenship (Nationals and foreigners) in MIGR. The only other source of annual data on the number of foreigners by broad group of citizenship is the Labour Force Survey (LFS), in which however, population numbers for individual nationalities can not be estimated.

Moreover, the numbers of Bulgarian and Romanian citizens are not available from the 2006 census data, since the EU was comprised of 25 countries at the time of the census. The number of Bulgarian and Romanian citizens was therefore estimated by applying the ratio of EU27/EU25 citizens calculated from the 2002 census to the 2006 data on EU25 foreigners.

The initial estimation of population structure by citizenship, sex and age in the period 2003–2005 was made using cohort-wise interpolation between the two censuses. Next, the total numbers of EU27 and non-EU27 foreigners by sex were estimated using and combining annual data from MIGR and LFS. Nationals by sex were then calculated as the difference between total population by sex from DEMO and the estimates for foreigners.

For 2007–2008 the estimates were obtained by the IPF. For 2008, the IPF initial figures were the LFS data from the JMQ disaggregated from broad to 5-year age groups using the 2006 census proportions, while for 2007 – the average shares from the 2006 and 2008 estimates, applied to DEMO totals.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	census 2002	MIGR+LFS	MIGR+LFS	MIGR+LFS	census 2006	DEMO JMQ 2008 census 2006	DEMO JMQ 2008 census 2006

LFS = *Labour Force Survey.*

Summary of used estimations methods

Year	Method
2002	Aggregation from census 2002; proportionally adjusted to DEMO population by age and sex; "Unknown citizenship" distributed among Nationals, EU27 and non-EU27 categories
2003 – 2005	Cohort-wise interpolation between censuses using total numbers of foreigners by sex from MIGR and LFS data; proportionally adjusted to DEMO population by age and sex
2006	Aggregation from census 2006; proportionally adjusted to DEMO population by age and sex; Bulgarian and Romanian citizens estimated by applying EU27/EU25 ratio from census 2002; "Unknown citizenship" distributed among Nationals, EU27 and non-EU27 categories
2007	Initial estimates: average shares from the 2006 and 2008 estimates, adjusted to DEMO totals; followed by an IPF, in order to adjust the estimates to 2007 DEMO population by age and sex, and to marginal (also averaged) citizenship shares
2008	Initial estimates: 2008 LFS data from the JMQ disaggregated from broad to 5-year age groups using the 2006 census proportions; followed by an IPF, in order to adjust the estimates to the 2008 DEMO population by age and sex, and to 2008 LFS/JMQ citizenship shares

3.8. Greece

The data on Greece available in the Eurostat databases are the census of 18th March 2001, as well as the stocks by five-year age groups in DEMO. The only source of annual data on the number of foreigners and composition by age groups, sex and citizenship is the Labour Force Survey (LFS), in which however, population numbers for individual nationalities can not be estimated. Thus, the following data are available.

1. Population by five-year age groups, sex and citizenship (*N*, *EU*, *nEU*) from the census of 18th March 2001
2. Population by five-year age groups and sex in 2002-2008 from the DEMO section of the Eurostat database
3. Population by age groups (0–14, 15–19, 20–24, … , 70–74, 75+), sex and broad group of citizenship (Nationals, foreigners) and population by sex and broad group of citizenship (2002–2004: Nationals, EU15 foreigners, non-EU15 foreigners; 2005–2008: Nationals, EU27 foreigners, non-EU27 foreigners) from the LFS
4. Population by sex and broad group of citizenship (Nationals, foreigners) in 2002 and 2004 from the JMQ. There are data provided to JMQ in 2005-2008, but the figures are inconsistent (significantly smaller) with the estimated by the NSI number of foreigners in 2004, hence they are not used in computations.

The initial age and sex distribution of Nationals, EU foreigners, non-EU foreigners in the period 2002-2008 is taken from the LFS. First missing cell values (due to low sample sizes) were estimated using iterative proportional fitting (IPF). Since no age distribution of EU and non-EU foreigners is available from the LFS, the age distributions are assumed identical (which seems justified by the census 2001 data). Secondly, the numbers of EU27 foreigners for 2002-2004 were estimated from either the number of EU15 (2002–2004) available from the LFS using the EU27 to EU15 ratio available from the census 2001 assuming constant ratios in the period 2001–2004. Next, the estimated total numbers of EU27 and non-EU27 foreigners in 2002–2008 were adjusted to be in line with the total numbers from JMQ in 2002 and 2004 (that is, numbers are in line with JMQ and time trend is in line with LFS). Finally, the estimated distributions from combining LFS, JMQ and census 2001 census data were proportionally adjusted to fit the margins of the DEMO population by age group and sex.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	LFS JMQ2002 census	LFS census	LFS JMQ2004 census	LFS census	LFS census	LFS census	LFS census

Census = census 18th March 2001; LFS = *Labour Force Survey.*

Summary of used estimations methods

Year	Method
2002 – 2004	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimation of EU15 foreigners by age assuming identical age distribution of EU15 and non-EU15, and of EU27 foreigners from EU15 foreigners in LFS by applying census 2001 ratio EU27/EU15; Estimates proportionally adjusted to DEMO population by age group and sex
2005 – 2008	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimates proportionally adjusted to DEMO population by age group and sex

3.9. Spain

The register-based JMQ data on population stocks in Spain for the period 2002–2008 are complete. For years 2002-2004 the data were obtained by courtesy of Spanish NSI. All estimates obtained by direct aggregation into the three citizenship categories of interest. The estimates for 2005 and 2006 were computed earlier by NIDI.

The stateless population, ranging from 520 to 730, was allocated to the non-EU27 foreigners.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	NSI	NSI	NSI	JMQ2005	JMQ2006	JMQ2007	JMQ2008
Total population by sex and age	NSI	NSI	NSI	JMQ2005	JMQ2006	JMQ2007	JMQ2008
Population by citizenship, sex and age	NSI	NSI	NSI	JMQ2005	JMQ2006	JMQ2007	JMQ2006

Summary of used estimations methods

Year	Method
2002 – 2008	Direct aggregation from JMQ

3.10. France

For 1 January 2005 and 2006, the sex, age and citizenship structure were assumed that of the rolling census for 2005 (JMQ data for mid-2005) and fitted to the DEMO population. The same approach was followed for 1 January 2007 and 2008, based on the JMQ data for mid-2007[2].

For 2002–2004 the sex, age and citizenship structure was assumed that of the Labour Force Survey (LFS) and proportionally fitted to DEMO data. The proportion of EU27/EU15 was calculated using the proportion EU27/EU15 from the 2005 JMQ data.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	LFS DEMO JMQ2005	LFS DEMO JMQ2005	LFS DEMO JMQ2005	DEMO JMQ2005*	DEMO JMQ2005*	DEMO JMQ2007*	DEMO JMQ2007*

* Rolling census data; LFS = *Labour Force Survey.*

Summary of used estimations methods

Year	Method
2002 – 2004	Estimation of EU27 foreigners from EU15 foreigners in LFS by applying census mid-2005 ratio EU27/EU15 (JMQ 2005), proportionally adjusted to DEMO totals by age group and sex
2005 – 2006	Rolling census figures for mid-2005 (JMQ 2005), proportionally adjusted to the respective DEMO population totals by age group and sex
2007 – 2008	Rolling census figures for mid-2007 (JMQ 2007), proportionally adjusted to the respective DEMO population totals by age group and sex

[2] For the JMQ 2007, the age-specific totals were probably erroneous, since they replicated the ones from the 2005 JMQ. The distribution by citizenship, however, was totally different than the 2005 one, and this was in line with the expectations (e.g. shift towards more migrants from Central and Eastern Europe after the partial opening of French labour markets in 2006–7). The adopted solution was thus to take only the structure from the JMQ and re-adjust it to the totals from DEMO, themselves reflecting an increase in population size due to migration. It was judged that this solution would be anyway more exact than the rough approximations based on the LFS.

3.11. Italy

For Italy, the data on population stocks by sex and age or by sex and citizenship as of 1st January are available from the NSI website for the period 2003–2008. Additionally, the distribution of the number of all foreigners by sex and age is available for 2003–2008.

Since the census date (21st October 2001) was close to 1st January 2002, the distribution of the census population by age groups, sex and citizenship was proportionally adjusted to the marginal totals from the DEMO database, yielding the estimates for 1st January 2002. In case of the census data, Stateless persons were allocated to non-EU27 foreigners.

For 2003–2008, the number and the age-sex structure of Nationals were calculated directly from the data available on the NSI website, as the difference between the figures for total population and for the foreigners. The missing data on the distribution of Foreigners by broad citizenship, sex and age were estimated using an iterative proportional fitting method (see Section 2.5.3). To derive the starting points for the procedure, cohort-wise shares propagation from the 2001 census was used.

Given the large amount of information on population stocks readily available from various sources, and patchy information on the vital, migratory and regularisation events, simpler estimation methods (proportional fitting) have been found preferable towards more complex ones (projections), the latter requiring many more assumptions on the distribution of events by sex, age and citizenship.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	census DEMO	NSI	NSI	NSI	NSI	NSI	NSI
Total population by sex and age	census DEMO	NSI	NSI	NSI	NSI	NSI	NSI
Population by citizenship, sex and age	census DEMO	NSI	NSI	NSI	NSI	NSI	NSI

Census = census 21st October 2001, NSI: website of the National Statistical Institute (http://demo.istat.it).

Summary of used estimations methods

Year	Method
2002	Aggregation from the census, proportional adjustment to marginal totals from DEMO;
2003 – 2008	IPF of age, sex and citizenship structure to known age, sex and citizenship table margins. Starting points obtained via cohort-wise shares propagation from the 2001 census.

3.12. Cyprus

Data on the population of Cyprus by citizenship, sex and age have been provided were available only for the census of 1st October 2001, as well as for the annual stocks by five-year age groups in DEMO. The only source of annual data on the number of foreigners and composition by age groups, sex and citizenship is the Labour Force Survey (LFS), in which however, population numbers for individual nationalities can not be estimated.

Since the census date was close to 1st January 2002 the distribution of the census population by age groups, sex and citizenship is assumed to be representative for 1st January 2002. The census distribution was proportionally adjusted to fit the margins of the DEMO population by age and sex.

The initial age and sex distribution of Nationals, EU foreigners, non-EU foreigners in the period 2003–2008 was taken from the LFS. First missing cell values (due to low sample sizes) were estimated using iterative proportional fitting (IPF). Secondly, the numbers of EU27 foreigners were estimated from either the number of EU15 (2002–2004) or EU25 foreigners (2005–2006) available from the LFS. The ratios of EU27 to EU15 and EU27 to EU25 populations, available from the 2001 census were used for this purpose. For 2007–2008, no adjustments were necessary, since all the data were available for EU27. Finally, the estimated distributions from combining LFS and 2001 census data were proportionally adjusted to fit the margins of the DEMO population by age and sex.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	census	LFS + census	LFS + census	LFS + census	LFS + census	LFS + census	LFS + census

Census = census 1st October 2001; LFS = *Labour Force Survey.*

Summary of used estimations methods

Year	Method
2002	Aggregation from census 2001; data proportionally adjusted to DEMO population by age group and sex
2003 – 2006	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimation of EU27 foreigners from EU15 foreigners in LFS by applying census 2001 ratios. Estimates proportionally adjusted to DEMO population by age group and sex
2007 – 2008	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimates proportionally adjusted to DEMO population by age group and sex

3.13. Latvia

Calculations for the years 2003–2008 were made directly using the data from the relevant validated JMQs, aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*).

For 2002, the age structure and citizenship structure were available only separately from the JMQ, and the joint distribution has been obtained via the iterative proportional fitting method (for details, see Section 2.5.3). For the IPF, information from the 2003 JMQ was used as a starting point.

In all cases, Latvian non-citizens were moved from the category of nationals to non-EU foreigners, and their age distribution was assumed the same as for all Latvians (original code LV in the JMQ), except for 2008, where the breakdown by age was provided in the JMQ. After consultation with the NSI, the "Unknown" category was assumed to include non-EU27 citizens only.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002, 2003	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002, 2003	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002, 2003	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002	IPF with known marginal totals starting from the joint distribution for 2003; "Unknown citizenship" treated as non-EU27 citizens.
2003 – 2008	Aggregation; "Unknown citizenship" treated as non-EU27 citizens.

3.14. Lithuania

For 2005–2008, the calculations were based on the data from the relevant validated JMQs. The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). The "Unknown" category in 2007 and 2008, according to the recommendation from the Lithuanian NSI, was assumed to include non-EU27 foreigners only. Stateless persons have been counted as non-EU citizens.

For 2002–2004, the estimations were performed using the cohort-wise interpolation, described in Section 2.3. The interpolation was done between 6 April 2001 (Census data) and 1 January 2005 (JMQ data). When estimating the shares of broad citizenship categories in the census, the "Other" category was distributed between nationals, EU27 and non-EU27 foreigners.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	JMQ2005	JMQ2006	JMQ2007	JMQ2008
Total population by sex and age	DEMO	DEMO	DEMO	JMQ2005	JMQ2006	JMQ2007	JMQ2008
Population by citizenship, sex and age	DEMO, 2001 Census, JMQ 2005	DEMO, 2001 Census, JMQ 2005	DEMO, 2001 Census, JMQ 2005	JMQ2005	JMQ2006	JMQ2007	JMQ2008

Summary of used estimations methods

Year	Method
2002 – 2004	Cohort-wise interpolation of citizenship shares between the 2001 census and 1st January 2005. The "Other" category appearing in the census data was distributed between nationals, EU27 and non-EU27 foreigners
2005 – 2008	Aggregation; 'Unknown' category added to non-EU27

3.15. Luxembourg

For Luxembourg the estimates were based on the census of 15th February 2001, DEMO, data from MIGR part of the Eurostat database (2003-2006) and LFS data for 2001-2008 and JMQ data for 2007 and 2008. The data from JMQ 2005 and 2006 were not used as they were different from the totals in DEMO. The only source of annual data on the number of foreigners and composition by age groups, sex and citizenship is the Labour Force Survey (LFS), in which however, population numbers for individual nationalities can not be estimated. The following data are available.

1. Population by five-year age groups, sex and citizenship (*N*, *EU*, *nEU*) from the 2001 census
2. Population by five-year age groups and sex in 2002-2006 from the DEMO section of the Eurostat database
3. Population by sex and broad group of citizenship (Nationals, foreigners) in 2003-2006 from the MIGR section of the Eurostat database (2003 not broken down by sex)
4. Population by age groups (0–14, 15–19, 20–24, … ,70–74, 75+), sex and broad group of citizenship (Nationals, foreigners) and population by sex and broad group of citizenship (2002–2004: Nationals, EU15 foreigners, non-EU15 foreigners; 2005–2006: Nationals, EU25 foreigners, non-EU25 foreigners) from the LFS

The initial age and sex distribution of Nationals, EU foreigners, non-EU foreigners in the period 2002-2008 is taken from the LFS (EU15 in 2002-2004 and EU27 in 2005-2008). First missing cell values (due to low sample sizes) were estimated using iterative proportional fitting (IPF). Secondly, the numbers of EU27 foreigners were estimated from the number of EU15 for 2002–2004 available from the LFS using the EU27 to EU15 ratios available from the census 1999 assuming constant ratios in the period 2001-2004. Next the total numbers of EU27 and non-EU27 foreigners by sex is proportionally adjusted using and combining annual data from MIGR and LFS. Finally, the estimated distributions from combining LFS, and census 2001 census data were proportionally adjusted to first fit the margins of the MIGR population by sex and broad group of citizenship and secondly the margins of the DEMO population by age group and sex. For 2007 and 2007 the number of foreigners (by sex and age) is taken from JMQ, EU27 and nonEU27 structure is assumed as in the LFS data.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2007	JMQ2008
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2007	JMQ2008
Population by citizenship, sex and age	LFS + census	LFS + MIGR + census	LFS + MIGR + census	LFS + MIGR + census	LFS + MIGR + census	LFS + census JMQ2007	LFS + census JMQ2008

Summary of used estimations methods

Year	Method
2002 – 2004	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimation of EU27 foreigners from EU15 foreigners in LFS by applying census 2001 ratio EU27/EU15; proportional adjustment to MIGR population by sex and citizenship Estimates proportionally adjusted to DEMO population by age group and sex
2005 – 2006	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Proportional adjustment to MIGR population by sex and citizenship; Estimates proportionally adjusted to DEMO population by age group and sex
2007 – 2008	IPF of missing cells in LFS distribution by five-year age groups, sex and broad citizenship; Estimates proportionally adjusted to JMQ foreigners and DEMO population by age and sex

3.16. Hungary

For 2004–2008, the calculations were based on the data from the relevant validated JMQs. The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*).

For 2002–2003, the data on the number of Hungarian nationals was missing in the JMQ and was estimated as a difference between sex and age specific totals from DEMO and the corresponding numbers on foreigners from the JMQ.

For 2005, 2006 and 2008 "Other Europe", after consultation with the NSI identified to include persons who arrived to Hungary as citizens of the Soviet Union and Czechoslovakia, was assigned to non-EU27 foreigners.

After consultation with the NSI, the "Unknown" category was identified as non-EU citizens. Where available, citizens of former Czechoslovakia was included to the EU27 category.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	DEMO	DEMO	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	DEMO, JMQ 2002	DEMO, JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2004	Total taken from DEMO. EU27 and non-EU27 foreigners aggregated from the JMQ. Nationals calculated as a difference. "Unknown" and "Other Europe" categories added to the "non-EU27 foreigners" category
2005 – 2008	Aggregation. "Unknown" and "Other Europe" categories added to the "non-EU27 foreigners" category

3.17. Malta

For Malta, there are no annual data on population by citizenship, sex and age in the JMQ for the period 2002–2007. The NSI website contains demographic yearbooks with information on the total and national (Maltese) population distributed by sex and age. Desegregation of foreigners by citizenship is not available from the published sources.

Figures on total population by ten-year age groups, sex and citizenship (most important categories including EU25 but missing Bulgaria and Romania) from the population census of 27th November 2005 are available at the NSI's website. The structure of the population for 1 January 2006 was therefore obtained by proportional adjustment to the DEMO population assuming the structure from the Census. Since no information was available on the number of Bulgarians and Romanians, the number of EU25 foreigners is assumed to be representative for the number of EU27 foreigners.

The NSI data for 2002–2005 do not include a breakdown of foreigners by EU and non-EU foreigners. Therefore, the share of EU foreigners within all foreigners was assumed to equal the one from the 2005 census. The missing data on the distribution of foreigners by broad citizenship (EU27 and non-EU27), sex and five-year age groups was estimated using an iterative proportional fitting (IPF) method. Starting backwards from 1 January 2005 (itself adjusted to the known margins by age and sex), for each sex, an initial estimate based on the succeeding year was iteratively adjusted to the known age structure of foreigners and the known breakdown by citizenship.

Since for 2008 the complete set of data was available in the JMQ, the relevant figures were simply re-aggregated into the groups of interest. For 2007, the estimation of the age-citizenship structure of Foreigners was performed using the iterative proportional fitting procedure. The sex-age face was available from the 2007 JMQ, and in the sex-citizenship face, the share of EU27 group in the total Foreigners was assumed to be average of the 2006 and 2008 shares. As a starting point, the averaged age-sex-citizenship structures from 2006 and 2008 were used as approximation.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ 2007	JMQ 2008
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	NSI census	NSI census	NSI census	NSI, DEMO census	DEMO census	DEMO census JMQ 2008	JMQ 2008

Census = census 27th November 2005; NSI = website of the National Statistical Institute (http://www.nso.gov.mt).

Summary of used estimations methods

Year	Method
2002 – 2005	IPF of age, sex and citizenship structure to known age, sex and citizenship table margins Starting point: back-propagation of shares, starting from the 2005 census
2006	Direct aggregation from the 2005 census, adjusted to the 2006 population totals from DEMO
2007	IPF of age, sex and citizenship structure to known age, sex and citizenship table margins. Starting point: average shares of EU and non-EU foreigners for 2006 and 2008
2008	Direct aggregation from the JMQ 2008

3.18. The Netherlands

The Joint Migration Questionnaire data on population stocks by age, sex and citizenship in the Netherlands for the period 2002–2008 are complete. The data on population by age and sex are consistent between the JMQ and the Eurostat DEMO database. Dutch data on population stock by citizenship, sex and age were directly aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*) from the JMQ. The stateless population, ranging from 8,400 in 2003 to 4,800 in 2006, was allocated to the non-EU27 foreigners. The population with unknown citizenship (around 100,000 per year) was distributed proportionally among EU27 and non-EU27 categories. The calculations for 2002–2006 were prepared earlier by NIDI.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Direct aggregation from JMQ; "Unknown citizenship" category distributed among EU27 and non-EU27 categories

3.19. Austria

The Joint Migration Questionnaire data on population stocks by age, sex and citizenship in Austria for the period 2002–2008 are complete. The data on population by age and sex are consistent between the JMQ and the Eurostat DEMO database. Austrian data on population stock by citizenship, sex and age were directly aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*) from the JMQ. The stateless population (around 1,600 per year) was allocated to the non-EU27 foreigners. The population with unknown citizenship, ranging from 29,000 in 2002 to 14,000 in 2006, was distributed proportionally among EU27 and non-EU27 categories. The calculations for 2002–2006 were prepared earlier by NIDI.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Direct aggregation from JMQ; "Unknown citizenship" category distributed among EU27 and non-EU27 categories

3.20. Poland

The estimations for Poland were produced using the cohort-wise interpolation method between Census of 20 May 2002 and the 2007 aggregates from the JMQ. For 2007 and 2008 data were directly aggregated from the JMQ. When estimating the shares of broad citizenship groups in the Census, the "Unknown citizenship" category was distributed proportionally between nationals, EU27 and non-EU27 foreigners, while "Unknown foreigners" were distributed proportionally between EU27 and non-EU27 foreigners. In 2007 and 2008 the "Unknown" were distributed proportionally among nationals, EU27 and non-EU27 foreigners (according to the NSI suggestion).

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2007	JMQ2008
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2007	JMQ2008
Population by citizenship, sex and age	DEMO, 2002 Census	DEMO Census2002 JMQ2007	DEMO Census2002 JMQ2007	DEMO Census2002 JMQ2007	DEMO Census2002 JMQ2007	JMQ2007	JMQ2008

Summary of used estimations methods

Year	Method
2002 – 2006	Total population by age and sex taken from DEMO. Population by citizenship, sex and age estimated using cohort-wise interpolation between the 2002 Census and 2007 JMQ aggregates.
2007 – 2008	Direct aggregation from the JMQ, "Unknown" distributed proportionally among EU27 and nonEU27.

3.21. Portugal

The estimations for Portugal for years 2002-2004 were based on the data on foreigners available at the Portugal Ministry of Interior (SEF, http://www.sef.pt, data on 31 December) and DEMO age and sex structure. The data on foreigners for 2002-2003 are available in the JMQ, they are marked as provisional, though. Hence the priority was given to SEF data that are marked as final. SEF data, i.e. age, sex and citizenship structure of foreigners - residents (*POPULAÇÃO ESTRANGEIRA RESIDENTE*) were aggregated, sex and citizenship structure of the foreigners with stay permits (*AUTORIZAÇÕES DE PERMANÊNCIA CONCEDIDAS*) was adjusted to age structure of the residents and added to them. Nationals were calculated as a difference between DEMO totals and foreigners. It should be noted that the stay permits were included in the total population as for 2008 these is the case in the JMQ data. On the SEF webpage http://www.sef.pt/img/55/Grafico_80_08_.JPG figure shows the structure of foreigners in the period 1981-2009.

For 2005 estimations are the same as for previous years, but the last age group in the SEF data is 65+. It was distributed proportionally assuming the age structure of this group as in 2004.

For 2006 age (up to 65+), sex and citizenship structure to the residents, foreigners with stay permits and foreigners with long term visas (*PRORROGAÇÕES DE VISTOS DE LONGA DURAÇÃO*) was available (they are included in the total population following JMQ 2008 data) and was aggregated. Nationals were calculated as a difference. 65+ age group was distributed proportionally to the 2004 data.

For 2007 and 2008 citizenship structure is available in the JMQ. The data from SEF (age, sex and citizenship structure of residents is available only for 2007, sex and citizenship structure available for 2007 and 2008 for all groups of foreigners). For 2007 the data were aggregated, nationals calculated as a difference, 65+ age structure assumed as in 2004. For 2008 the IPF was fitted to known population age-sex (DEMO) and citizenship-sex (SEF, total nationals were available in JMQ) faces.

In all calculations 'Unknown' category distributed proportionally to EU27 and nonEU27 foreigners.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	JMQ2007	JMQ2008
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	DEMO SEF	DEMO SEF	DEMO SEF	DEMO SEF	DEMO SEF	DEMO JMQ2007 SEF	DEMO JMQ2008 SEF

Summary of used estimations methods

Year	Method
2002 – 2004	Total population by age and sex taken from DEMO. Population by citizenship, sex and age aggregated from the SEF data, Nationals calculated as a difference. "Unknown" distributed proportionally among EU27 and nonEU27.
2005 – 2007	Total population by age and sex taken from DEMO. Population by citizenship, sex and age aggregated from the SEF data (for 2007 adjusted to JMQ data on citizenship). Nationals calculated as a difference. "Unknown" distributed proportionally among EU27 and nonEU27. 65+ age structure assumed as in 2004.
2008	IPF to known age-sex face from DEMO and citizenship-sex face from SEF and JMQ (nationals)

3.22. Romania

For 2004–2006, the calculations were based on the data from the relevant validated JMQs (for 2004, the revised tables were obtained from the NSI). The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*).

The estimations for 2003 and 2003 were based on the observation that the absolute numbers of foreigners provided by the NSI for 1 January 2004 are identical to the numbers from the 2002 Census (conducted on 18 March 2002). Thus, in the current estimates, the same numbers were assumed for 1 January 2002 and 1 January 2003. The sex and age specific numbers on nationals were calculated as a difference between the corresponding numbers on total population from DEMO and the above assumed numbers on foreigners.

After consultation with the NSI, the "Unknown citizenship" category was identified as foreigners. It was distributed proportionally between EU27 and non-EU27 foreigners, while the "Other" category was added to non-EU27 citizens.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	Provided by NSI	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	DEMO	DEMO	Provided by NSI	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	DEMO, Census/NSI 2004	DEMO, Census/NSI 2004	Provided by NSI	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2003	EU27 and non-EU27 foreigners assumed the same as in the 2002 Census/JMQ 2004 data. Nationals calculated as a difference between total population from DEMO and foreigners. "Unknown" category distributed between EU27 and non-EU27 foreigners
2004 – 2008	Aggregation. "Unknown" category distributed between EU27 and non-EU27 foreigners

3.23. Slovenia

Calculations for all years (2002–2008) were made using the data from the relevant validated JMQs, aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). After consultation with the NSI, the "Unknown" category was identified to include foreigners only and was distributed proportionally among EU27 and non-EU27 categories.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories.

3.24. Slovakia

In Slovakia, the numbers on total population by sex and age published by the NSI (available from DEMO and JMQ) refer to permanent residents of Slovakia only. The data provided in the JMQ 2003–2006 are inconsistent: the numbers on total population by age and sex refer to permanent residents, while the data on foreigners by age and sex refer to foreigners with long-term residence permits. Nationals were calculated as a difference between these inconsistent numbers.

In order to ensure consistency of data, the total population was taken as given in DEMO (for 2002–2003) and in JMQ (for 2004–2008), and the total number of Foreigners equal to the number of persons with permanent residence permit. The latter data were obtained from the yearbooks of the Border and Aliens Police, downloaded from the Ministry of Interior website (http://www.minv.sk/?rocenky). Foreigners were distributed into EU27 and non-EU27 citizens, by sex and age using the shares estimated from the JMQ data on Foreigners with long-term residence permits. The "Unknown citizenship" category was distributed proportionally between EU27 and non-EU27 Foreigners.

For 2004, the distribution of Foreigners aged 70+ into 5-year age groups was missing in the JMQ. It was assumed to be the same as the 2005 age structure of Foreigners aged 70+ (separately for EU27, non-EU27 and Unknown).

For 2002 and 2003, the JMQ data are not available. For these years, the shares from the JMQ 2004 were used for estimating the number of Foreigners by broad citizenship group, sex and age.

For all years, sex- and age-specific numbers of Nationals were calculated as a difference between the total population and the estimated number of Foreigners by age and sex.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	DEMO	DEMO	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	DEMO JMQ 2004 Ministry of Interior	DEMO JMQ 2004 Ministry of Interior	JMQ 2004 Ministry of Interior	JMQ 2005 Ministry of Interior	JMQ 2006 Ministry of Interior	JMQ 2007 Ministry of Interior	JMQ 2008 Ministry of Interior

Summary of used estimations methods

Year	Method
2002 – 2003	Total foreigners assumed the same as the number of foreigners with permanent residence permit according to the Slovak Ministry of Interior data. Foreigners disaggregated into EU27 and Non-EU27 by sex and age using the shares estimated for 2004. Nationals calculated as a difference between total population taken from DEMO and estimated foreigners.
2004 – 2008	Total foreigners assumed the same as the number of foreigners with permanent residence permit according to the Ministry of Interior (www.minv.sk). Foreigners disaggregated into EU27 and Non-EU27 by sex and age using the shares from the JMQ for the given year. "Unknown citizenship" distributed proportionally between EU27 and non-EU27 foreigners. Nationals calculated as a difference between total population from the JMQ and estimated foreigners. For 2004, distribution of foreigners 70+ into 5-year age groups taken from 2005.

3.25. Finland

The Joint Migration Questionnaire data on population stocks by age, sex and citizenship in Finland for the period 2002–2008 are complete. The data on population by age and sex are consistent between the JMQ and the Eurostat DEMO database. Finnish data on population stock by citizenship, sex and age were directly aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*) from the JMQ. The stateless population (around 900 per year) was allocated to the non-EU27 foreigners. The population with unknown citizenship (around 500 per year) was distributed proportionally among EU27 and non-EU27 categories. The calculations for 2002–2006 were prepared earlier by NIDI.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Direct aggregation from JMQ; "Unknown citizenship" category distributed among EU27 and non-EU27 categories

3.26. Sweden

All calculations for 2002–2008 were made using the data from the relevant validated JMQs, aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). The "Unknown" category was assumed to include foreigners only and was distributed proportionally among EU27 and non-EU27 categories.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories

3.27. United Kingdom

In the United Kingdom, the data used to estimate population stocks come from various sources. The only source of annual data on the number of foreigners and composition by citizenship is the Labour Force Survey (LFS), in which however, population numbers for some nationalities could not be estimated due to small samples. For 2002 to 2008, the LFS data are available in the Eurostat database. In addition, for years 2005–2008 the figures for are available for EU27 / non-EU27 citizens. Moreover, data on population stocks (DEMO and LFS) are not consistent between the sources. Therefore, the total population of the UK, by sex and age, was universally taken from DEMO.

For 2002–2003, the disaggregation into nationals and foreigners was performed, separately for each sex and 5-year age group, using the shares calculated from the LFS data. The "No response" category in the LFS was assumed to include foreigners only. When calculating the shares, the number of nationals and foreigners was estimated as an average from the first quarter of the given year and the last quarter of the previous year. The common distributions by citizenship were applied to 5-year age groups belonging to the same LFS broad age group (0–14 and 75+). The partition between the EU27 and non-EU27 foreigners follows the shares estimated from the 2003 JMQ both for 2002 and 2003. The "Unknown citizenship" category in the JMQ was assumed to include foreigners only.

For 2004–2007 the JMQ data for appropriate years were proportionally adjusted to the DEMO totals.

For 2008, the structure by sex, age and citizenship was assumed to follow the 2008 LFS (an average between the surveys for Q4 2007 and Q1 2008). Also here common distributions by citizenship were applied to the broad LFS age groups (0–14 and 75+ years). Here, 'no response' was assumed to depict non-EU foreigners, since, unlike for 2002 – 2003, this year was already well after the EU enlargement.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Total population by sex and age	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO	DEMO
Population by citizenship, sex and age	DEMO LFS 2001/2 JMQ 2003	DEMO LFS 2002/3 JMQ 2003	DEMO JMQ 2004	DEMO JMQ 2005	DEMO JMQ 2006	DEMO JMQ 2007	DEMO LFS 2007/8

Summary of used estimations methods

Year	Method
2002 – 2003	Sex- and age-specific totals taken from DEMO. For each sex and age group, shares of nationals taken from the LFS (average from the LFS for Q4 of the preceding year and Q1 of the current one). Common distributions by citizenship applied to the broad LFS age groups (0–14 and 75+). Partition between EU27 and non-EU27 follows the pattern from JMQ 2003. 'No response' assumed as unknown foreigners.
2004 – 2007	Sex- and age-specific totals taken from DEMO, disaggregated by citizenship using the JMQ for a given year.
2008	Sex- and age-specific totals taken from DEMO, disaggregated by citizenship using the shares from the LFS (averages from Q4 2007 and Q1 2008). Common distributions by citizenship applied to the broad LFS age groups (0–14 and 75+). 'No response' assumed as non-EU foreigners (unlike for 2002 – 2003, this is after the EU enlargement).

3.28. Iceland

For 2002–2003, the calculations were based on the data from the relevant validated JMQs. The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). The "Unknown" category was assumed to include foreigners only and was distributed proportionally among EU27 and non-EU27 categories.

The missing data for 2004–2008 (not provided to Eurostat by the NSI) were downloaded from the NSI website (http://www.statice.is/?PageID=1174). The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). In the JMQ data for 2005 and 2006, Slovenes were included in the 'ex-Yugoslavia' category and thus in the current estimates for 2005 and 2006 they were counted as non-EU27 foreigners (however, the numbers considered are marginal: in 2004, there were 6 people altogether). The "Foreign country unknown" category was distributed proportionally among the EU27 and non-EU27 categories (for 2007 and 2008 it was zero).

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2003	JMQ 2004	NSI website	NSI website	NSI website	NSI website	NSI website
Total population by sex and age	JMQ 2003	JMQ 2004	NSI website	NSI website	NSI website	NSI website	NSI website
Population by citizenship, sex and age	JMQ 2003	JMQ 2004	NSI website	NSI website	NSI website	NSI website	NSI website

Summary of used estimations methods

Year	Method
2002 – 2003	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories
2004 – 2008	Aggregation; "Foreign country unknown" category distributed among EU27 and non-EU27 categories

3.29. Liechtenstein

The data for all years (2002–2008) were obtained from the National Statistical Institute and aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*).

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI
Total population by sex and age	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI
Population by citizenship, sex and age	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI	Provided by NSI

Summary of used estimations methods

Year	Method
2002 – 2008	Direct aggregation

3.30. Norway

The calculations for all years (2002–2008) were made using the data from the relevant validated JMQs, which were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). The "Unknown" category was assumed to include foreigners only and was distributed proportionally among EU27 and non-EU27 categories.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	JMQ 2002	JMQ 2003	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories.

3.31. Switzerland

For 2004–2008, the calculations were based on the data from the relevant validated JMQs. The data were aggregated into the three citizenship categories of interest (*N*, *EU*, *nEU*). After consultation with the NSI, the "Unknown" category was identified to include foreigners only. It was distributed proportionally among EU27 and non-EU27 categories. For 2002–2003, the revised data have been received from the NSI and followed the same aggregation principles.

Summary of data used for the estimations

Population stocks	2002	2003	2004	2005	2006	2007	2008
Total population	Provided by NSI	Provided by NSI	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Total population by sex and age	Provided by NSI	Provided by NSI	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008
Population by citizenship, sex and age	Provided by NSI	Provided by NSI	JMQ 2004	JMQ 2005	JMQ 2006	JMQ 2007	JMQ 2008

Summary of used estimations methods

Year	Method
2002 – 2008	Aggregation; "Unknown citizenship" treated as unknown foreigners and distributed among EU27 and non-EU27 categories.

4. Summary

In the current section, a brief synthetic overview of the sources, solutions and estimation methods ultimately applied for the individual countries is presented in a tabular form (Table 2).

Table 2. Available data and estimation methods for population by citizenship

Country	Data availability	Estimation methods
Belgium	2002-2003,2008: JMQ 2002-2006: NSI website 2007: NSI	2002: aggregation, adjustment 2003-2008: aggregation
Bulgaria	2001 Census, 2008: JMQ	2008: aggregation 2002-2007: interpolation
Czech Republic	2002-2008: JMQ	Aggregation
Denmark	2002-2006: JMQ 2007-2008: NSI website	Aggregation
Germany	2002-2005: NSI 2006-2008: JMQ, NSI	Aggregation, 2002-2006: Aggregation, adjustment
Estonia	2000 Census: NSI website	Shares propagation
Ireland	2002-2006, 2008: JMQ (broad age) 2002 Census, 2006 Census: NSI website	2002, 2006: adjustment 2003-2006: cohort-wise interpolation 2007-2008: IPF (combined)
Greece	2001 Census 2004, 2005-2008: JMQ (F, likely biased) LFS, NSI website	Combined methods (IPF, adjustment)
Spain	2002-2004: NSI 2005-2008: JMQ	Aggregation
France	1999 Census, 2002-2004: LFS 2005 and 2007: JMQ (rolling census)	Combined sources; adjustment
Italy	2002: Census 2003-2008: NSI website (F: partial)	2002: aggregation and adjustment 2003-2008: IPF, based on shares propagation
Cyprus	2002 Census 2003-2008: LFS	2002: adjustment 2003-2008: combined methods, adjustment
Latvia	2002: JMQ (without age) 2003-2008: JMQ	2002: IPF 2003-2008: aggregation
Lithuania	2005-2008: JMQ 2001 Census	2002-2004: interpolation 2005-2008: aggregation
Luxembourg	2007-2008: JMQ (partial), LFS, 2001 Census 2002-2006: MIGR, LFS, 2001 Census	Combined methods (IPF, adjustment)
Hungary	2002-2003: JMQ (F) 2004-2008: JMQ	Aggregation
Malta	2002-2006: NSI website (T, N) 2005 Census: NSI website 2007: JMQ (T, N), 2008: JMQ	2006: adjustment 2002-2005, 2007: Combined methods (aggregation, propagation / interpolation, IPF) 2008: aggregation
The Netherlands	2002-2008: JMQ	Aggregation
Austria	2002-2008: JMQ	Aggregation
Poland	2007-2008: JMQ 2002 Census	2002: adjustment 2003-2006: interpolation 2007-2008: aggregation

Notes: see next page

Table 2. Available data and estimation methods for population by citizenship (continued)

Country	Data availability	Estimation methods
Portugal	2007 (F, partial), 2008 (partial) 2002-2007: Ministry of Interior website (F) 2008: Ministry of Interior website (F, without age)	2002-2007: aggregation, adjustment 2008: IPF to 2007 structure
Romania	2002 Census 2004: NSI 2005-2008: JMQ	2002-2003: aggregation and adjustment (assuming F as in 2002 Census and 2004) 2004-2008: aggregation
Slovenia	2002-2008: JMQ from the NSI website	Aggregation
Slovakia	2004-2008: JMQ (inconsistencies; 2004: F) 2002-2008: Border & Aliens Police (F: partial)	Combined sources and methods (proportional fitting to the total number foreigners with permanent residence)
Finland	2002-2008:JMQ	Aggregation
Sweden	2002-2008: JMQ	Aggregation
United Kingdom	2003-2007: JMQ 2002-2008: LFS, DEMO	2002-2003, 2008: combined methods 2004-2007: adjustment
Iceland	2002-2003: JMQ 2004-2008: NSI website	Aggregation
Liechtenstein	2002-2008: NSI	2002-2008: aggregation
Norway	2002-2008: JMQ	Aggregation
Switzerland	2002-2004: NSI 2005-2008: JMQ	Aggregation

Notes: **T** – Total; **N** – Nationals; **F** – Foreigners. **Adjustment** usually depicts proportional adjustment to the data from DEMO; **Interpolation** is followed by proportional adjustment to the data from DEMO. The citizens of the former Czechoslovakia were added to EU27 (where applicable). Unless noted otherwise, 2002–2008 data on population by sex and age are complete and available in DEMO for all the countries.

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Annex: Selected age pyramids for particular countries

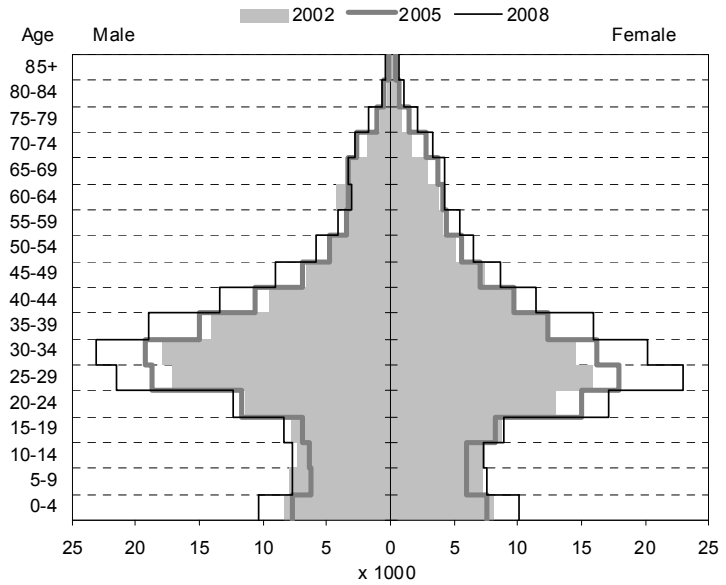
This Annex presents selected results of the estimations in the form of age pyramids. For each country, four graphs have been prepared. The first three present changes of the age pyramids in time for each broad citizenship group: nationals, foreigners – EU27 citizens and foreigners – non EU27 citizens. On these graphs the pyramids were shown for 3 years: 1 January 2002, 2005 and 2008. The fourth graph compares age pyramids of the three broad citizenship groups on 1 January 2008.

Order of countries and their abbreviations:

1.	Belgium	BE
2.	Bulgaria	BG
3.	Czech Republic	CZ
4.	Denmark	DK
5.	Germany	DE
6.	Estonia	EE
7.	Ireland	IE
8.	Greece	GR
9.	Spain	ES
10.	France	FR
11.	Italy	IT
12.	Cyprus	CY
13.	Latvia	LV
14.	Lithuania	LT
15.	Luxembourg	LU
16.	Hungary	HU
17.	Malta	MT
18.	The Netherlands	NL
19.	Austria	AT
20.	Poland	PL
21.	Portugal	PT
22.	Romania	RO
23.	Slovenia	SI
24.	Slovakia	SK
25.	Finland	FI
26.	Sweden	SE
27.	United Kingdom	UK
28.	Iceland	IS
29.	Liechtenstein	LI
30.	Norway	NO
31.	Switzerland	CH

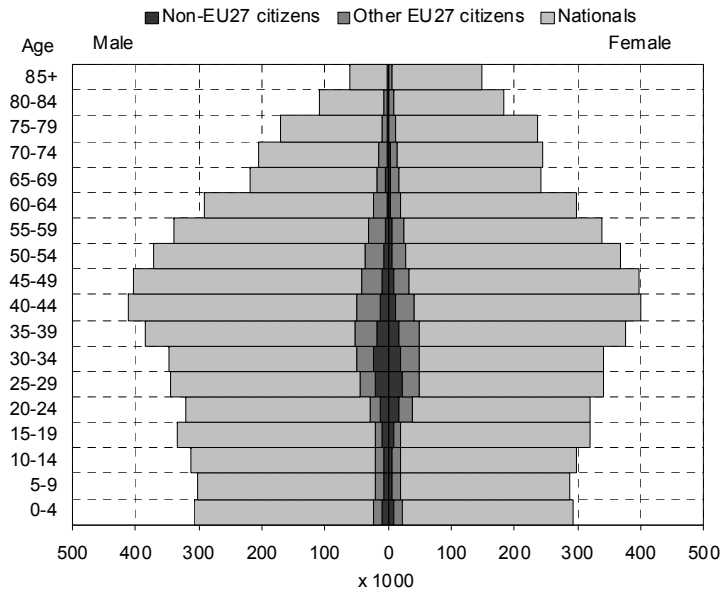
BE: Nationals by sex and age on 1 January 2002, 2005 and 2008

BE: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



BE: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

BE: Population by citizenship group, sex and age on 1 January 2008



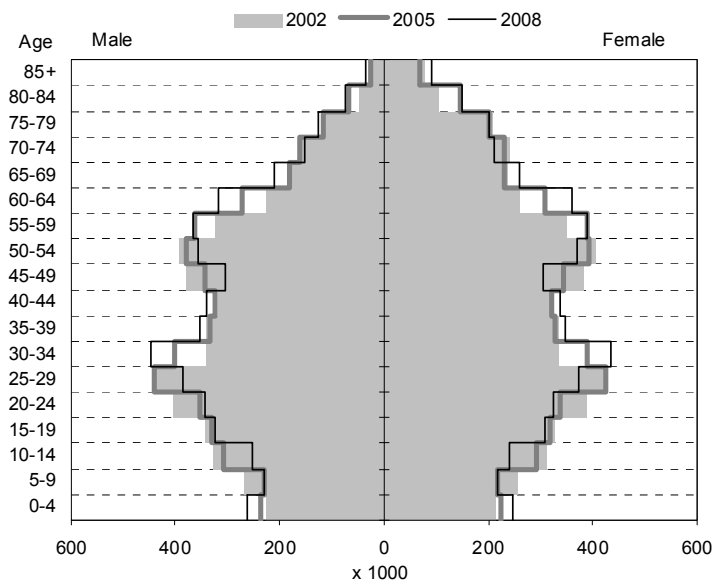
BG: Nationals by sex and age on 1 January 2002, 2005 and 2008

BG: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

BG: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

BG: Population by citizenship group, sex and age on 1 January 2008

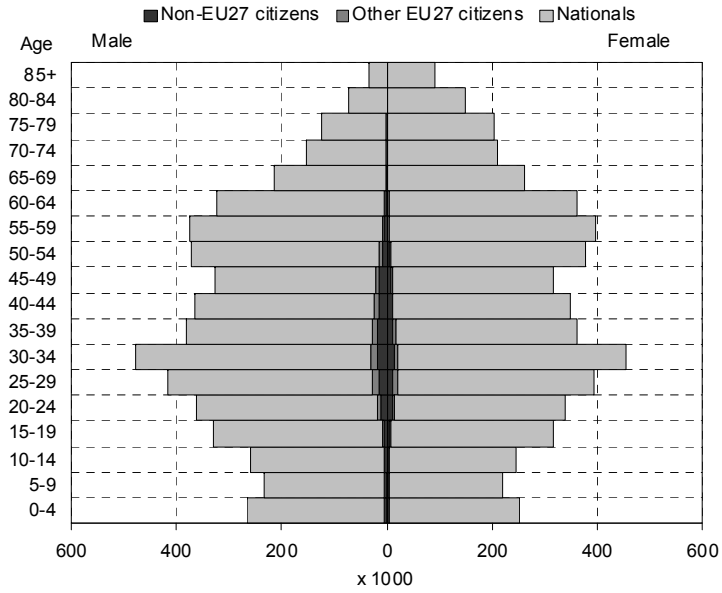
CZ: Nationals by sex and age on 1 January 2002, 2005 and 2008



CZ: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

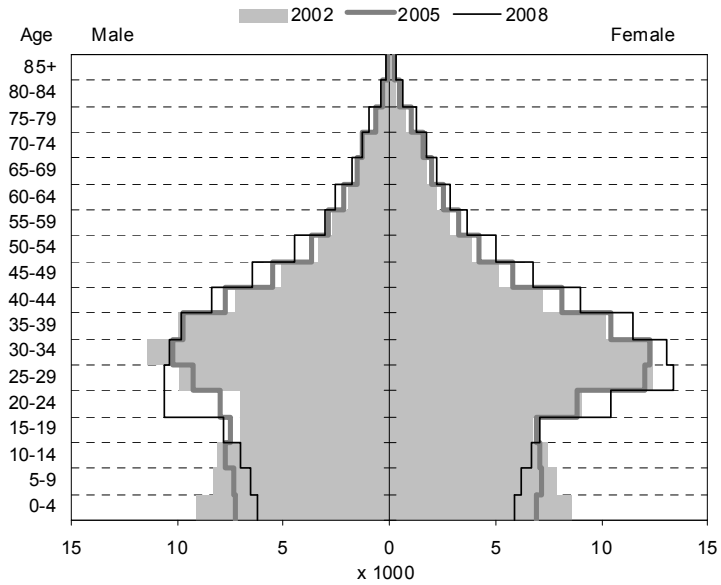
CZ: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

CZ: Population by citizenship group, sex and age on 1 January 2008

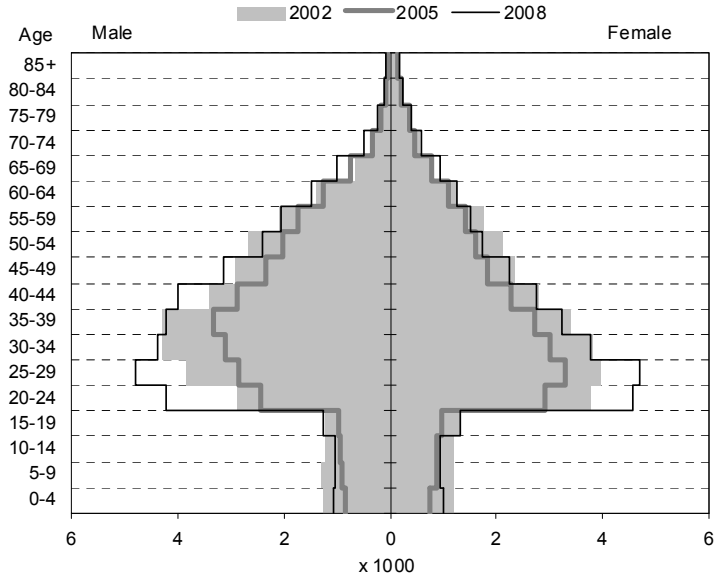


DK: Nationals by sex and age on 1 January 2002, 2005 and 2008

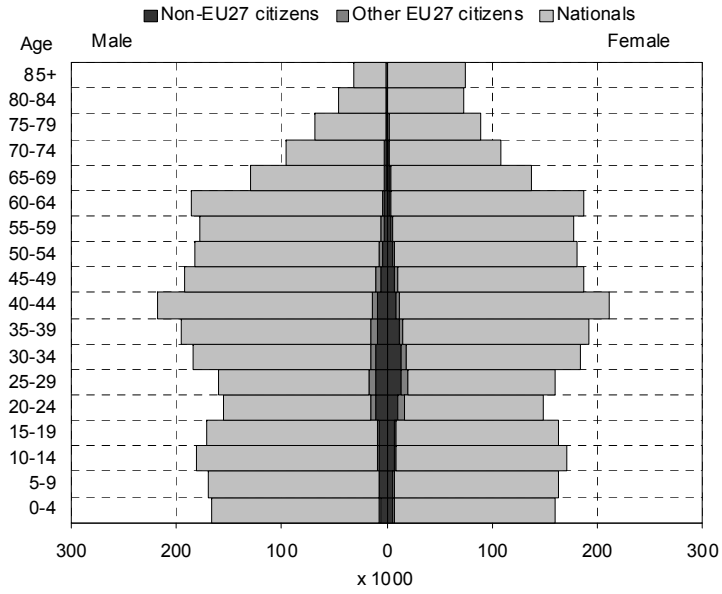
DK: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



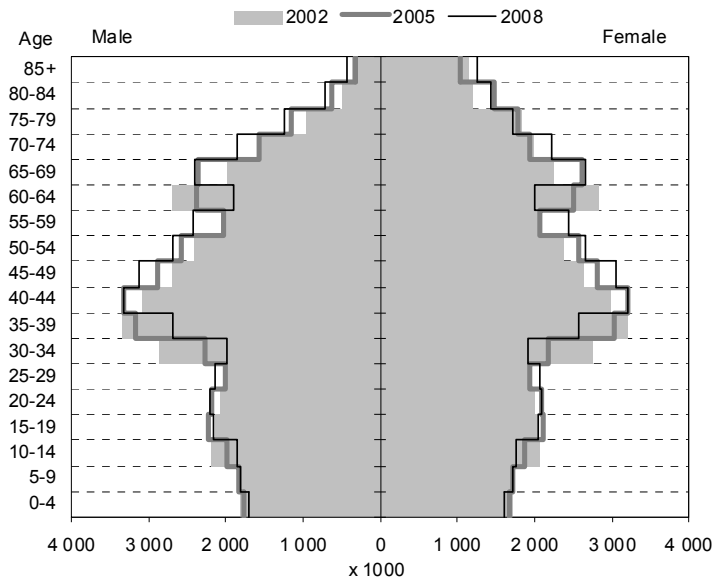
DK: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



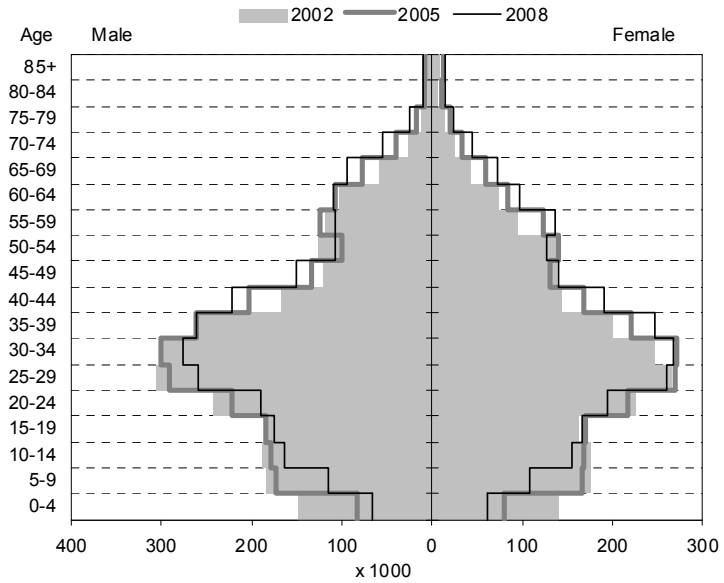
DK: Population by citizenship group, sex and age on 1 January 2008



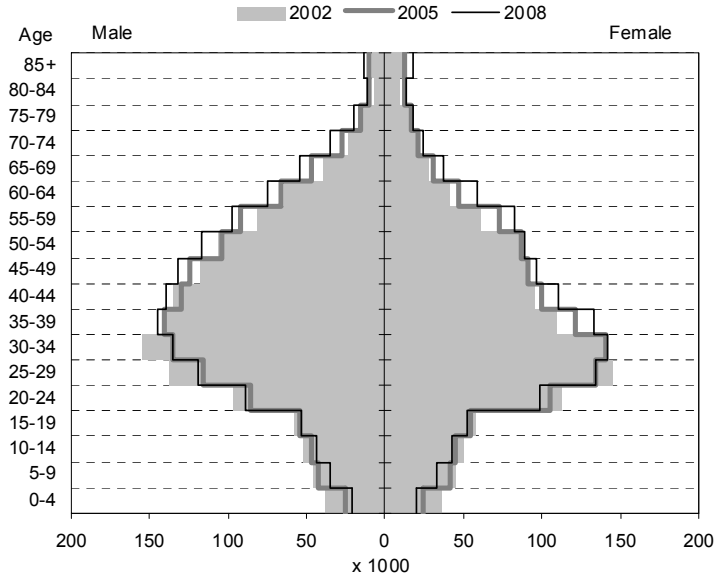
DE: Nationals by sex and age on 1 January 2002, 2005 and 2008



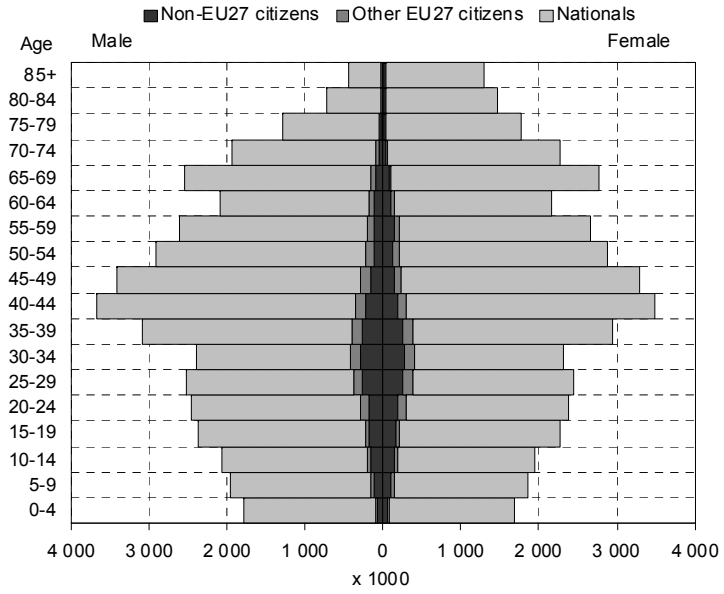
DE: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



DE: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



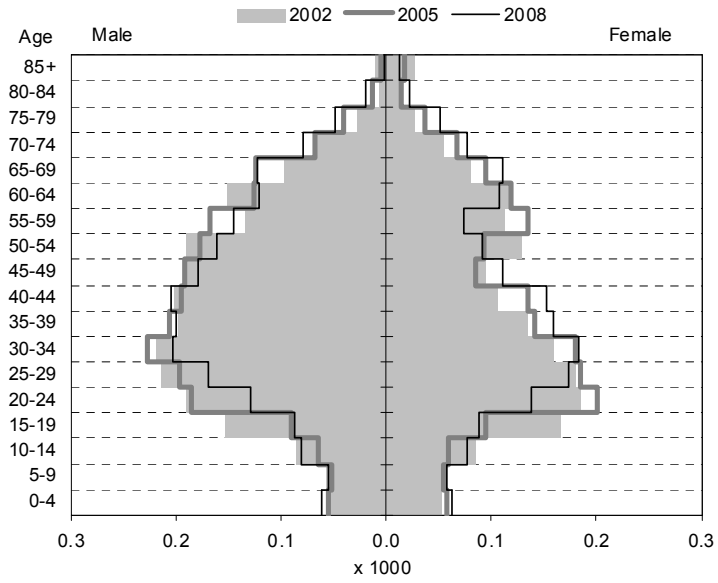
DE: Population by citizenship group, sex and age on 1 January 2008



EE: Nationals by sex and age on 1 January 2002, 2005 and 2008

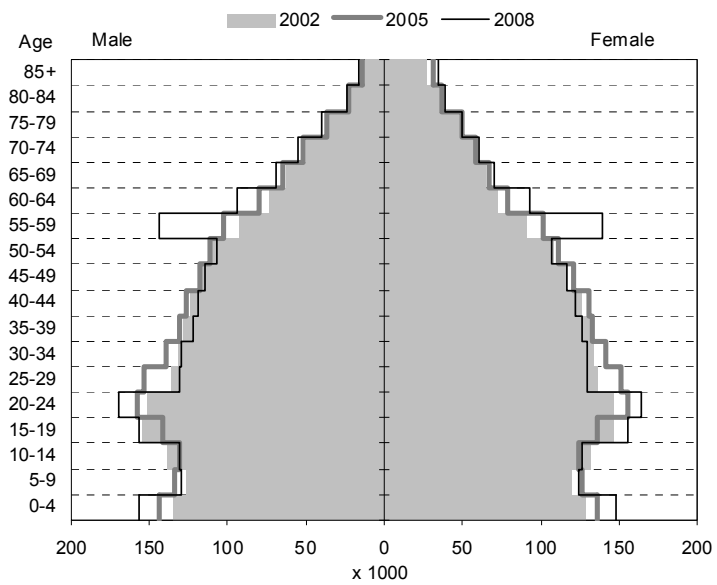
EE: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

EE: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

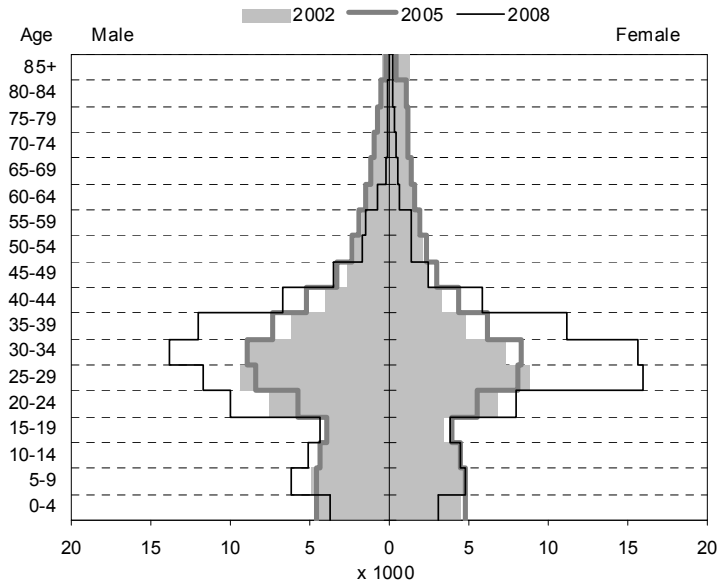


EE: Population by citizenship group, sex and age on 1 January 2008

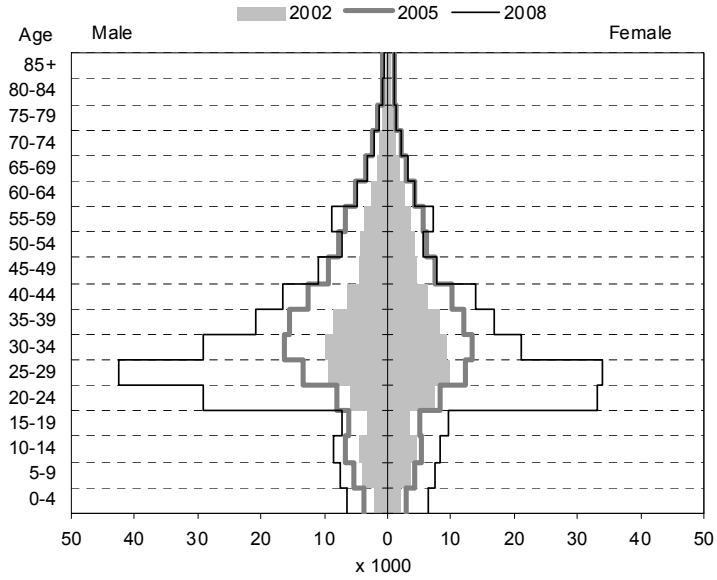
IE: Nationals by sex and age on 1 January 2002, 2005 and 2008



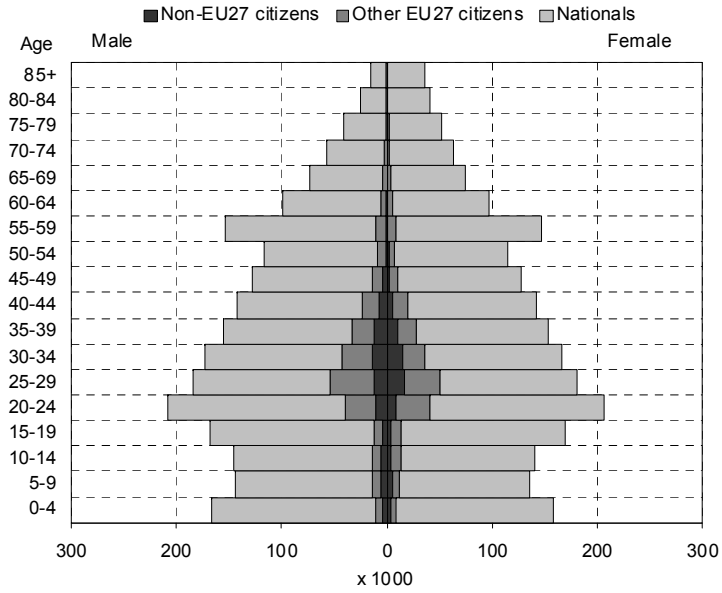
IE: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



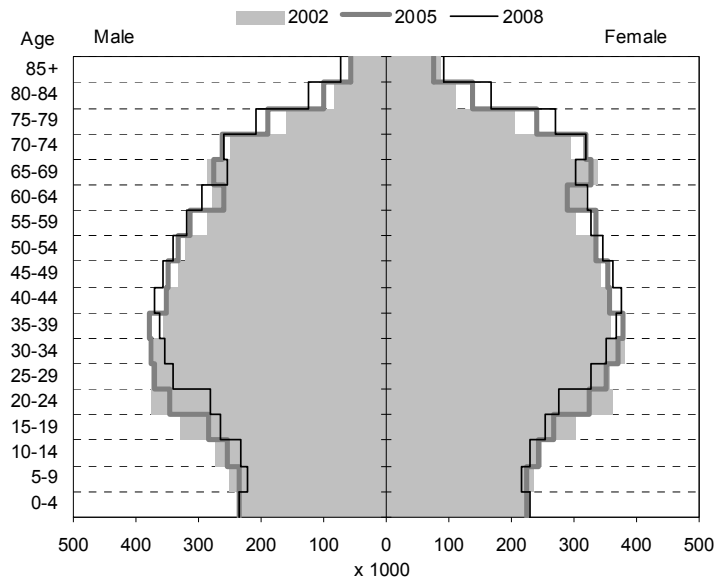
IE: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



IE: Population by citizenship group, sex and age on 1 January 2008



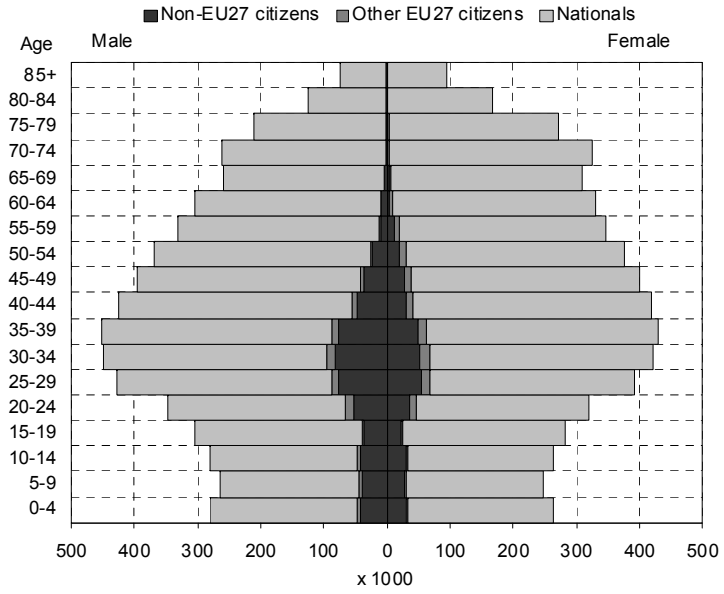
GR: Nationals by sex and age on 1 January 2002, 2005 and 2008



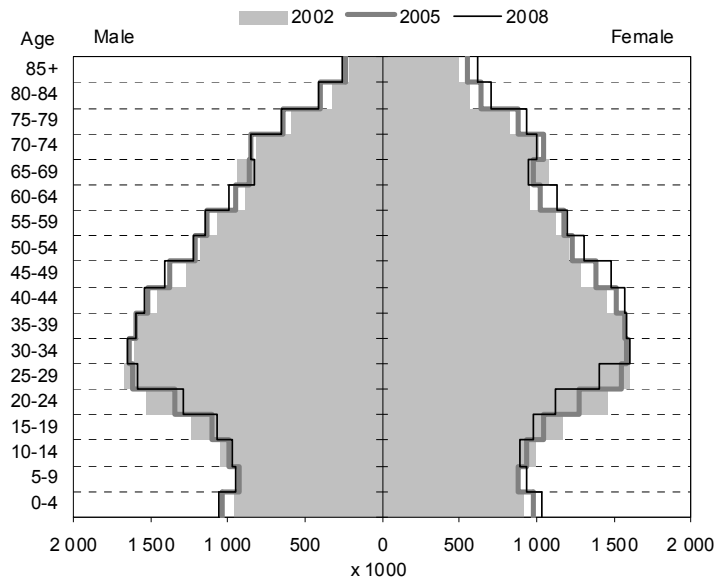
GR: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

GR: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

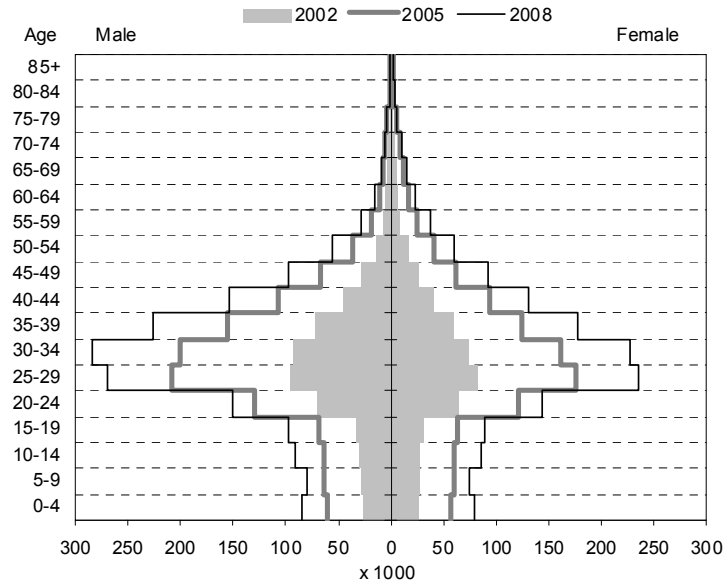
GR: Population by citizenship group, sex and age on 1 January 2008



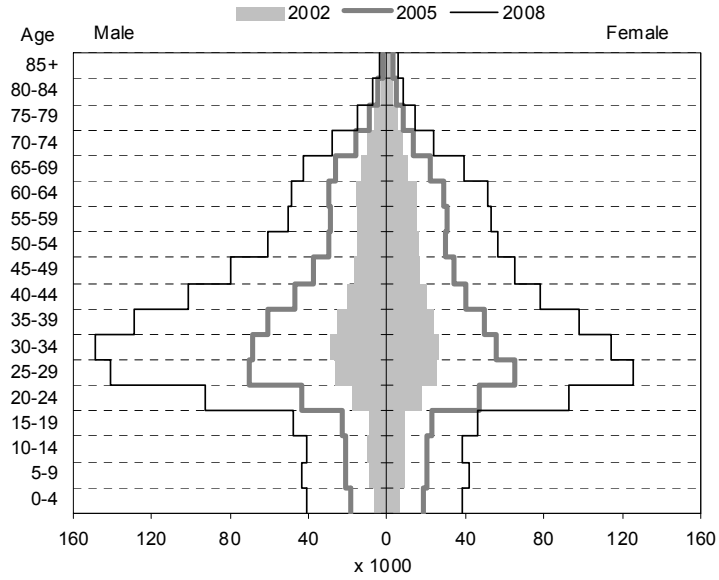
ES: Nationals by sex and age on 1 January 2002, 2005 and 2008



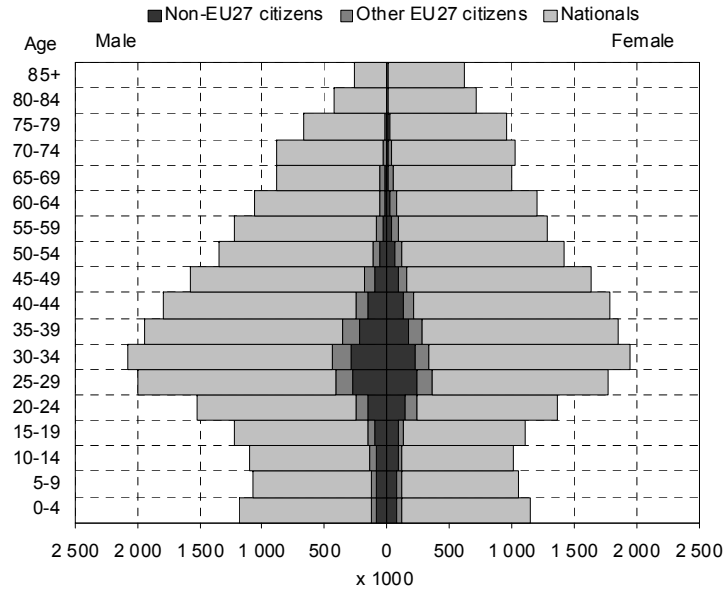
ES: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



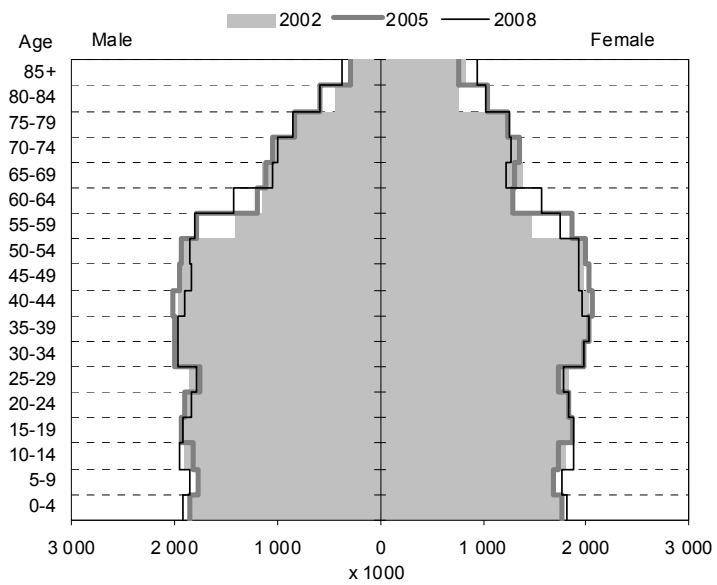
ES: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



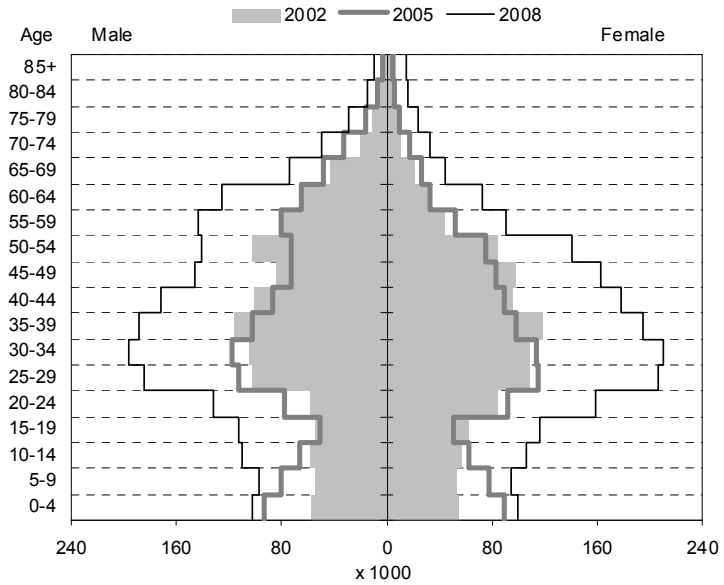
ES: Population by citizenship group, sex and age on 1 January 2008



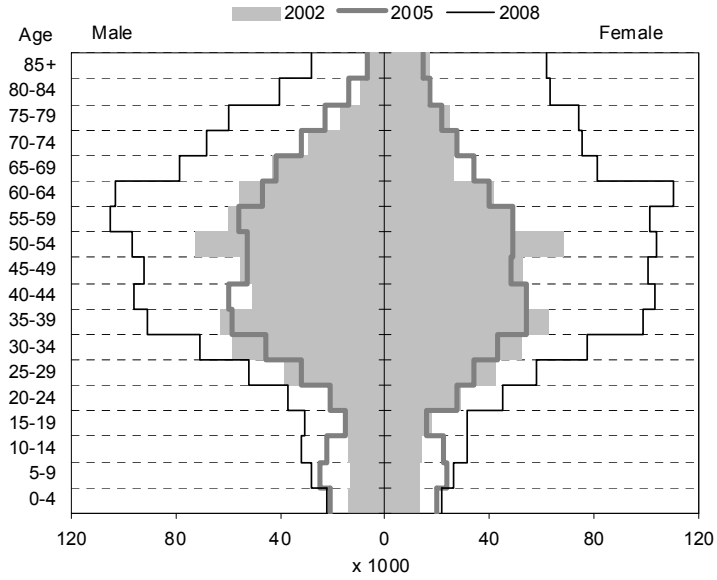
FR: Nationals by sex and age on 1 January 2002, 2005 and 2008



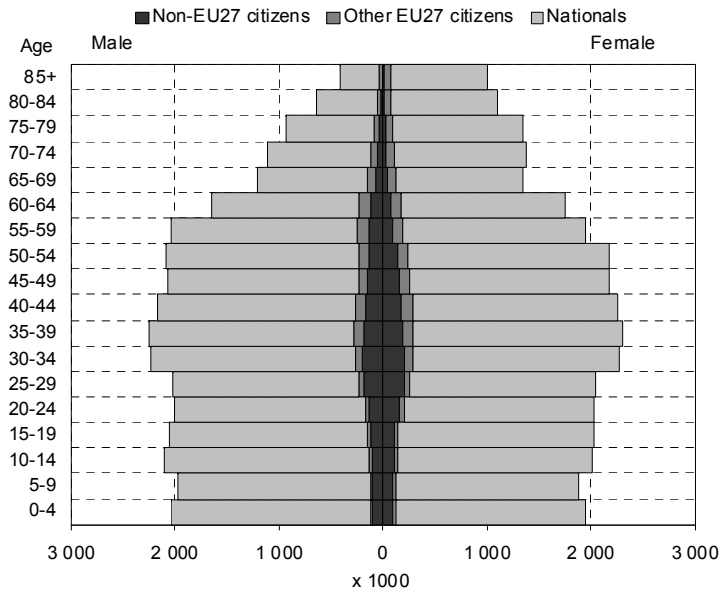
FR: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



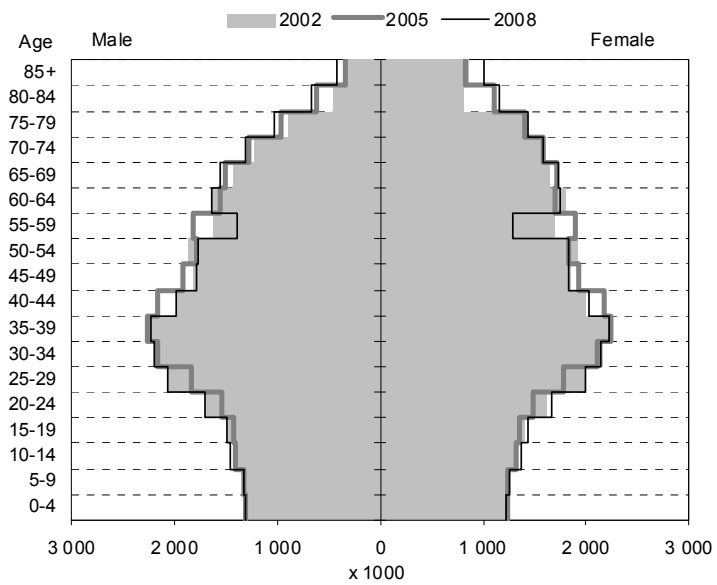
FR: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



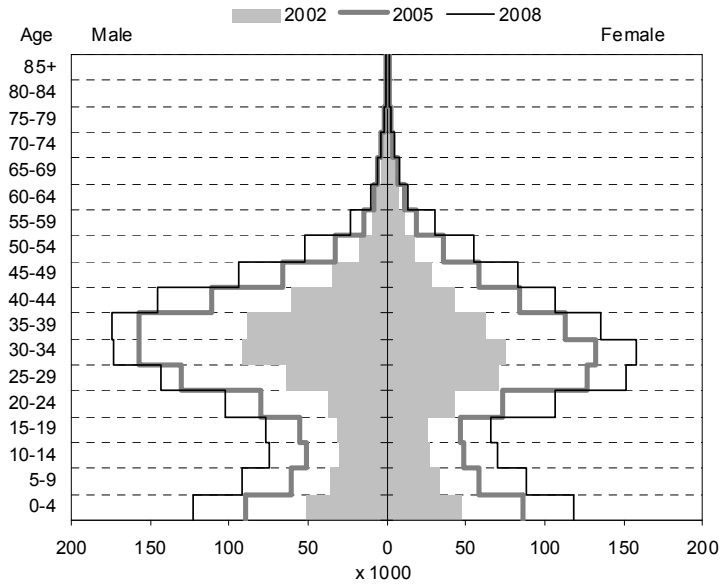
FR: Population by citizenship group, sex and age on 1 January 2008



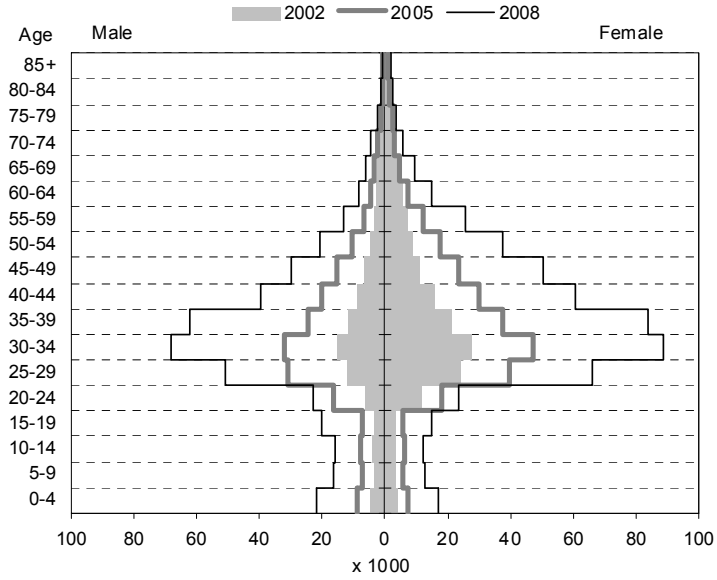
IT: Nationals by sex and age on 1 January 2002, 2005 and 2008



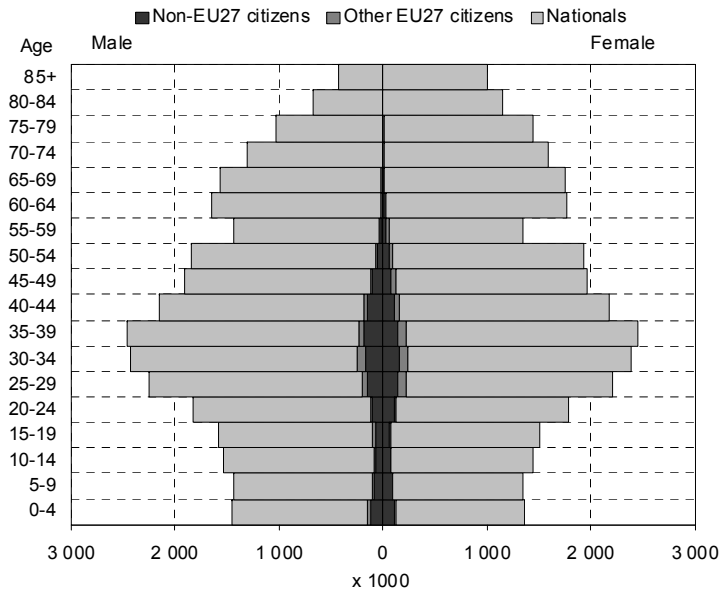
IT: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



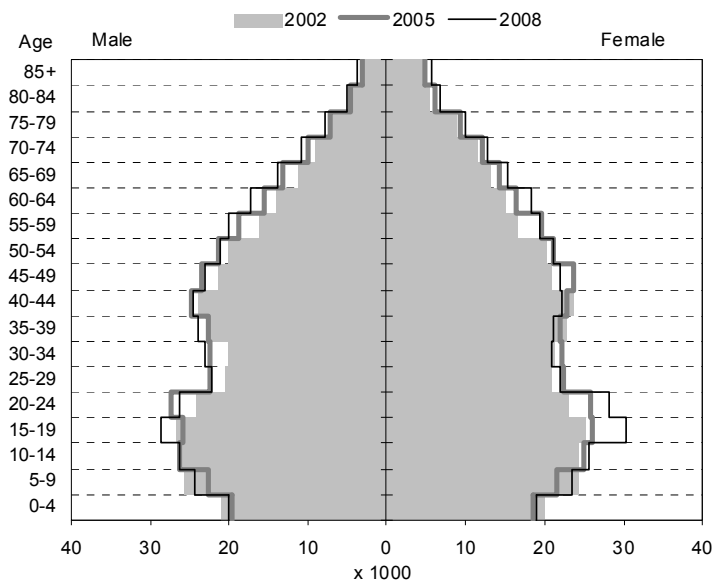
IT: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



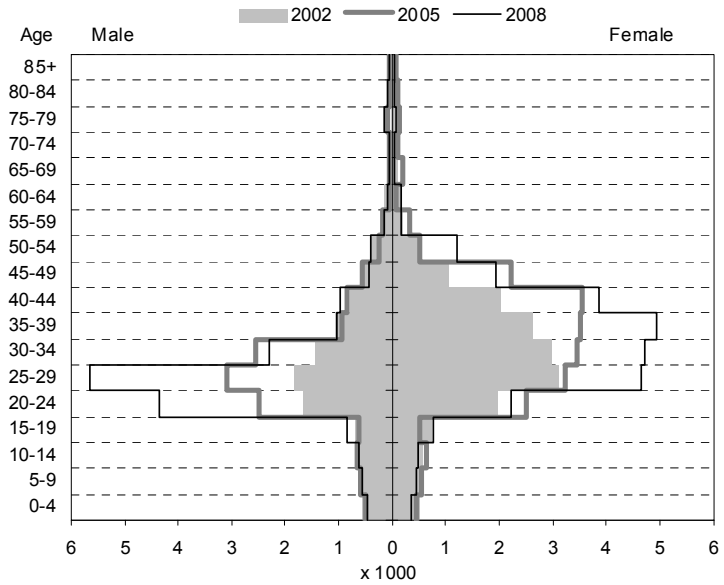
IT: Population by citizenship group, sex and age on 1 January 2008



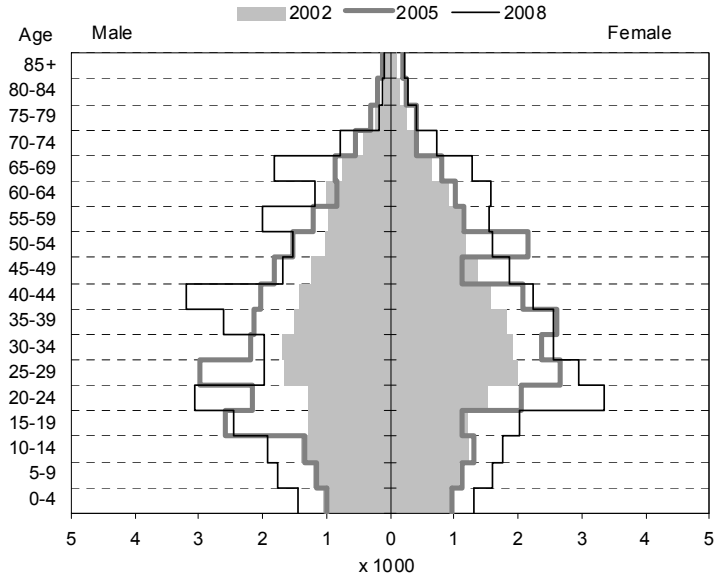
CY: Nationals by sex and age on 1 January 2002, 2005 and 2008



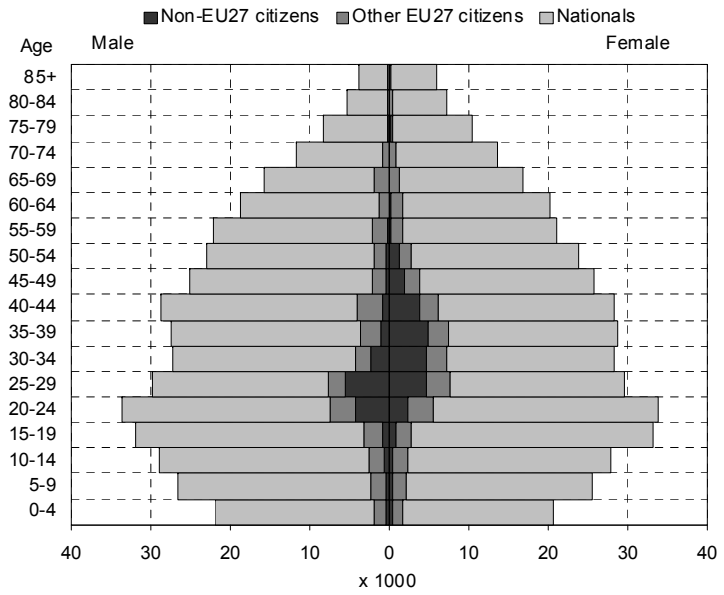
CY: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



CY: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

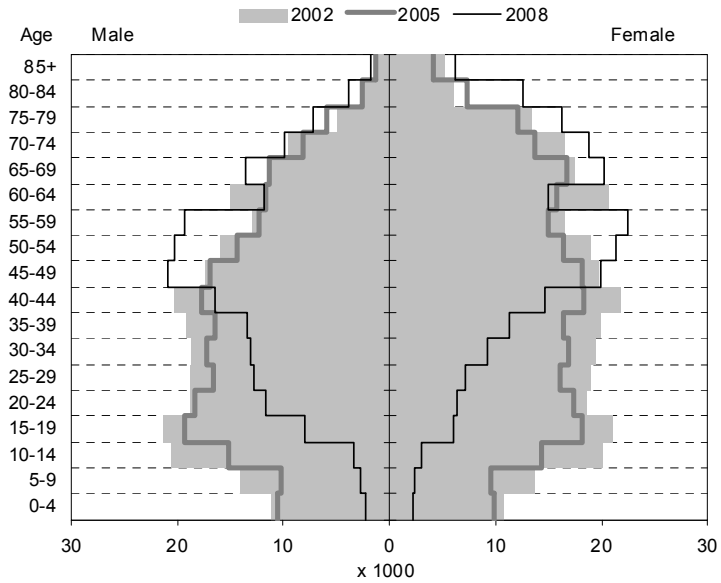


CY: Population by citizenship group, sex and age on 1 January 2008

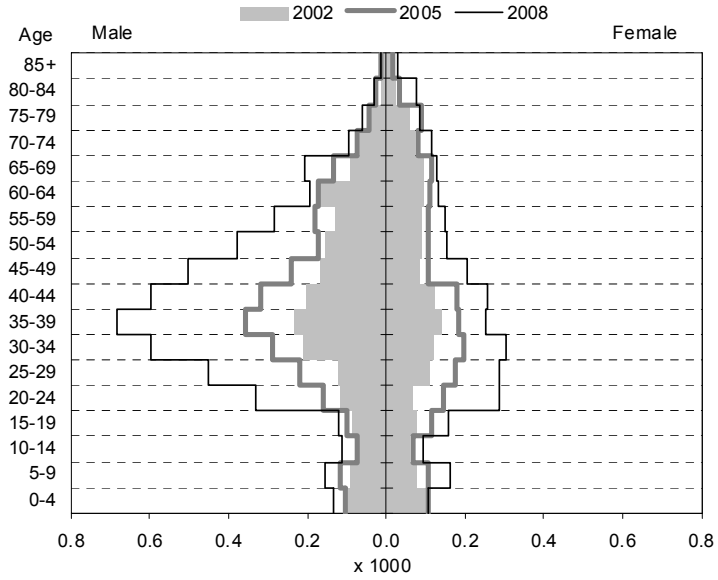


LV: Nationals by sex and age on 1 January 2002, 2005 and 2008

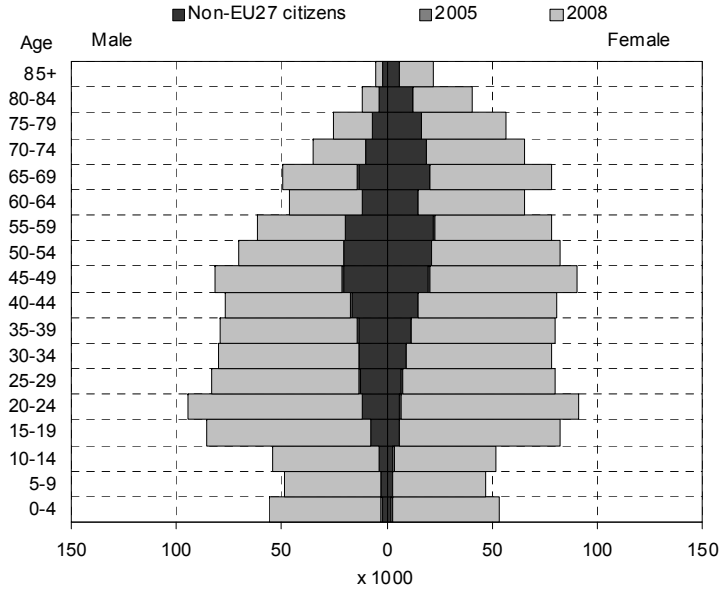
LV: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



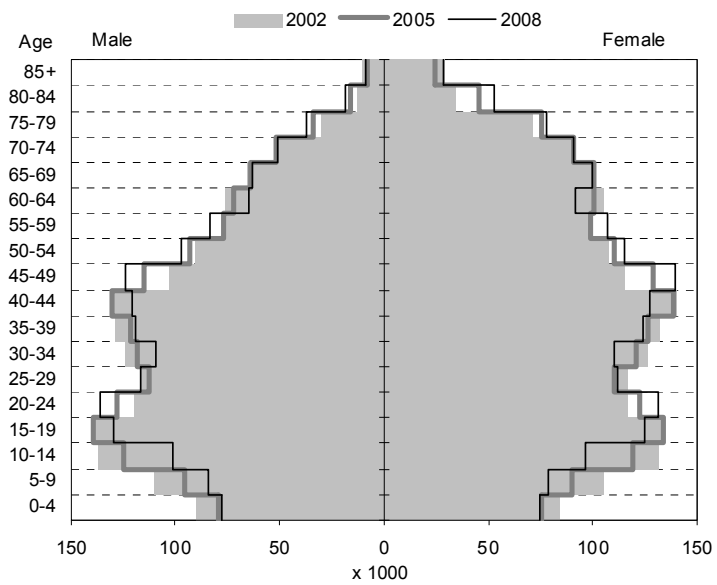
LV: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



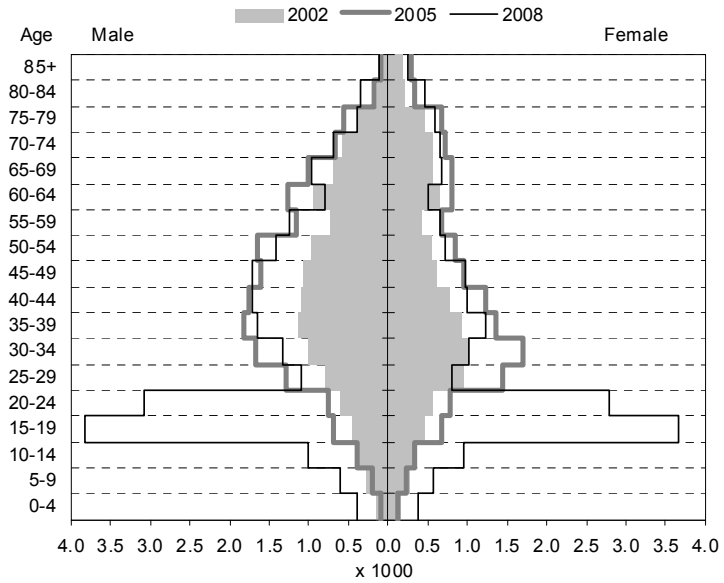
LV: Population by citizenship group, sex and age on 1 January 2008



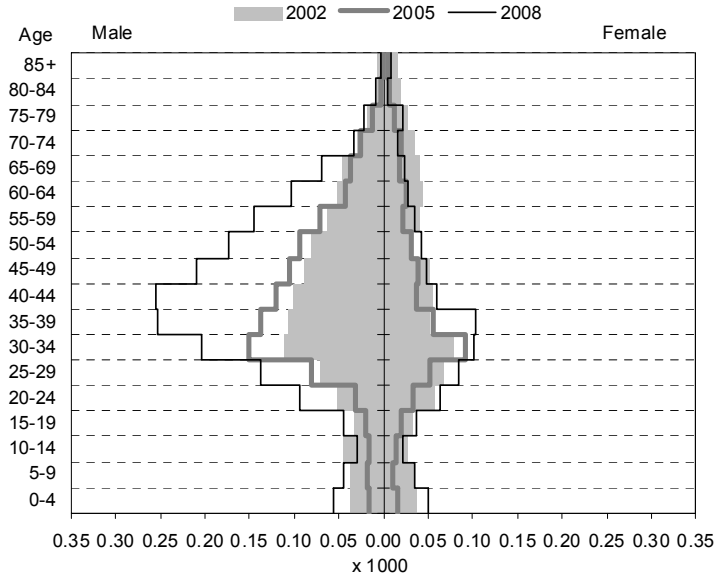
LT: Nationals by sex and age on 1 January 2002, 2005 and 2008



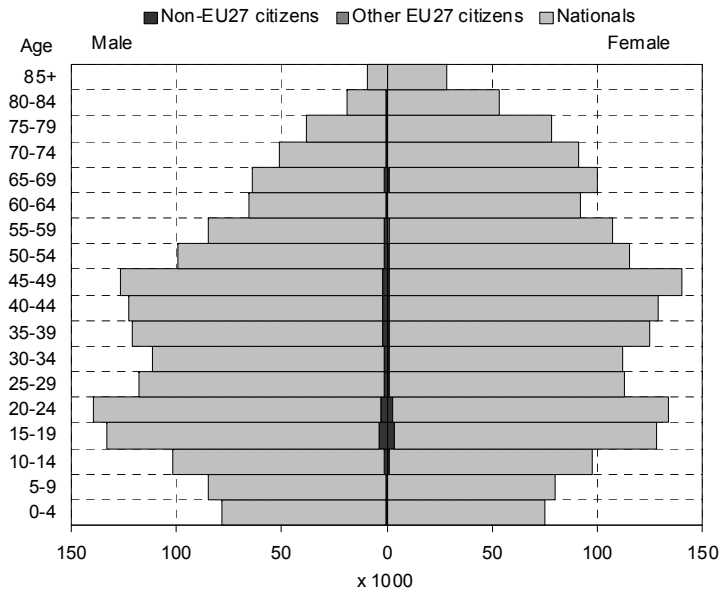
LT: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



LT: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

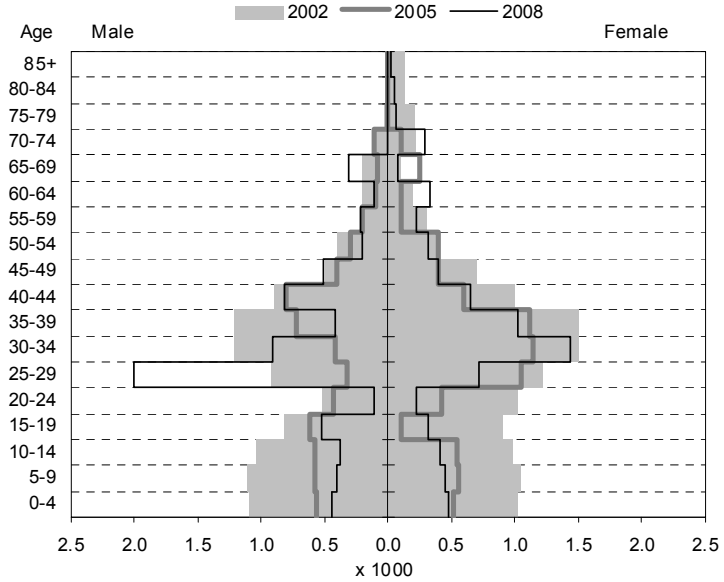


LT: Population by citizenship group, sex and age on 1 January 2008

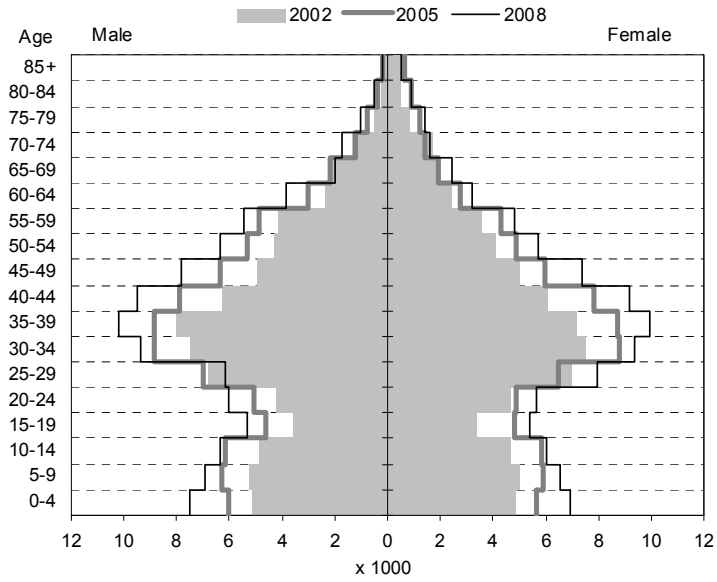


LU: Nationals by sex and age on 1 January 2002, 2005 and 2008

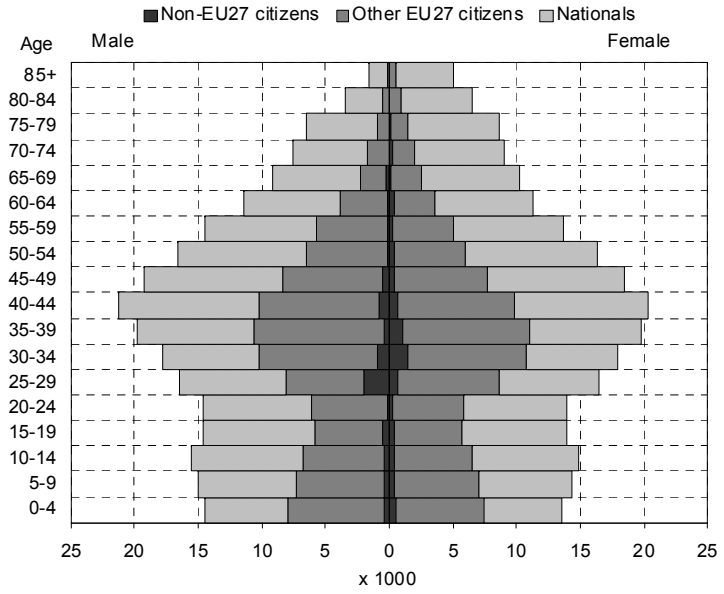
LU: Non-EU27 citizens by sex and age on 1 January 2002, 2004 and 2006



LU: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

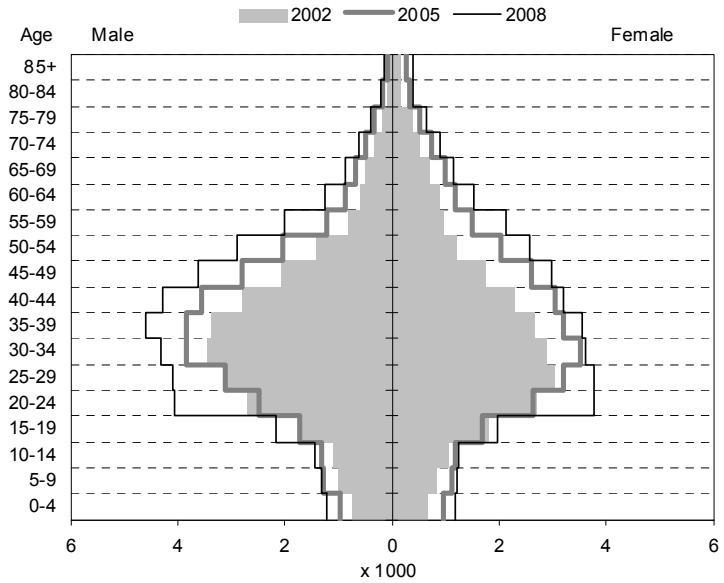


LU: Population by citizenship group, sex and age on 1 January 2008

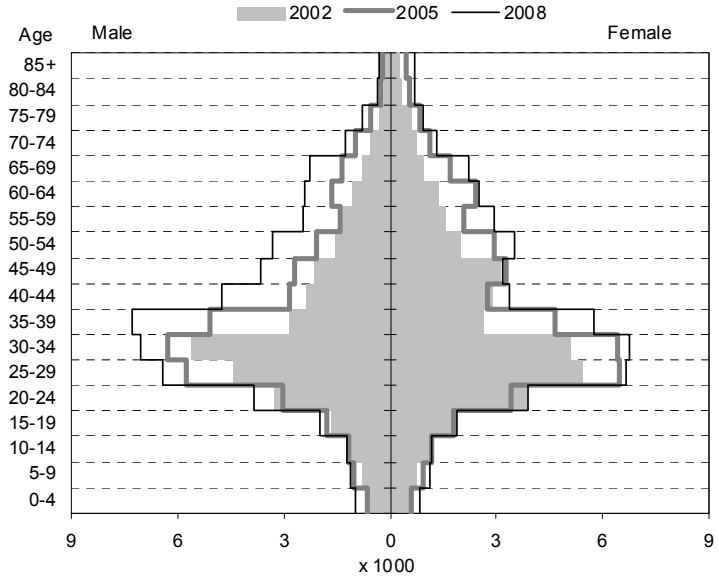


HU: Nationals by sex and age on 1 January 2002, 2005 and 2008

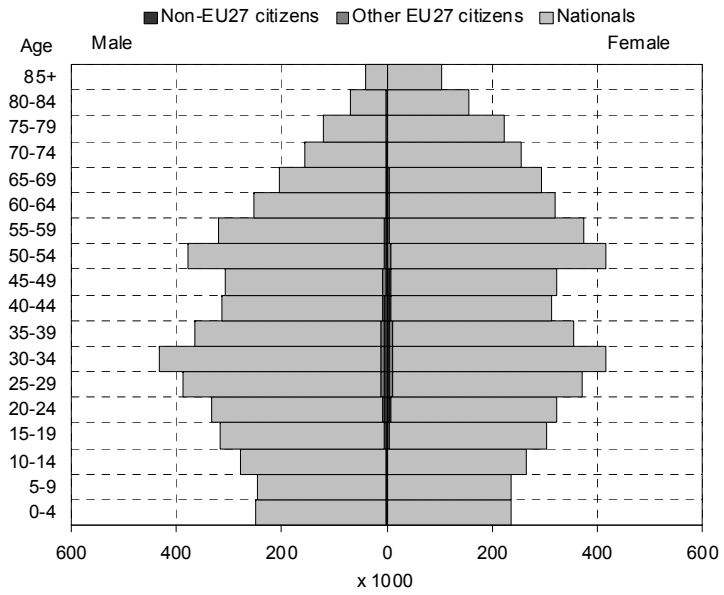
HU: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



HU: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

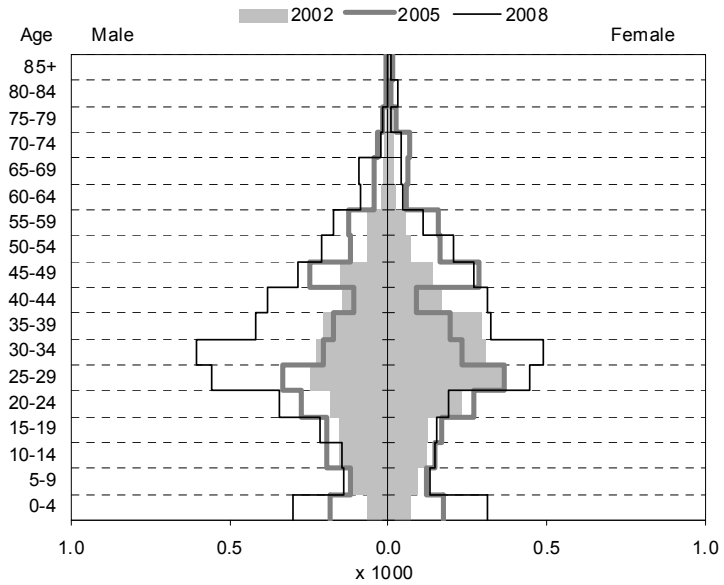


HU: Population by citizenship group, sex and age on 1 January 2008



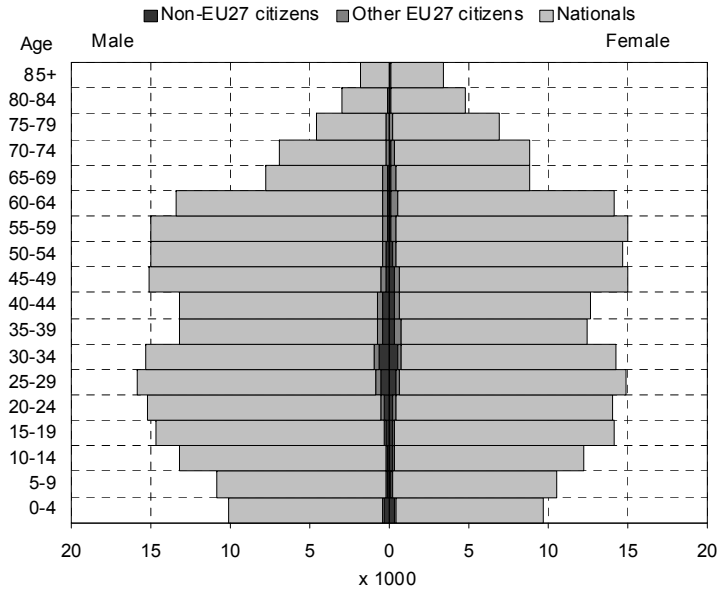
MT: Nationals by sex and age on 1 January 2002, 2005 and 2008

MT: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

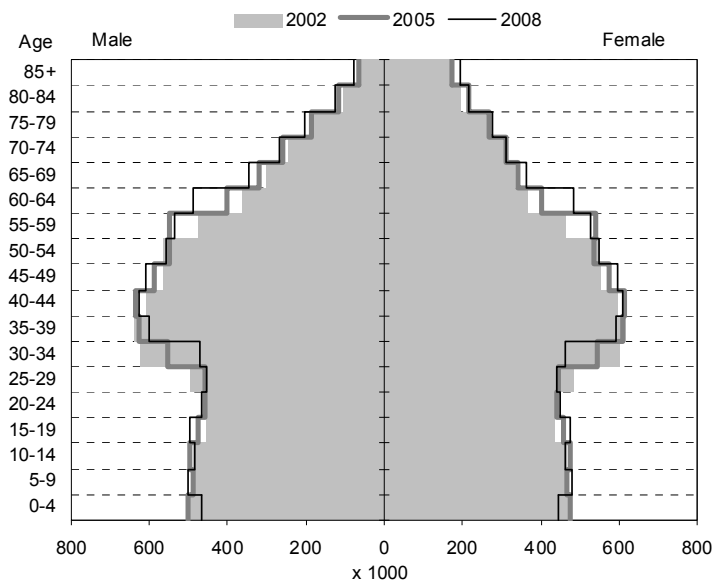


MT: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

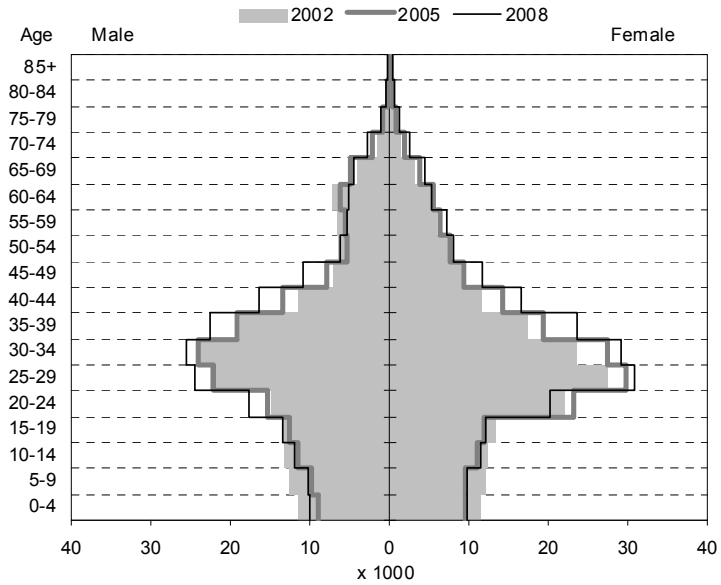
MT: Population by citizenship group, sex and age on 1 January 2008



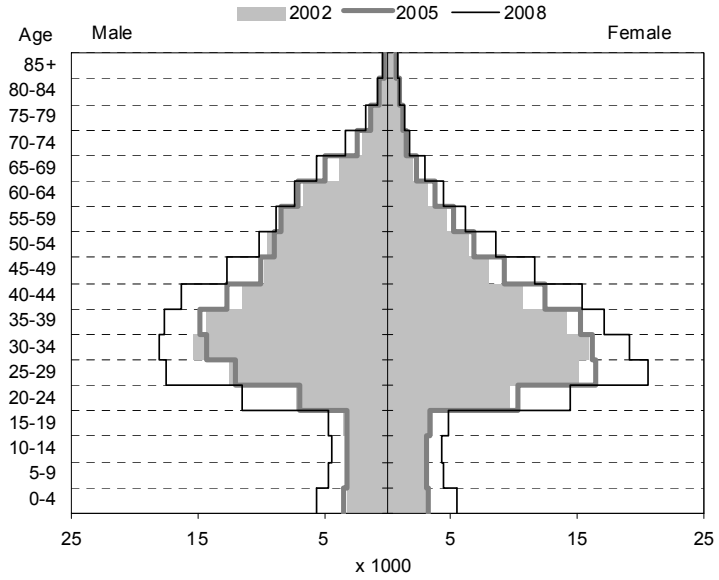
NL: Nationals by sex and age on 1 January 2002, 2005 and 2008



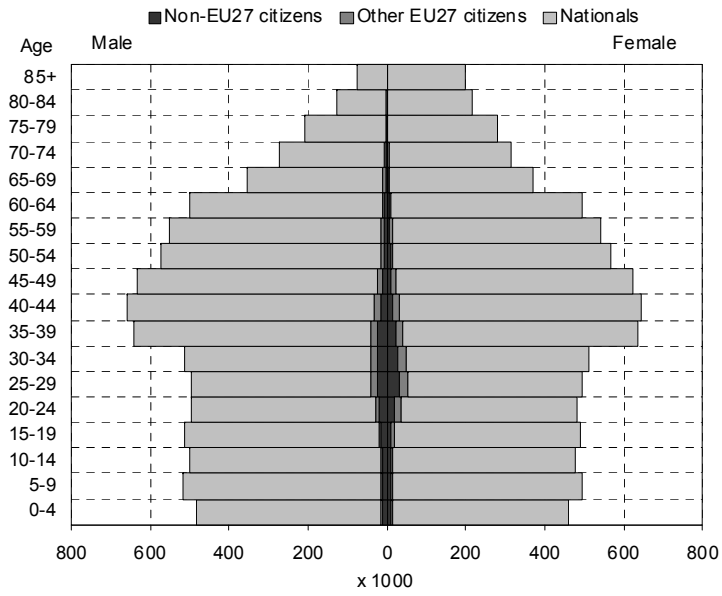
NL: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



NL: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

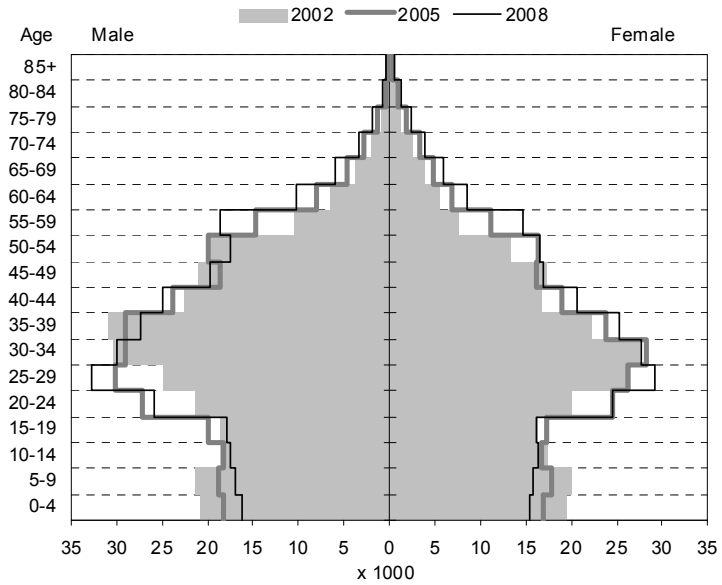


NL: Population by citizenship group, sex and age on 1 January 2008

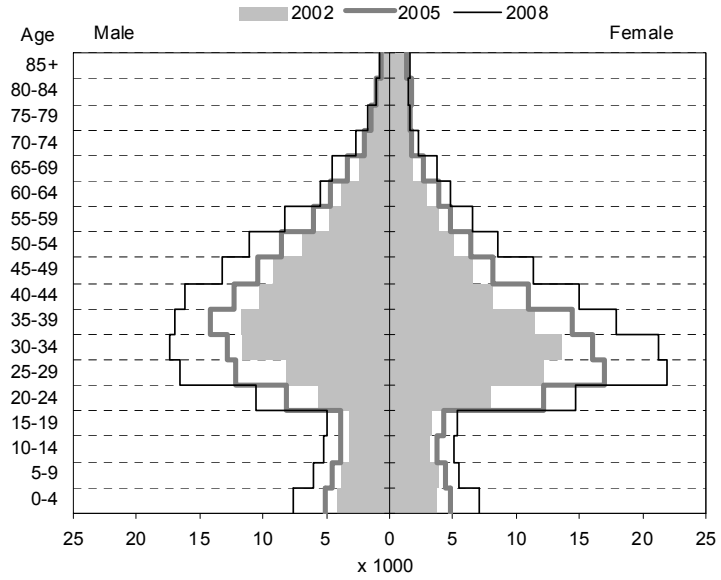


AT: Nationals by sex and age on 1 January 2002, 2005 and 2008

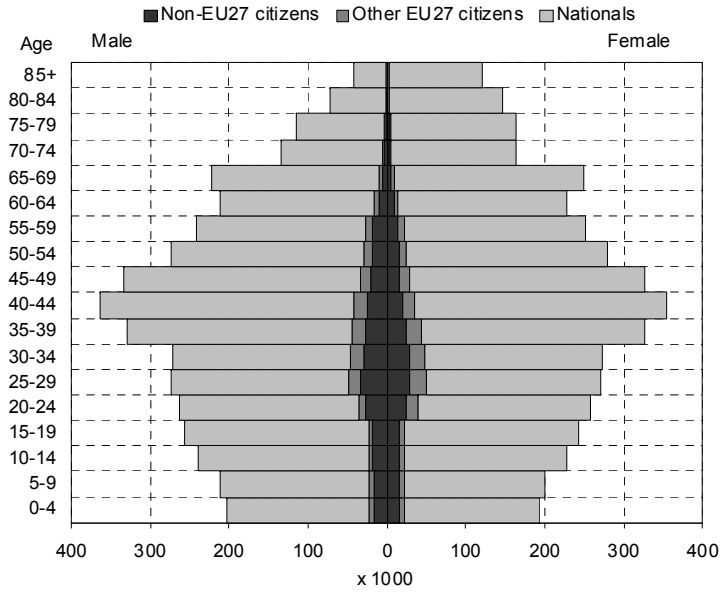
AT: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



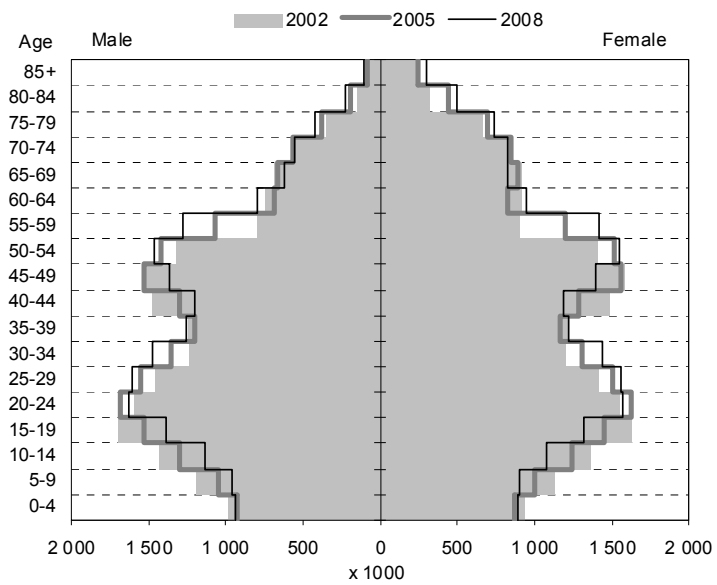
AT: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



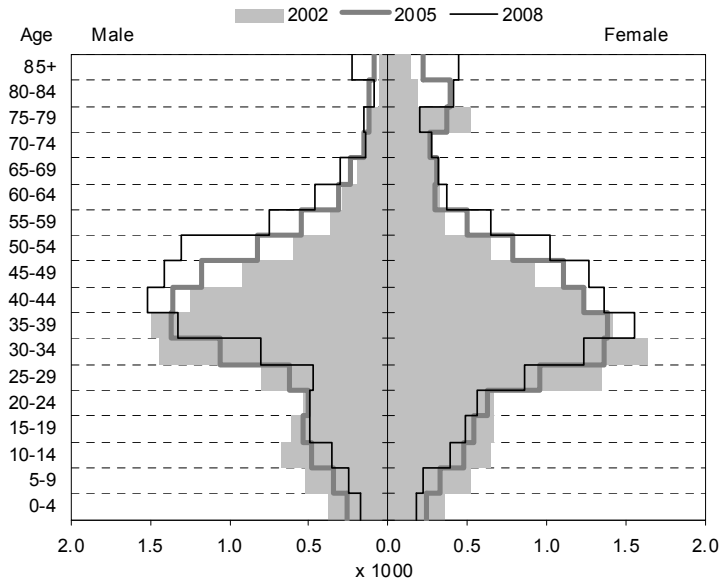
AT: Population by citizenship group, sex and age on 1 January 2008



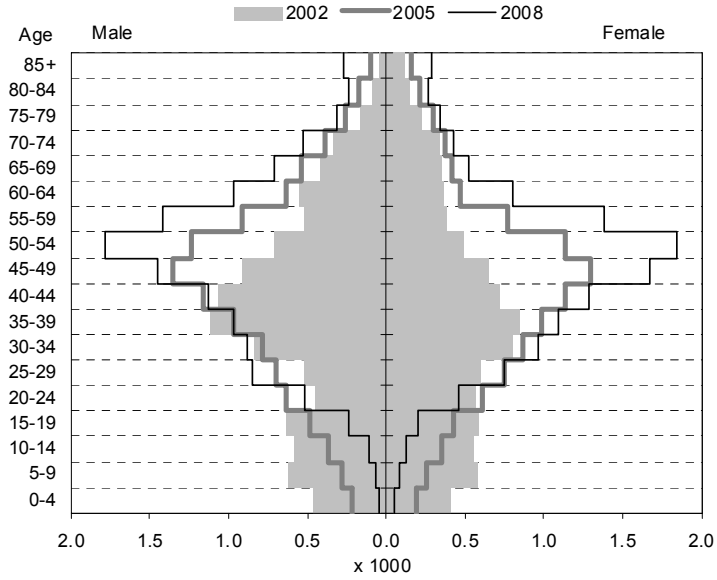
PL: Nationals by sex and age on 1 January 2002, 2004 and 2006



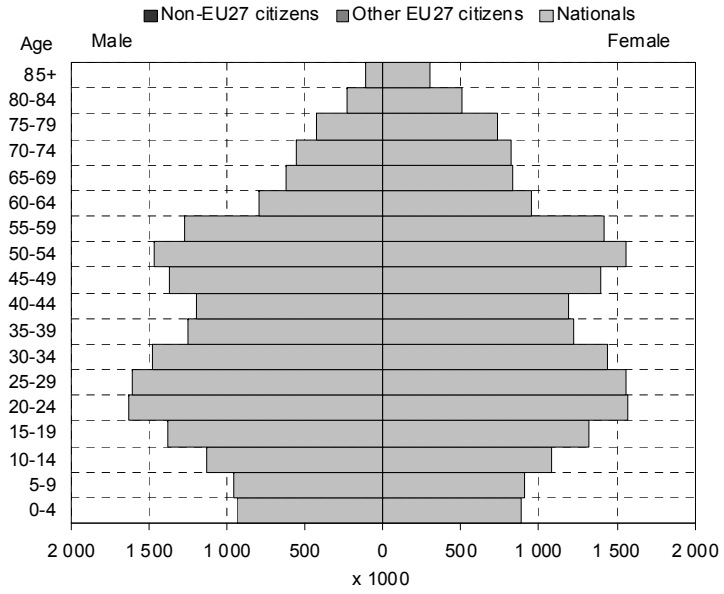
PL: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



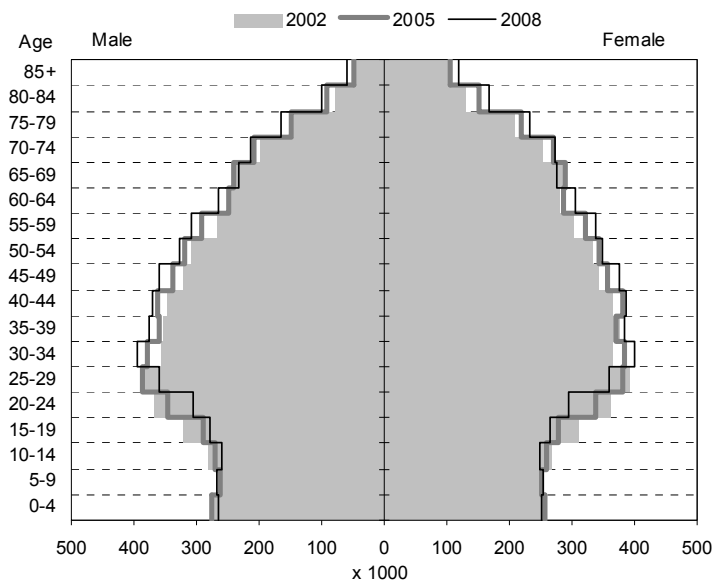
PL: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



PL: Population by citizenship group, sex and age on 1 January 2008

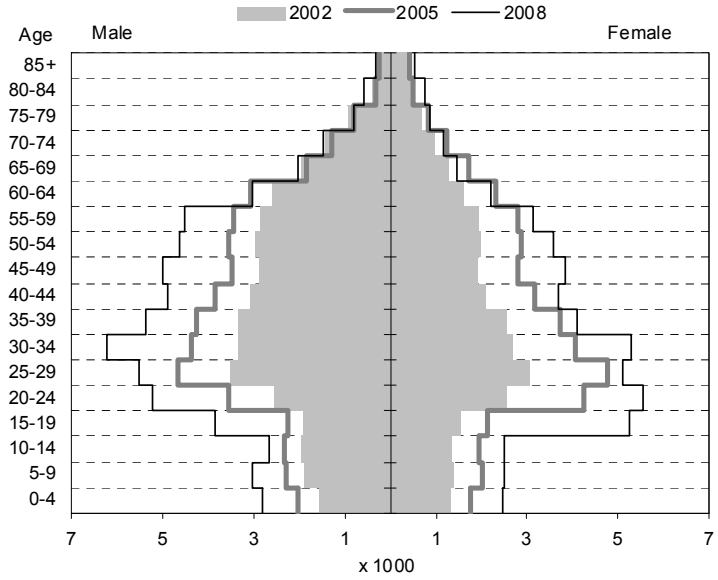


PT: Nationals by sex and age on 1 January 2002, 2005 and 2008

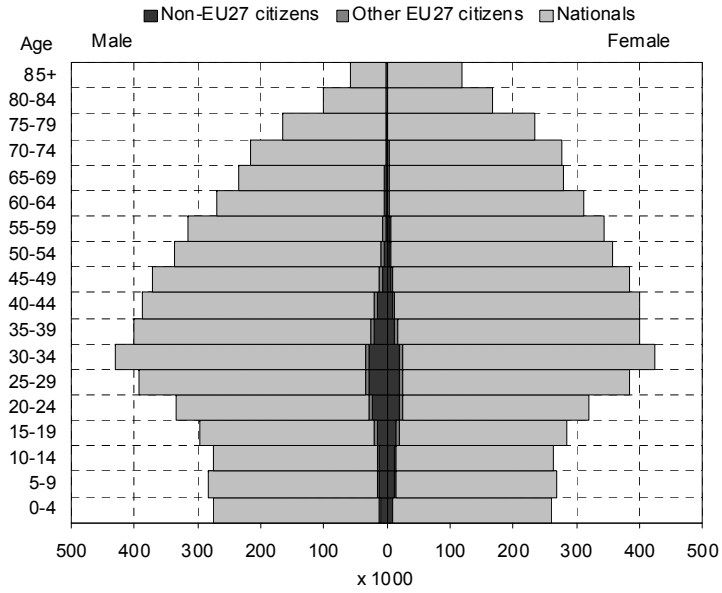


PT: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

PT: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

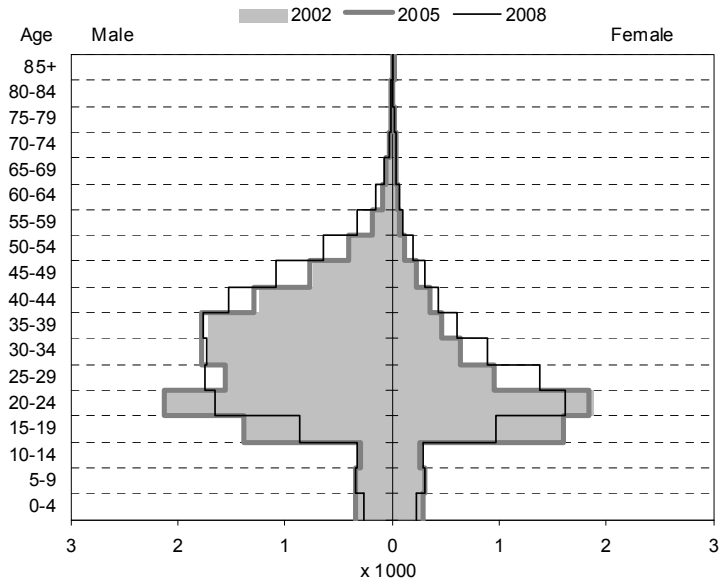


PT: Population by citizenship group, sex and age on 1 January 2008

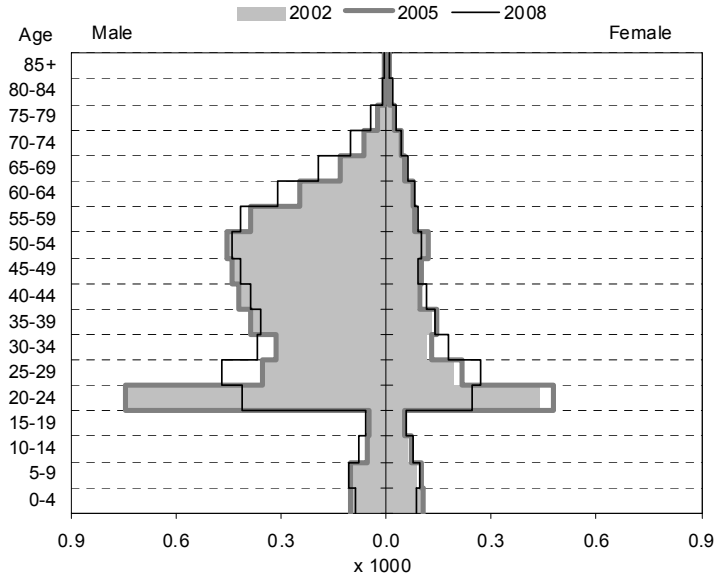


RO: Nationals by sex and age on 1 January 2002, 2005 and 2008

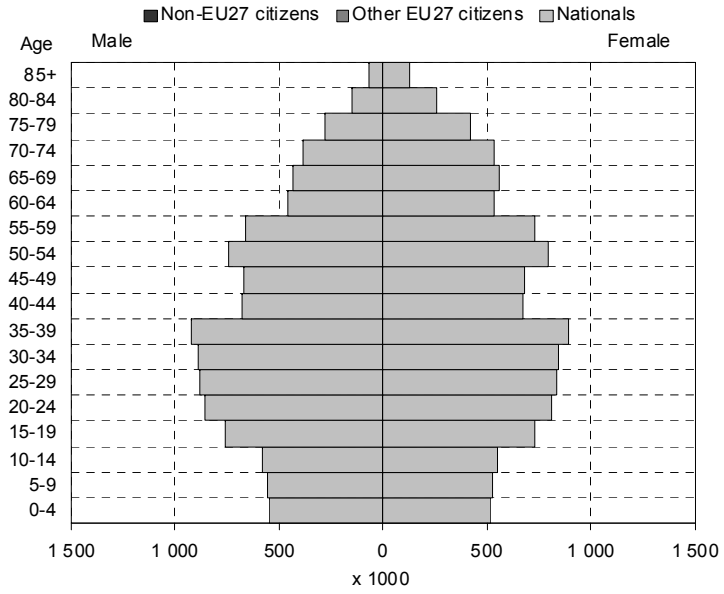
RO: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



RO: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

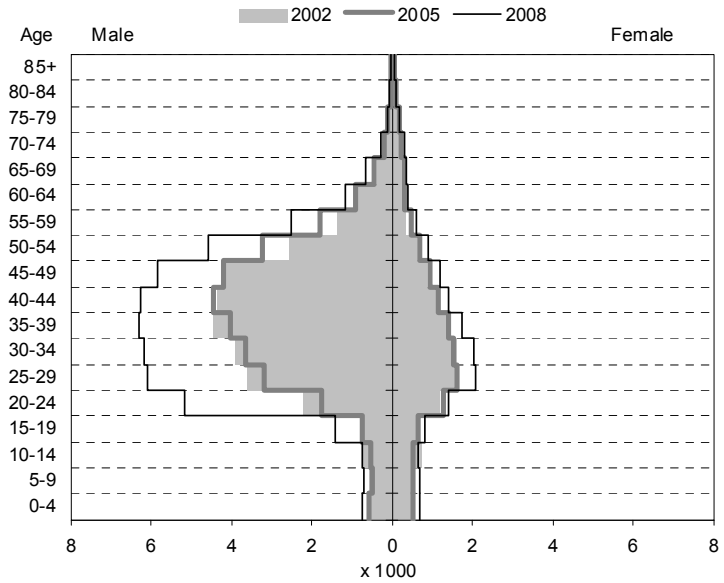


RO: Population by citizenship group, sex and age on 1 January 2008

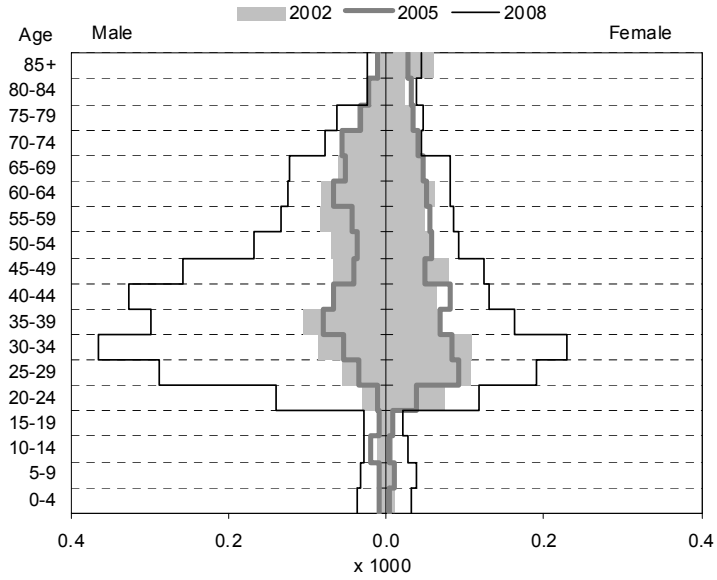


SI: Nationals by sex and age on 1 January 2002, 2005 and 2008

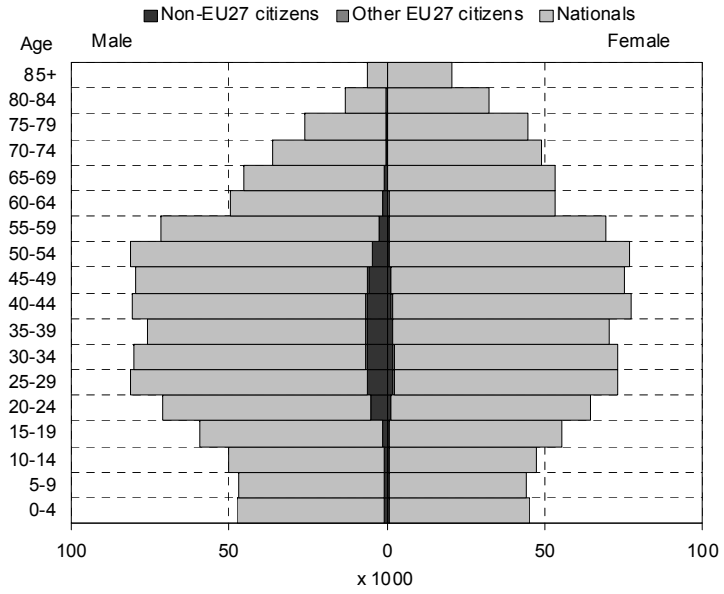
SI: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



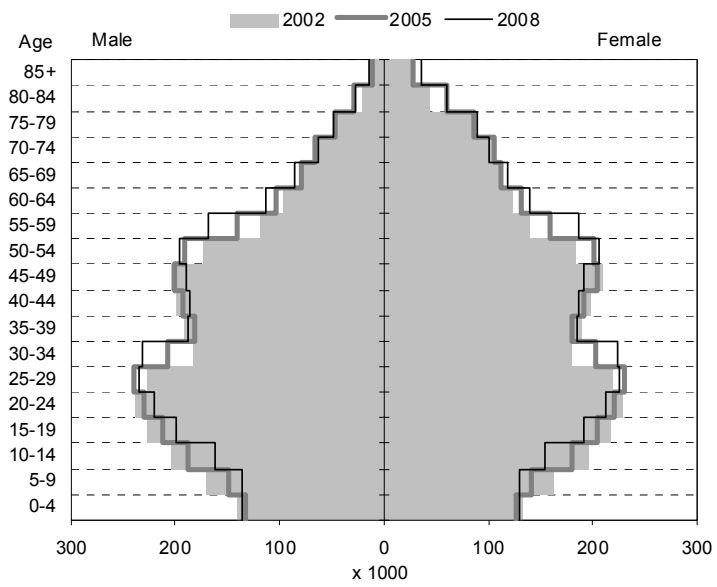
SI: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



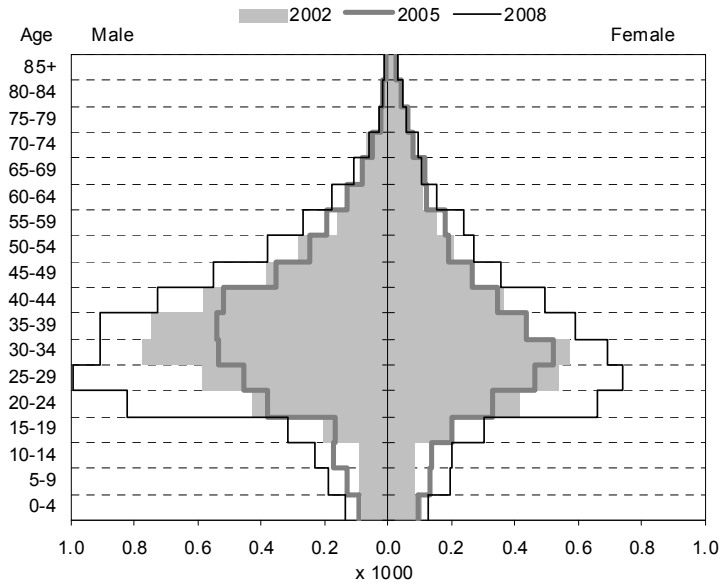
SI: Population by citizenship group, sex and age on 1 January 2008



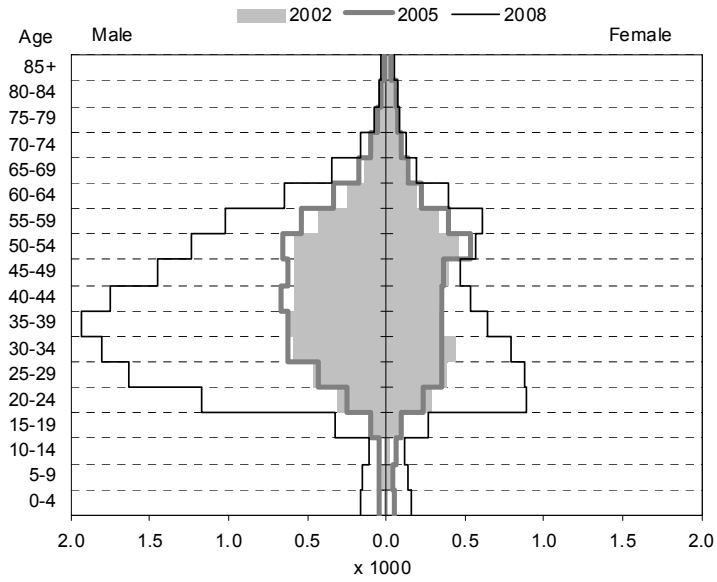
SK: Nationals by sex and age on 1 January 2002, 2005 and 2008



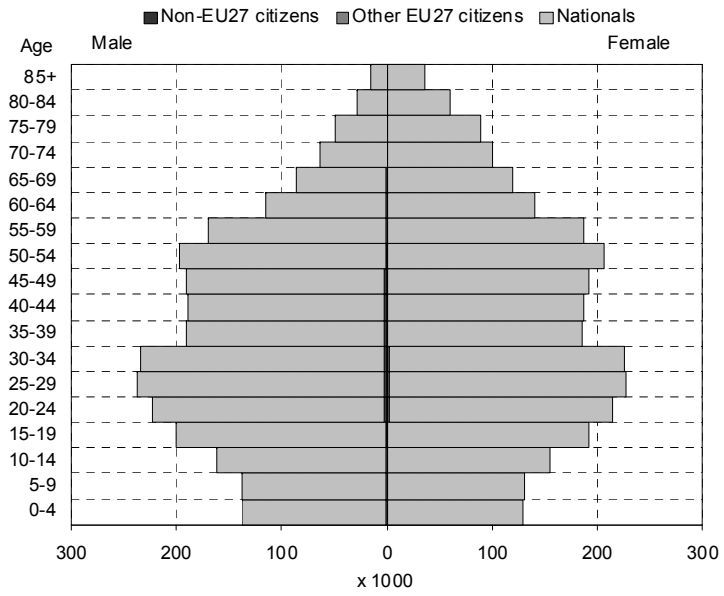
SK: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



SK: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

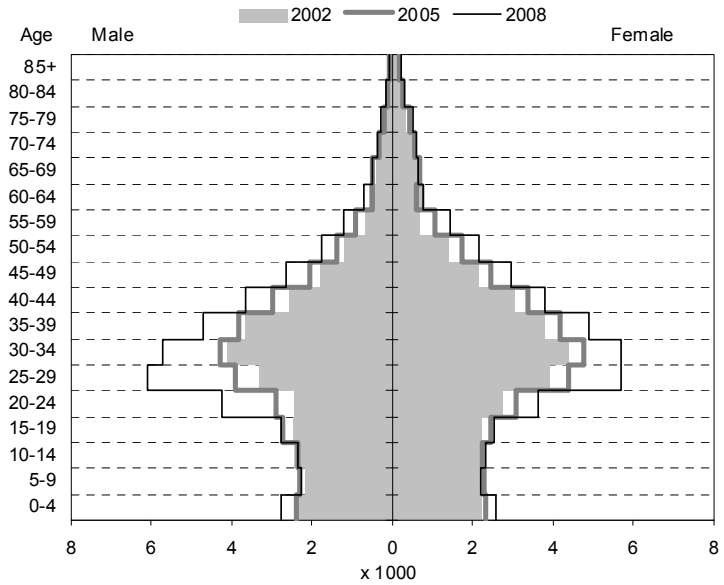


SK: Population by citizenship group, sex and age on 1 January 2008

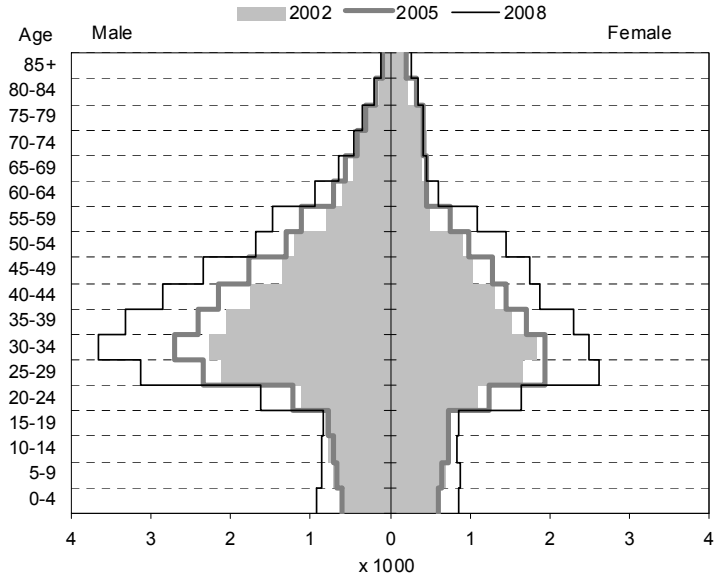


FI: Nationals by sex and age on 1 January 2002, 2005 and 2008

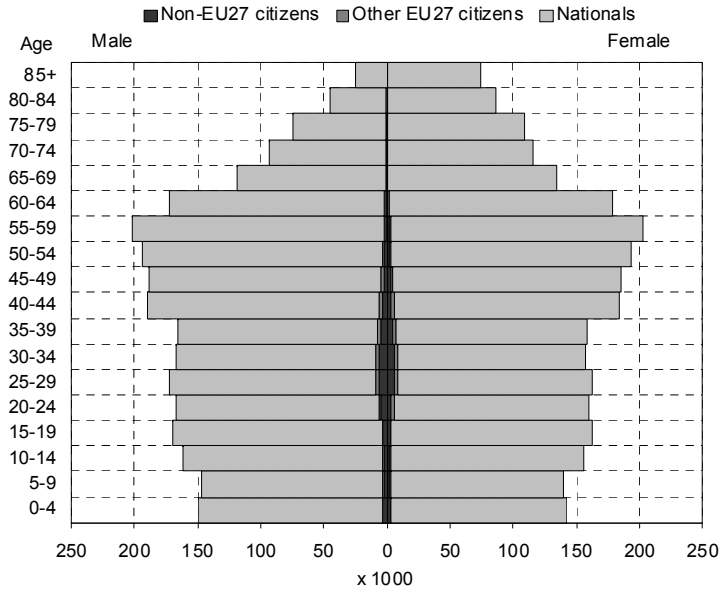
FI: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



FI: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



FI: Population by citizenship group, sex and age on 1 January 2008

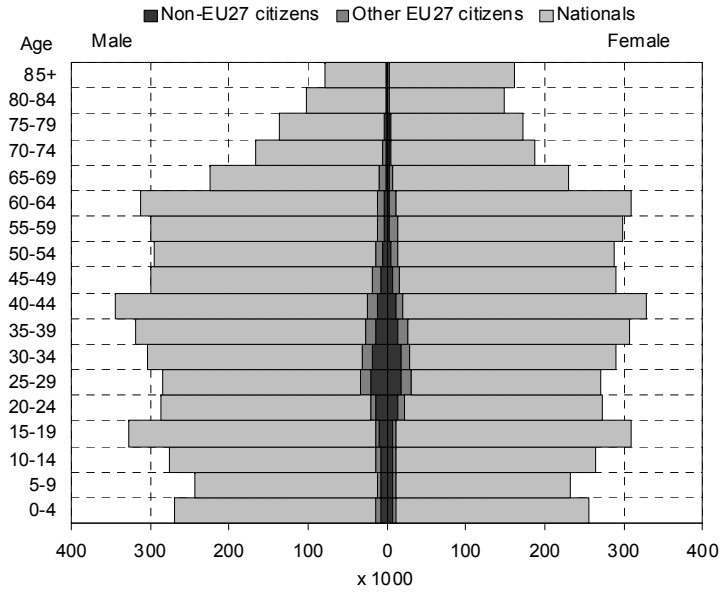


SE: Nationals by sex and age on 1 January 2002, 2005 and 2008

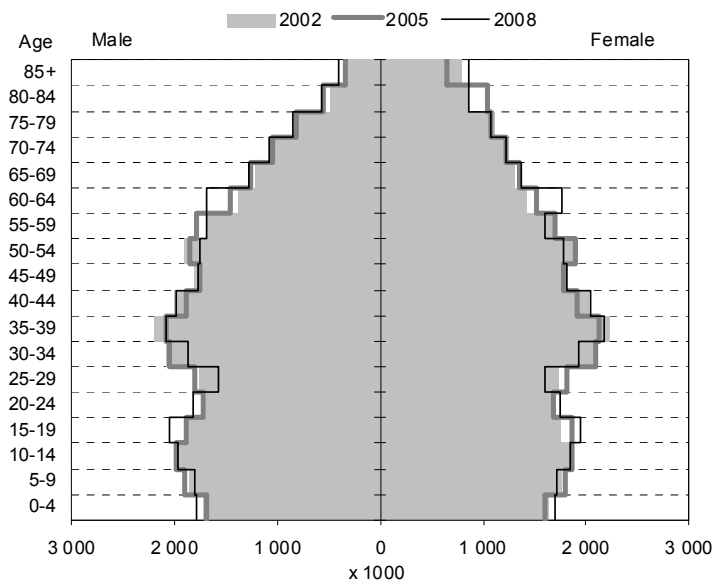
SE: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

SE: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

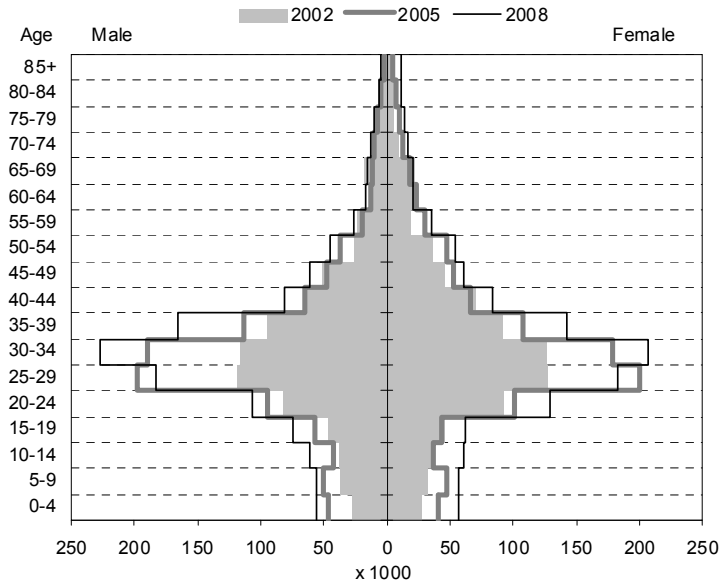
SE: Population by citizenship group, sex and age on 1 January 2008



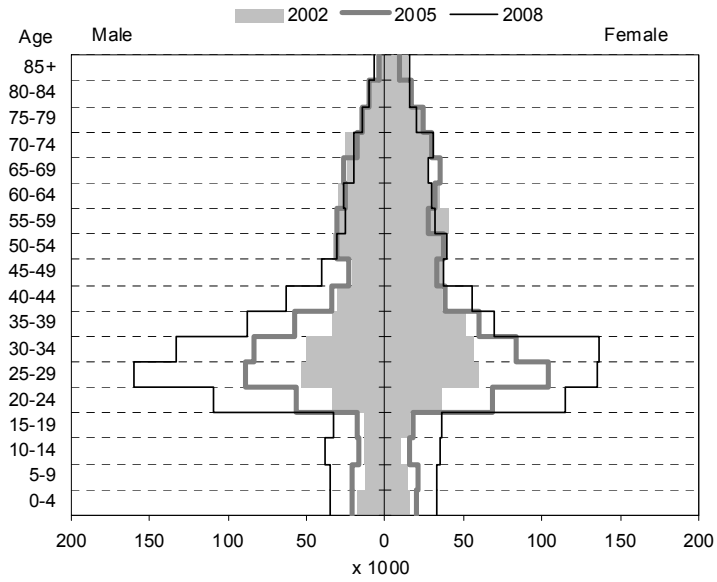
UK: Nationals by sex and age on 1 January 2002, 2005 and 2008



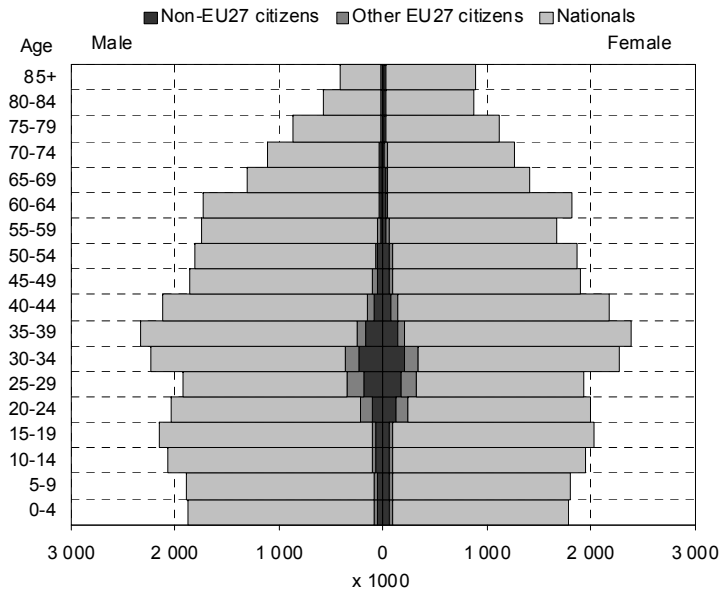
UK: Non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



UK: Other EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

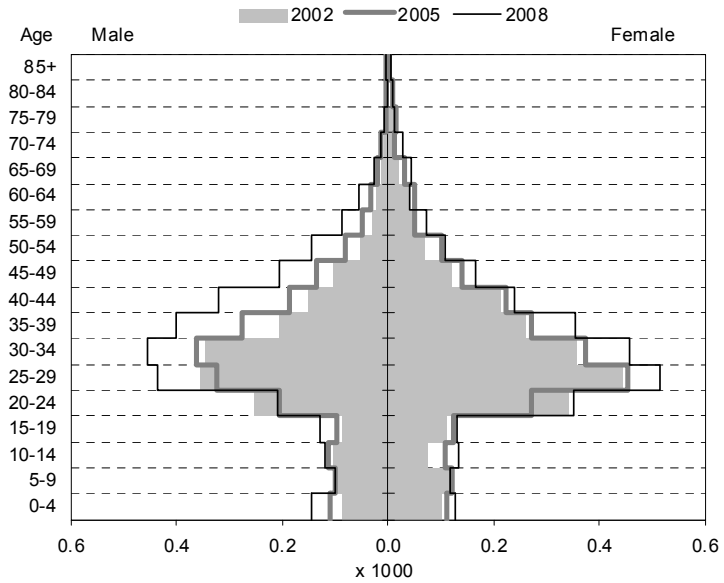


UK: Population by citizenship group, sex and age on 1 January 2008



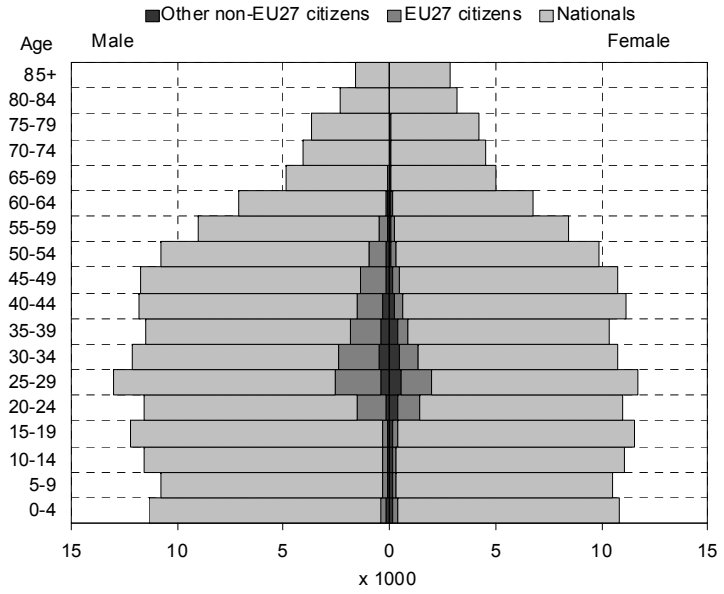
IS: Nationals by sex and age on 1 January 2002, 2005 and 2008

IS: Other non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



IS: EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

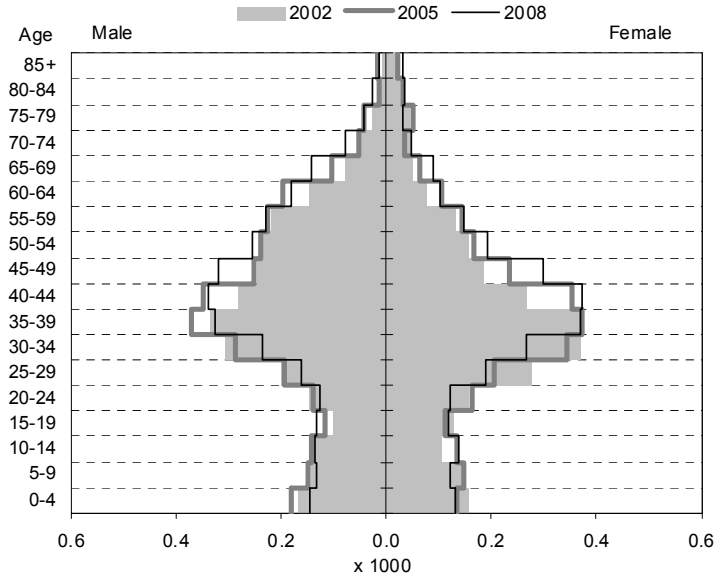
IS: Population by citizenship group, sex and age on 1 January 2008



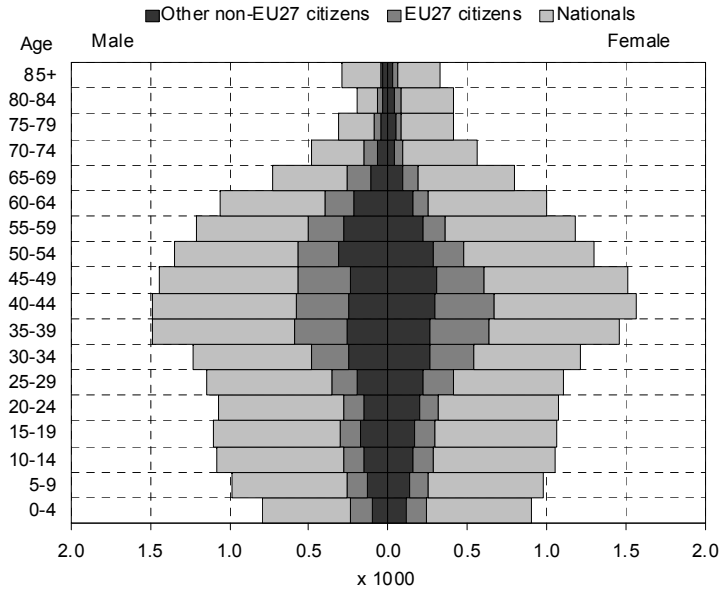
LI: Nationals by sex and age on 1 January 2002, 2005 and 2008

LI: Other non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

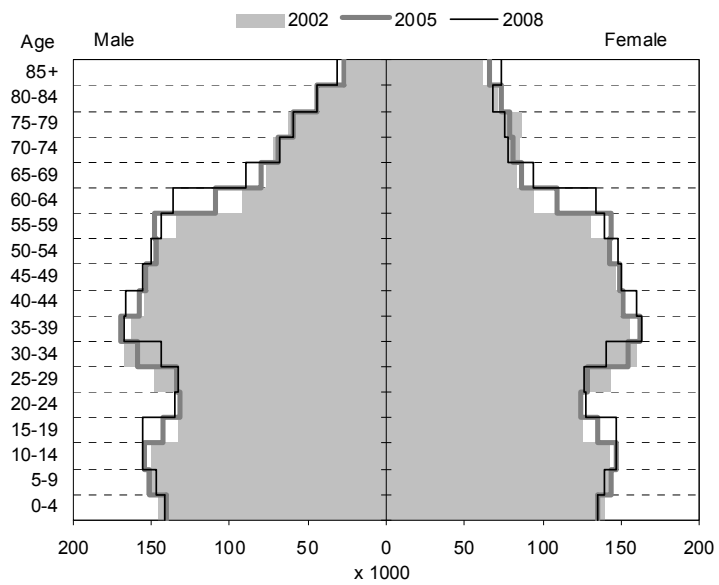
LI: EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



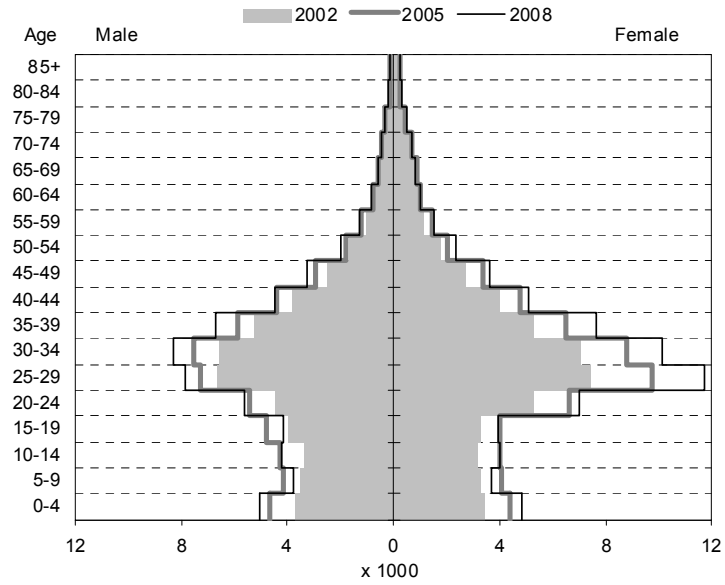
LI: Population by citizenship group, sex and age on 1 January 2008



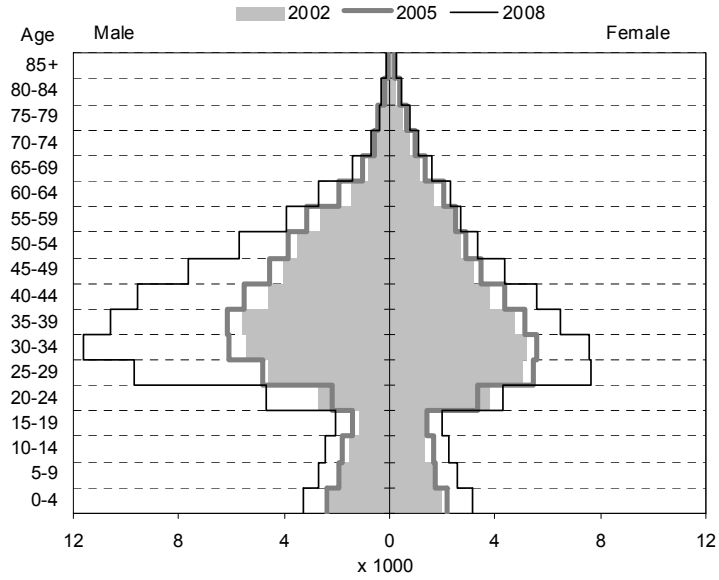
NO: Nationals by sex and age on 1 January 2002, 2005 and 2008



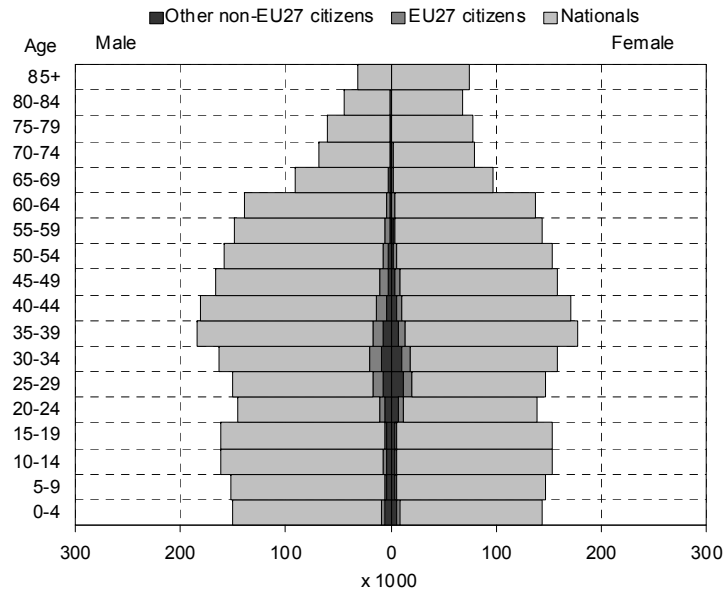
NO: Other non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



NO: EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



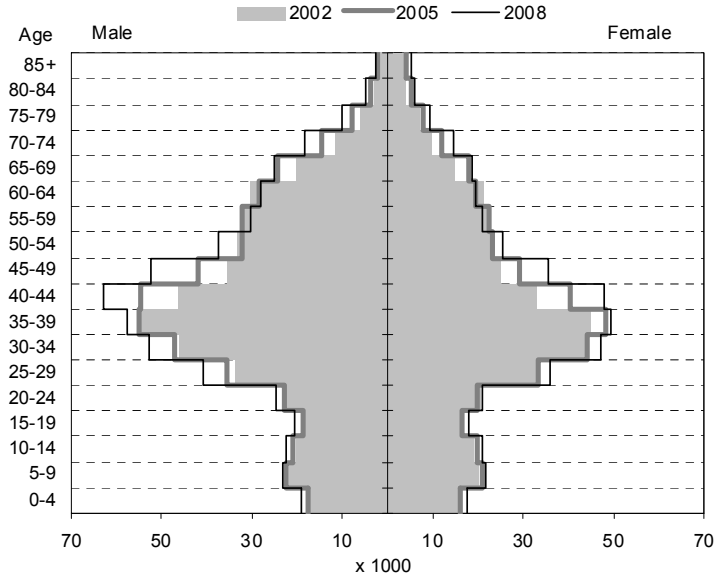
NO: Population by citizenship group, sex and age on 1 January 2008



CH: Nationals by sex and age on 1 January 2002, 2005 and 2008

CH: Other non-EU27 citizens by sex and age on 1 January 2002, 2005 and 2008

CH: EU27 citizens by sex and age on 1 January 2002, 2005 and 2008



CH: Population by citizenship group, sex and age on 1 January 2008