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Common methodology for the SEEMIG population projections

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http://www.seemig.eu/downloads/outputs/SEEMIGPopulationProjectionsMethodology.pdf

1. INTRODUCTION

The aim of this study to summarize the main methods applied in population projections and special methods used in this project.

To prepare the population projections, the following activities have been accomplished in SEEMIG WP5:

- data collection on births, deaths and migration for Hungary and Slovakia;
- special data collection for migration: census data, mirror statistics, UN data on migration by country of birth, OECD flow data on migration
- analyzing the long-term processes on fertility, mortality and migration;
- developing assumptions on fertility, mortality and migration;
- developing a new method to assess net migration.

2. BASIC POPULATION PROJECTIONS

The basic population projections are projections by age, sex and total population. These are demographic projections that provide the size and structure of the population.
The basic population projections cover the period between 1st January 2013 and 2060.

2.1. Data and definitions[1]

Data are provided by the National Statistical Institutes. The data are administrative data. This holds for both national and subnational level data.

2.1.1. Population

Population on 1st January should be based on concept of *usual resident population*, and it is number of the inhabitants of a given area on 1 January of the year in question (or, in some cases, on 31 December of the previous year). The population figures can be based on data from the most recent census adjusted by the components of **population change** produced since the last census, or based on population registers.

Usually resident population means all persons having usual residence in a country at the reference time.

[1] http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/demoreg_esms.htm

Usual residence means the place where a person normally spends the daily period of rest, regardless of temporary absences for purposes of recreation, holidays, visits to friends and relatives, business, medical treatment or religious pilgrimage.

The following persons alone are considered to be usual residents of the geographical area in question:

- those who have lived in their place of usual residence for a continuous period of at least 12 months before the reference time; or
- those who arrived in their place of usual residence during the 12 months before the reference time with the intention of staying there for at least one year.

Demographic balance - is the equation that describes the change in the size of the population due to the flows of live births, deaths, immigration and emigration that occur in the reference year T.

Population[T+1] = Population[T] + Births[T, T+1] - Deaths[T, T+1] + Immigrants[T, T+1] - Emigrants[T, T+1]

where:

Population[T+1] = total population on 1st January of the year T+1;

Population[T] = total population on 1st January of the year T;

Births[T, T+1] = total number of live births occurred in the time interval T to T+1;

Deaths[T, T+1] = total number of deaths occurred in the time interval T to T+1;

Immigrants[T, T+1] = total number of immigrants occurred in the time interval T to T+1;

Emigrants[T, T+1] = total number of emigrants occurred in the time interval T to T+1;

Natural increase/decrease – difference between live births and deaths of the area in question during the time period in question, often expressed per 1000 population.

Net Migration - difference between immigrants and emigrants of the area in question during the time period in question, often expressed per 1000 population.

Total increase/decrease of population – sum of natural increase (decrease) and net migration of the area in question during the time period in question, often expressed per 1000 population.

Population density - the ratio of the (annual average) population of a region to the (land) area of the region; total area (including inland waters) is used when land area is not available.

2.1.2. Projection

The forecast differs from projection scenarios (simulations) introduced below, since their essence is a little bit different (Keilman and Kučera 1991, Smith et al. 2001). Unlike projections are, the population forecasts are unconditional. They represent the forecasters´ view on the future most likely population change. Forecasts are unconditional expressing the future „true" according to their authors, whereas projections put some primary external preconditions thus showing *what* will happen *if* some assumptions are given. Sometimes they play the role of so called "warning" scenarios. As Smith et al. mentioned, projections "are always true", the only source of errors lies in formal-mathematical calculations. The population forecasts give the most reliable subjective view on the future. In other words, all forecasts are projections in terms of future time- horizon, however not all projections are forecasts.

The differentiation between forecast and projection is very important and meaningful. From the users ´point of view is very necessary to know whether the future development is conditional (under some theoretical) conditions or unconditional (very probable according to the forecast ´s authors). Local and central-governments representatives sometimes do not distinguish between them. Thus, during the presentation of them, clarification of this is very meaningful. Unluckily, the clear distinguishing does not occur in several official forecasts of national and international institutions.

2.1.3. Mortality

Crude death rate - the ratio of the total number of **deaths** during the year to the **average population** in that year. The value is expressed per 1000 population.

Infant mortality rate - the ratio of the total number of deaths of children under one year of age during the year to the number of live births in that year. The value is expressed per 1000 live births.

Life expectancy at given exact age - the mean number of years still to be lived by a person who has reached a certain exact age, if subjected throughout the rest of his or her life to the current mortality conditions (age-specific probabilities of dying).

Life table is one of the most important and most widely used devices in demography, summarizing various aspects of the variation of mortality with age and showing, for each age, the probability that a person of that age will die before his next birthday. Functions pertaining to mortality are available in distinct tables: age specific death rates, probabilities of dying between exact ages, probability of surviving between exact ages, number left alive at a given exact age, number dying between exact ages, person-years lived between exact ages, total person-years lived above given exact age and life expectancy at given exact age. Eurostat uses the concept of age completed for the calculation of the mortality indicators by age.

2.1.4. Fertility

Crude birth rate - the ratio of the total number of **live births** during the year to the **average population** in that year. The value is expressed per 1000 population.

Total fertility rate (TFR) - the mean number of children that would be born alive to a woman during her lifetime if she were to pass through her childbearing years conforming to the fertility rates by age of a given year.

Fertility rates by mother's age (Age Specific Fertility Rate) - the number of births of mothers of age x to the average female population of age x.

Eurostat uses the concept of 'age completed' for calculation of the fertility indicators.

2.1.5. Migration

Net migration - the difference between the number of immigrants and the number emigrants from a given region during the year (net migration is therefore negative when the number of emigrants exceeds the number of immigrants).

Net migration including statistical adjustments - a general estimation of the net migration based on the difference between population change and natural change between two dates (in Eurostat database it is called *net migration plus statistical adjustment*). In different countries net migration including statistical adjustment may cover, besides the difference between inward and outward migration, other changes observed in the population figures between 1 January for two consecutive years which cannot be attributed to births, deaths, immigration or emigration.

Crude rate of net migration including statistical adjustment - the ratio of the **net migration including statistical adjustment** during the year to the **average population** in that year. The value is expressed per 1000 inhabitants. The crude rate of net migration is equal to the difference between the **crude rate of population change** and the **crude rate of natural change** (that is, net migration is considered as the part of population change not attributable to births and deaths). It is calculated in this way because immigration or emigration flows are either not available or the figures are not reliable.

2.2. Methods of projections[2]

Several general methods for making population projections are available. The general methods are:

- Graphical or mathematical projections of the curve of past population growth (trend based methods).
- Projections based on relationships of population growth in an area to that in other areas (ratio methods).
- Projections of natural increase and net migration (component methods).
- Forecasts based on specific estimates of future employment and other occasionally used methods.

[2] See http://www.un.org/esa/population/techcoop/PopProj/module1/chapter2.pdf

The simplest method of estimating the future size of a population is to take the number of individuals as determined at a more or less recent date in the past and to apply to it an assumed rate of increase, as a function of time. The trend based methods assume that population growth follows natural laws and, therefore, can be expressed in mathematical or graphical form. Basically, population is forecast by examining and projecting past trends into the future. Various types of expressions have been used such as linear, geometric, exponential, logarithmic, etc., to explain past historical growth and predict future growth.

The factors and influences that accelerate or retard natural population increase are pervasive and tend to speed it up or slow it down concurrently throughout the Nation. Moreover economic and social conditions that cause birth rates to rise, or decline, also tend to accelerate or decelerate internal migration. Because of this, the rate of population growth in most areas and communities is related to some extent to the growth rate of the national population.

Population growth in an area or community is usually closely related to, or affected by, economic and population changes in the economic region in which it lies. Future population changes in those larger areas may have an important influence on growth or decline in the smaller area. Hence, past relationships between population growth in an area or community and that of its economic region or State are valuable guides for projection of the local population. If logically founded population projections for the Nation, State, or economic region are available, projections for the area or community can be derived directly there from. .

Component methods study separately several factors, such as births, deaths, and migration which affect the future size of population. The theory behind component analysis is that more accurate estimates can be made using the rates of change of the individual components of population than can be made using the rates of change for the population as a whole. Based on historic experience, it is possible to forecast the rates for such a homogenous group with reasonable accuracy.

Several other methods have also been used for population forecasts and estimations. For example forecasts based on economic projections or comparative or analogy methods or the holding capacity method.

Selection of an appropriate projection method is influenced mainly by the amount and type of data available and by size of projected population. For more than 100 years demographers drew attention to the importance of population age structure for population development and therefore they abandoned the global methods. The widely used method for population projection is cohort component method. It provides a flexible and powerful approach to population projections. It can take the form of a purely theoretical accounting procedure or can incorporate insights from a variety of theoretical models. It can incorporate many application techniques, types of data and assumptions regarding future population development. It can be used at any level of geography from national down to subnational levels. The universality is certainly the main advantage of cohort-component method. And perhaps most important, it provides projections of total population, demographic composition and individual components of growth.

The major strength of this technique is its ability to project a population in a straightforward and unambiguous manner. The technique does not embody restrictive or arbitrary assumptions and generates results which faithfully reflect the initial population structure and the fertility, mortality

and migration conditions specified by the user. It yields projection results which are indispensable to any planning exercise seeking to take the future population change into account.

It is important not to confuse these strengths with the capacity to provide sound forecasts of future demographic change. A projection prepared by cohort-component method may not necessarily be an accurate prediction of future population change. Given the initial population, the technique can only provide an indication of the future population, if the components of population change turn out to be as specified by the initial assumptions. The degree to which a specific projection will correspond to future demographic events will depend on the accuracy with which the initial population was specified and trends in the components of population change were forecast.

2.2.1. Inputs and outputs of the cohort component method

Inputs for applying the cohort component method:

1. Initial age and sex structure of the population

2. Assumptions on mortality:
    Survival ratios by age and sex; or
    Expectations of life at birth by sex; or
    Infant mortality rates by sex and
    Expectations of life at single ages by sex

3. Assumptions on fertility:
    Fertility rates by age; or
    Total fertility rates and
    Proportionate fertility rates by age

4. Assumptions on international migration (if population is open to international migration):
    Net international migration rates by age and sex; or
    Total net international migration rates by sex and
    Proportionate net international migration rates by age, by sex; or
    Net change to the population due to international migration by age and sex

5. Assumptions on internal migration (if subnational populations are being projected):
    Net internal migration rates by age and sex; or
    Total net internal migration rates by sex and
    Proportionate net internal migration rates by age, by sex; or
    Net change to the population due to internal migration by age and sex.

Outputs of the cohort component method:

1. Age and sex structure of the population (national or subnational)

2. Population aggregates (national or subnational):

Population size
Population in selected broad age groups
Mid-interval population size
Number of person-years-lived
Population growth
Births
Deaths
Net change due to migration (international, internal and/or combined international and internal)

3. Indicators of the population structure (national or subnational):

Proportions by broad age groups
Dependency ratios
Median age of the population
Proportion of women in childbearing ages
Sex ratio of the population

4. Indicators of the population distribution (national; if subnational populations are being projected):

Proportion of different territorial units

5. Rates of population change (national or subnational):

Crude birth rate
Crude death rate
Rate of natural increase
Crude net migration rates (international, internal and/or combined international and internal)
Rate of population growth

2.2.2. Computational steps to project a national population

Computational steps to project a national population closed to international migration:

(1) Use mortality assumptions to derive survival ratios by age and sex for the single years.

(2) Apply the survival ratios to the age and sex structure of the population for single years to obtain the age and sex structure of the population.

(3) Use fertility assumptions to derive fertility rates by single ages.

(4) Use the fertility rates, the numbers of women in the childbearing ages for single ages, and the sex ratio at birth to calculate the numbers of births by sex occurring during a calendar year.

(5) Apply appropriate survival ratios to the numbers of births by sex to obtain the segment of the age and sex structure.

(6) Derive various population aggregates, such as the population size, population of broad age groups and then numbers of births and deaths.

(7) Calculate various indicators of the population structure, such as proportions of population in various broad age groups, dependency ratios and the sex ratio of the population.

(8) Calculate various rates of population change such as the crude birth and death rates as well as rates of natural increase and population growth.

Computational steps to project a national population open to international migration:

(1) Use mortality assumptions to derive survival ratios by age and sex for the single year.

(2) Apply the survival ratios to the age and sex structure of the population for single years to obtain the age and sex structure of the population.

(3) Use international migration assumptions to derive net international migration rates by age and sex for the end of the single years.

(4) Use net international migration rates to modify the numbers of survivors at single ages and thus derive the age and sex structure of the population at the end of the year.

(5) Use fertility assumptions to derive fertility rates by single ages.

(6) Use the fertility rates, the average numbers of women in the childbearing ages in a given calendar year and the sex ratio at birth to obtain the numbers of births by sex occurring during the year.

(8) Apply appropriate survival ratios to the numbers of births by sex to obtain the numbers of survivors by sex at the end of the year.

(9) Use appropriate net international migration rates to modify those survivors and in the process obtain the age and sex structure of the population at the end of the year.

(10) Derive various population aggregates, such as the population size, population of broad age groups and the numbers of births and deaths along with the net change due to international migration.

(11) Calculate various indicators of the population structure, such as proportions of population in various broad age groups, dependency ratios and the sex ratio of the population.

(12) Compute various rates of population change, including the crude birth, death and international migration rates as well as rates of natural increase and population growth.

3. POPULATION PROJECTION SCENARIOS

3.1. Different scenarios

The six scenarios of the future national population developments have been prepared for both Hungary and Slovakia. First of all, the common three-variant demographical forecast represents the basic output. It has been prepared with using of most often applied Cohort-Component method in the deterministic (variant) way. The three major components of the future demographical change are modelled, namely the processes of fertility, mortality and migration. The respective estimated rates of probabilities of these processes are being applied to demographical cohorts. There are a couple of other methods (e.g. probabilistic, micro-simulation, accounting methods), however, the Cohort-Component one is still the most frequent in the practice, at least in case of the UN, EUROSTAT and official national forecasts.

Zero-migration scenario shows what will be the population development if no migration gains occur. In other words, it puts the view on demographic future influenced by the fertility and mortality exclusively. The difference between forecast with incorporated migration and zero-migration projection actually represents the clear impact of migration on the population change being positive in case of the European countries.

The "real migration" scenario takes the unregistered migration into consideration. The estimations and incorporation of the undocumented migration flows are the main goal of scenario. Since the official data on migration are very likely under-estimated in case of out-migration especially, there is a strong need for such scenarios. The real-migration variant was put together with the medium variant of fertility and mortality.

Finally, **the "replacement migration" scenario** has been calculated (see UN 2000, Coleman 2003, Lutz and Scherbov 2003 for further information). The results of such scenario answer the following question. What net migration is enough in order to avert depopulation? In other words, the simulation demonstrates what level of net migration is inevitable to avoid the natural decrease. It represents "the compensation" level of net-migration. The real-migration variant was put together with the medium variant of fertility and mortality.

As for a sub-national level, one medium (most likely) scenario for the NUTS-III regional level together with one for local partners´ cities (City of Turčianske Teplice and Pécs) has been prepared.

The starting point for the projections is the base population. This is taken as the 1st of January of the year in question or the 31st December of the previous year's population estimate from each country.

Projections should extend from 1st January of 2013 or 31st of December 2012 to 1st of January of 2035 or 31st of December 2034 in case of NUTS-III level projections and to 1st of January of 2060 or 31st of December 2059 in case of NUTS-II level projections.

The projections frequency is annual.

Table 1. Overview of the forecasting scenarios in the WP5

Level	***Scenarios***	***Horizon***
National level	Low	2060
	Medium	2060
	High	2060
	Real-migration	2060
	Zero-migration	2060
	Replacement migration	2060
Regional level (NUTS-III)	Medium	2035
Local level (Turčianske Teplice, Pécs)	Medium	**2025**

3.2. Migration in population projection

The process of migration is perceived as very volatile and unstable in the demographic literature. The uncertainty and inaccuracy of forecasts, especially on local and regional level, is very often caused by migratory assumptions that are inaccurate. Demographers pay a strong attention to the evaluation of population forecasts (Keyfitz 1981, Keilman and Kučera 1991, Keilman 1997, Bleha, 2007). Process of migration is very comprehensive system and the matrix of factors is very complicated. In the second half of the 20th Century, the fertility had the major impact on the inaccuracy of the population forecasts. Its level changed over time, waves caused by post-World War baby booms were later replaced by the Second demographic transition. Moreover, some pronatalist measures influenced the fertility in several communistic countries. Recently, the fertility fluctuates in a very narrow interval being very low. Thus, the relative importance of migration concerning the inaccuracy has been growing.

Talking about sources of uncertainty, the dispute should start with impact of crisis on migration. Unfortunately, the economic forecasters are still not able to put the accurate economic forecasts with respect to the estimated time of ending the economic crisis, however, this information is very crucial for migratory predictions. Moreover even if sufficient economic predictions existed, the rate of impact on migration is indistinct. Is the impact lowering or is it stable? Are migrants now less sensitive to the crisis´ s effects than 5-6 years ago when crisis started? Are new behavioural patterns and "crisis-adjustment" migratory behaviour coming? These questions are hardly to answer, but they must be answered at least partly. Demographers should pay attention to the attempts to discover

the causal linkages between migration and social-economical developments. To do it, review of existing studies on the relation crisis versus migration has made, since there are several studies of social scientists that investigate the impact of crisis on international migration bringing very interesting results. The results are not unified with respect to evidences of impact. Martin (2009) is pointing out that the current crisis differs much from all others in the past (Oil shock, Asian crisis in 1990s, and others). He discusses if the current crisis is shaping like the V-curve (quick recuperation), the U-curve (longer recuperation), the W-curve (several transitive periods of declination and growth), or even the L-curve (very long-lasting depression). According to Martin, there is no doubt that the displays of the crisis are much more global than in the past were. Martin stresses one of the major differences – fact that the crisis started in most developed countries thus having prevented the migrants to move into the "boom" countries. This was typical for the 1970s crisis for example. Castles and Vezzoli (2009) try to answer if the crisis interrupted the migratory trends only temporarily or represents a very new structural change. Like the other studies, they stress the facts like the migrants´ vulnerability and growing return migration. They suppose that if migrants have some basic background, linkages, if they new skills in destination country, then they try to stay even in worsening situation on labour market. They dispute on function of migrants being like "safety valve" in time of the crisis. Papademetriou et al. (2010) used some case country studies and shows among others interesting figure the 60 per cent drop in migration flows from the new member states to Ireland between 2008 and 2009, the drop to Spain was more than 65%. Some destination countries became emigration countries sharply. The best examples represent Ireland and Greece. Kohler et al. (2010) explain some difference in reactions of EU migrants and non-EU migrants. Return migration from the Great Britain and Ireland is bigger to the EU countries than to the non-EU countries. They argue that it depends on situation in homelands and possibilities to find job there as well as to get some social allowances.

Besides the impact of crisis, some other sources of uncertainty have been identified. They are strongly bound to globalisation aspects, geopolitical questions, position of the macro-regions in the globalised World. The question of migration policies must be tightly under demographers´ supervision too. Some useful comments from other SEEMIG partners were received. We tried to include into the future assumptions because of high need for such "interconnecting" approach. According to Hungarian colleagues (Dobos Erika), the economic crisis has obviously affected the migration. However, it isn't expected that the decrease or the end of the crisis will completely eliminate the migration. First, the topic should be treated in accordance with the specifics of each country or region. The migration history, practice and social, historical, cultural factors are not the same in the new member states. In some countries, regions, the migration has already begun several years (after the transition) before the economic crisis and has become very intense (Romania, including Harghita County). In these countries, the economic crisis has increased the rate of migration but not drastically. In other countries, the migration started (Hungary) in the post-economic crisis. Secondly, in the last two decades the phenomenon of migration shows that the process has become highly automatized: it has become a social practice which remains even if the direct causes disappear (as in this case the economic crisis). Presumably, with the reduction of the crisis the number of migrants will decline somehow, but the social practice persists. According to the Austrian UNIVIE partners, return-migration became important and is linked to the arguments above (a unified European migration space, the establishment of growing networks between sending and receiving regions). However it is hard to predict the quantitative of amount of return migration. It

depends on the economic development in the sending regions as well as in the target regions. The Polish-UK migration link was a wonderful example to study these trajectories.

3.3. Methodology for estimation of "real migration"

It is well known that due to lack of interest of migrants for registration of their residence emigration is underestimated in many countries. Therefore, it is necessary to find methods for the estimation of the more realistic number of emigrants. It is important assumption for correct settings of migration parameters in the projection of populations.

One method of doing this is the **estimate of "real migration"**.

Migration assumptions for "**real migration"**[3] are designed in two steps:

1. Estimation of net migration of foreigners
2. Estimation of net migration of citizens/persons born in the sending country

1. Estimation of real net migration of foreigners is based on three sources:
    a. *Migration flows of foreigners* (immigration, emigration, net migration) from balances of population in intercensal period (in Hungary from vital statistics)
    b. *Migration stocks of foreigners* - data from two subsequent censuses
    c. Data on *naturalisation of foreigners*

The estimation is based on increase of foreigner's stock in the given country in the intercensal period. When subtracting the natural increase from it, net migration of foreigners plus adjustment is the result. Real net migration of foreigners in intercensal period is calculated as the sum of net migration (plus adjustment) and the number of naturalized foreigners. Then calculate the average annual net migration of census data and average annual net migration from balances. The difference between them is talking about how much yearly net migration from balances needs to be adjusted. Applying this adjustment we get the modified net migration. The real number of net migration of foreigners in particular years is then calculated as the difference between number of net migration of foreigners from balances and number of the modified net migration.

2. Estimation of real net migration of citizens is based on:
    a. *Migration flows of citizens from sending countries* - data from balance of population in intercensal period (in Hungary from vital statistics)
    b. *Migration stocks of persons living abroad and born in the sending country* - as an alternative to numbers of *citizens of the same country who are living abroad* - data from Censuses 2001, 2011[4] and from the UN statistics.

The estimation is based on increase of number of persons living abroad and born in the sending country. To this increase we add the number of those persons who were born in the sending country

[3] In this paper the concept of„real migration" is understood in terms of more realistic migration.

[4] There are also other data sources, however, providing only partial data - the mirror statistics of the destination countries (EEA countries only), data on persons born in a given country, from the OECD statistics (OECD countries only).

and have died in intercensal period.[5] The result is the net migration of persons born in the sending country. Then we calculate difference between average annual number of emigrating citizens from balances[6] and average annual net migration of persons born in the sending country. Annual numbers of emigrating citizens from the balances should be adjusted by this calculated difference to obtain real net migration of citizens of the sending country (respectively emigrants born in the sending country) in particular years.

Finally, summing number of net migration of foreigners and net migration of citizens/migrants born in the sending country, we can obtain probably more realistic net migration in the given country - "real migration".

[5] As the data on deaths are not available, the estimate needs to be done. The simplest estimate of deaths abroad (born in the sending country) can be obtained by using, for example, the same sex and age structure and the same probabilities of dying persons as for population living in the sending country.

[6] It menas that we use the data on emigrating citizens (from vital statistics) to estimate the trend of net migration of citizens/migrants born int he sending country.

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