Distr.: General
1 April 2016

English only

Economic Commission for Europe

Conference of European Statisticians

Joint Eurostat/UNECE Work Session on Demographic Projections
Geneva, 18-20 April 2016
Item 4 of the provisional agenda
Assumptions on fertility

Projecting Future Fertility in Russia: using cohort approach together with the idea of the Second Demographic Transition[1]

Note by the Federal State Statistics Service, Russian Federation[2]

Summary

Nearly all previous projections of future fertility in Russia failed to predict it accurately; the growing need for a more adequate projection has emerged.

The paper is aimed at describing experience in projecting future fertility trends in Russia for medium- and long-term period. This study distinguishes two different approaches: the first one uses a hypothesis that fertility in Russia is set to converge by its characteristics with average for all developed countries. The second one assumes that Russia has become a local trendsetter and converges only with some English-speaking countries while diverges from most developed countries in the continental Europe and Eastern Asia.

The main idea of the 1st half of the study is to use both common and specific fertility trends in different developed countries. For these reasons the cohort approach has been chosen. The idea of the Second Demographic Transition (SDT) has become a basic concept on which many aspects of this part of study are heavily based. It helps to establish a theoretical framework for the study. A turning point for an onset of the SDT was chosen at the beginning of fertility aging, which is a universal process all over the developed world. Different scenarios of future fertility patterns were worked out based on two main concepts. The first hypothesis assumes that Russia will follow universal way, and the second one predicts that unique fertility patterns will not be eliminated completely and will remain the same in the future.

The 2nd half of the study is focused on domestic processes undergoing in Russian fertility on its own. While some trends are of universal or region-specific nature, there has been discovered a number of unique processes that distinguish Russia among most Eastern European countries as well as among continental Europe. Therefore the third hypothesis has been worked out.

NOTE: Tables and figures related to this paper are presented in the addendum WP 12/Add.1

1 This study is partly based on results of project “Demographic trends in Russia and OECD countries: comparative analysis and policy implications”, which was concluded in the Higher School of Economics as a part of fundamental research program..
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I. Introduction

1. Fertility characteristics and their change have major impact on future size and structure of population in any given country. This is even more evident in long-term projections.

2. Russian fertility patterns saw dramatic changes during last 35 years. Its level consequently has been one of the highest (in 80's), then one of the lowest (at the edge of millennia) and now becomes one of the highest among developed countries again. All previous projections failed to predict these changes.

3. The United Nations Population Department (UNPD) use mature theory of the Demographic Transition as the basis for projecting above-replacement fertility for a long time already (Alkema, 2010). But projecting below-replacement fertility has not been established on any well-recognized theory yet (Expert group meeting on below-replacement fertility, 1997) (Wilmoth, 2015). This leads to increasing bias and greater uncertainty in projections. The UN, Population Reference Bureau and U.S. Census bureau project asymptotic character of Total Fertility Rate (TFR)3 dynamics, where limits are often chosen deterministically and have small differences between them. Errors of such projections could be sufficient. For example, the average post-factum error in projected TFR's for Scandinavian countries exceeded 0.3 after 12-20 years (Keilman, Time Series Based Errors and empirical errors in Fertility Forecasts in the Nordic countries, 2004).

4. There are usually only one or two parameters of fertility being used for the purposes of projection: the TFR (always used) and the Mean Age of Birth (MAB), which is calculated using ASFR's instead of absolute numbers. Program code usually creates ASFR's using these two parameters. Independent projection of ASFR's (5- or 1-year) is a rare phenomenon, however, it increases precision.

5. In most cases, 3 variants of TFR are projected nowadays: low, medium and high, which usually have different hypothesizes at their base. Constant or replacement levels of the TFR are used for illustration of possible outcomes in cases of stable or stationary populations respectively (UN). UN also used to lower or raise projected TFR level by 0.5 children for entire period of projection.

6. In the XXI century, as calculation capabilities grew, UN and other institutions began using Bayesian hierarchical models which include uncertainty (Raftery, 2014). While it allowed formally avoid deterministic approach, in reality many model parameters are still often set manually. This method is applicable not only for aggregated TFR, but for ASFR's as well (Keilman, Predictive Intervals for Age-specific Fertility, 1998).

7. However, all methods, mentioned above, are used for projecting period fertility (of synthetic cohorts) only. It has been illustrated, though, that period fertility measures are affected by structural shifts and other factors, and could show misleading picture while measuring true fertility level (Sobotka, 2011). For example, if women give births progressively later in their life comparing to their predecessors each calendar year, period ASFR's and hence TFR levels are lowered in comparison to stable situation, and vice versa: when fertility gets younger, it's levels are higher just because of that fact only (Sobotka T. , Tempo-Quantum and Period-Cohort interplay in Fertility Changes in Europe. Evidence from the Czech Republic, Italy, the Netherlands and Sweden, 2003). Sometimes the difference is big enough to create misleading expectations (Myrskyla, 2012). Some researchers notice that aging of fertility is the sign of the Second Demographic Transition (SDT) in fertility (Billari F.C., 2006) (Sobotka T. , Is lowest-low fertility explained by the postponement of childbearing?, 2004).

[3] Total Fertility Rate (TFR) is a sum of Age-Specific Fertility Rates (ASFR). It shows potential final number of children that will be born by average person if all ASFR's keep stable during her (his) reproductive lifetime.

8. The concept of the SDT was initially introduced by Ron Lesthaeghe and Dirk Van de Kaa in 1986. Initially the SDT had been mostly focused on deeply depressed fertility levels in Western countries, but soon this hypothesis grew in complexity, addressing fertility aging, growth of extramarital fertility, and, in general, shifting in values regarding to individual versus family ones. Later some researchers highlighted the fact that fertility ageing, associated with the SDT, depresses period fertility levels, so that an adjustment is needed to evaluate true fertility level, if using cohort one is not an option.

9. This paper describes new method of projecting fertility using both period and cohort indices.

II. Russian fertility today: highlights

10. Nearly all measures and indices lead to conclusion that fertility in Russia grows. Russian TFR has been growing since 2000, and since 2006 – non-stop, which means 10 years of uninterruptable growth.

11. The TFR grew by 54% since 1999[4], which hasn't been occurred in any country[5] during peace times since baby-boom in 50's in the English-speaking countries[6]. The TFR accounted for 1.78 in 2015, while it was only 1.16 in 1999. This places Russia at least at 8th place among all developed countries (49 countries and territories) in 2015 (and 6th in Europe, among 40 countries) in contrast with the situation in 1999, when the TFR was lower only in Ukraine and Czech Republic. In contrast with the fertility growth of 80's, the postponement of fertility to older age continues in a whole (fig. 1), particularly for 1st births. This means that cohort fertility might be even higher.

12. Indeed, the Average Parity (AP)[7] of synthetic cohort (period measure) grew from 1.60 in 2006 to 1.82 in 2015. This indicator fluctuates much less than TFR by its nature, so the growth by 0.22, or by 14% just in 9 years is impressive and unprecedented[8]. Researchers previously emphasized that AP has good correlation with cohort fertility level and has strong predictive power for this very important measure (Zakharov, 2014).

13. Finally, the Complete Cohort Fertility Rate (CCFR), or the Cohort Total Fertility Rate (CTFR) – a real generation measure – is to be already known to pass its lowest point at 1970-1972 years of birth of female cohorts. Women born in that period are now 42-46 years old, and their completed real fertility level could be known rather well already[9]. It will be 1.60, which is rather low, and constitutes significant drop from the level of 1.86-1.87 for cohorts born in 1952-1957, just 15-20 years before, which benefited most both from pro-natalist and anti-alcohol policies of 80's. It becomes more obvious with each passed year that female cohort fertility in Russia raises since the 1973 year of birth. It is known already that by no means this indicator will be lower than 1.67 for women born in 1982, and this is the lowest possible scenario with a collapse of fertility beginning in 2016. Moderate scenario, which predicts 'freezing' of fertility level after 2015, predicts CCFR of women born in the year of 1985 at 1.79 children, and the high one – at 1.92, but the probability of the latter is low. In any case, this is a sizeable growth of an indicator that rarely grows at all, especially that much. It's worth mention that Russian women, born in

[4] The countries next to Russia in terms of recovery growth magnitude are Latvia and Belarus.
[5] Except the case of Romania, in which the TFR almost doubled the next year after abortions become illegal (1966).
[6] It's worth mention that previously, during 1988-1999, the TFR almost halved in Russia (from 2,23 to 1,16) and many other post-soviet countries, so this growth actually is a recovery, and nowhere in Eastern Europe this recovery is even close to reach previous fertility rates of socialist era.
[7] Average Parity, in contrast to Mean Birth Order (MBO), is calculated using ASFR's but not absolute birth numbers.
[8] The one and only example of higher growth of AP in recorded history during 9 years was in the USA during the period of baby-boom from 1947 to 1956 (+16%).
[9] Women born in 1972 turned 43 years in 2015, which means that 99.8% of their cohort fertility is already realized.

1982, already have almost 5/6 of their lifetime fertility been realized, and that born in 1985 – almost 70%.

14. These changes seem even more dramatic when comparing them with projections made just 8 - 9 years ago. In 2007, when current pro-natalist policy measures have been introduced, some researchers predicted just temporary or weak effect, like the one observed in 1982-1987. Debates on whether observed positive fertility changes have temporary or prolonged nature were undergoing regularly both in academic circles and in the media since. In contrast with predictions and with the economic situation, fertility patterns developed surprisingly positive since that time. Drastic contrast between earlier (yet not-so-distant) projections and reality stresses researchers to develop solid theoretical basement for future projections to raise their accuracy. A need for a new approach to projecting routine has emerged.

15. This paper is aimed to partly address this question. Author used the method of historical analogues partly based on the concept of the SDT10,11. The key element of the method is to combine the history of fertility transformation during SDT in all developed countries into one synthetic database, which aggregates key indices for further use. This approach emerged as it had become obvious that no any particular country, of which underwent fertility transformation earlier than Russia, could become the only reference for the projection. This conclusion, in its turn, came from realizing the magnitude of difference between fertility patterns among the group of developed countries.

III. MEDIUM, or base, projection scenario with RAPID aging of fertility

16. The basement of this variant is concluded in creating of the custom database, mentioned above. For that purpose a number of sources has been used, namely Human Fertility Database (HFD), Human Fertility collection (HFC), Eurostat database and numerous official sites of national statistics offices. Total number of countries, mostly developed, exceeded 50. It’s worth mention that the quality and completeness of the data from different sources differs greatly. That said, HFD data is often of the best quality, as it uses universal approach and believed to be bug-free, but unfortunately it contains data for selected countries only, and the data is often severely outdated. The Eurostat data is often more useful, as it’s been regularly updated and contains almost complete data at least for 28 EU countries plus number of other European countries. United States National Vital Statistic System has excellent and up-to-date data. Japanese Ministry of Health, Labour and Welfare uploads number of births by single year of age and parity monthly approximately 130 days after the period has finished. But many other national statistics websites have poor quality or incomplete data or even don’t have it at all for free access. Several countries have only 5-year age group data, the same is often true for HFC, which implements interpolation procedures, but the interpolation technique or initial data quality could result in insufficient data. Several countries have too short data rows to include into the database.

17. Nevertheless, overall big number of countries in the database allowed to smooth results when aggregated.

18. Fig. 4 illustrates different patterns of age-fertility curves for some countries. Further analysis confirmed fertility growth over the age of 30 (fig. 6) virtually everywhere, but growth rates are different as well as initial levels. In contrast, fertility below age 30 decreases in most countries (fig. 5). Notable exceptions from that process are several

[10] The result of the projection for Russia based on this study is available at the official Rosstat site
[11] Elements of this method were partly used for earlier projections since 90’s (Zakharov S. V., 1997) (Zakharov, Fertility Trends in Russia and the European Newly Independent States: Crisis or Turning Point?, 1999)

Eastern-European countries (namely Russia, Ukraine, Belarus, Romania and Bulgaria) and English-speaking European countries until recently.

19. An interesting pattern has been discovered during analysis: cohort fertility in age 30+ usually mirrors (echoes) dynamics of cohort fertility before reaching age of 30, but magnitude and timing of such mirroring (echoing) differ. Usually mirroring (in age 30+) magnitude is less in absolute terms and comes a bit later, often being postponed by several years, although this timing parameter of shifting varies from 0 to 10 and more years. The shift in timing and the magnitude of older fertility ‘echo’ often determines changes in total cohort fertility (obviously it would be flat stable if a mirroring was perfect).

20. This pattern is well-illustrated in the case of Sweden, which has been chosen because of the long row of fertility data of good quality (fig. 7). Usually ‘mirroring-echoing’ begins after cohort fertility reaches 2 and follows the pattern described above. Another illustrating case is Czech Republic (fig. 8). The country has very high tempo of ongoing SDT, so fertility gets older rapidly, but noted ‘mirroring’ could be seen well enough also.

21. Mentioned decline of the “young” and rising of the “old” fertility are key evidences of the ongoing SDT in fertility, with shifting from universal pattern of early marriage and childbearing of at least first child (when social norms were still strictly followed and contraception wasn’t very effective, at least until a first child is born) to multi-variant matrimonial and procreative mass behaviour. The situation reached its apogee in Eastern-European countries by the end of 70’s, when Eastern Germany and Bulgaria had youngest observed fertility in history, just before the start of the SDT there.

22. The situation in Russia is rather unique: while “younger” fertility stopped declining, the “older” one grows by very stable manner and with high tempo (fig. 9). If the hypothesis of “mirroring-echoing” of fertility would apply to Russia, it means that this growth should soon stop. This scenario served as a base for developing LOW projection variant with SLOW fertility aging.

23. Dividing total cohort fertility into 2 parts helped to calculate and compare three points on generational time scale, which are evidences of the beginning of the SDT process:

(i) When cohort Mean Age at Birth (MAB) stops falling and begin to increase.

(ii) When “younger” fertility stops rising and starts to decline

(iii) When “older” fertility” stops declining and starts to rise.

24. All these 3 points usually are situated rather close to each other on generational time scale, and sometimes even merge into the one. The latest one usually is No. 3. A question arose on which one to use for the only starting point for the SDT onset for any particular country in universal manner, to include into the database. It’s worth mention that data of satisfactory quality for most countries are available only for the time after WWII, so 3rd point was available for biggest number of countries, and had been chosen accordingly.

25. It turned out thereafter that in 3 developing countries signs of the SDT are virtually non-evident (in Chile, Brazil and Costa Rica). As they were the only developing countries in the study, the limitation of using only developed countries in the research has been proved itself. Further 5 countries have the point of minimum cohort MAB unknown, but have the known point of minimum “older” cohort fertility. The rest 47 countries have both points been able to determine, from which in 14 countries these 2 points have merged into one single year of cohort birth, and in further 24 countries the time difference between the point of minimum cohort MAB and the point of minimum cohort fertility in age 30+ is only 3 years or less.

26. The result of this analysis regarding fertility 30+ is shown in the Table 1.

27. The next stage of the study was to model the SDT for abstract typical developed country with average characteristics of fertility. In order to perform this, first of all, data rows for all countries were chronologically moved and merged into one with a single conditional year of the onset of SDT by shifting of annual cohort fertility rates for each country individually over time so that the point of minimum fertility at ages 30+ became the same universal conventional "zero" year - the reference point – for all countries.[12]

28. 50 individual birth rate curves (one from each contributing developed country) for each single year of reproductive age range, having a different length in years, were combined into single average one, starting at the same conventional "year zero". For this, for each year of age and for each year since the onset of the SDT, including zero, an unweighted average annual cohort fertility rate was calculated, and the corresponding curve was built. The author intended to weigh on the population originally, but methodologically this appeared not indispensible. Instead, an idea emerged to calculate the weights for each country later in another approach described below in the next chapter.

29. Since the set of countries, starting from a certain year after the onset of the SDT, began to decrease rapidly (primarily due to the countries that joined the SDT last and therefore have a shorter time-series data), the curve for the latest generations since onset of SDT was distorted as can be seen in Fig. 10, 13 and 14.

30. Smoother curves required to include in the model. The solution was the choice of approximating functions which could describe the dynamics of the average fertility rate for each one-year age group of women in most accurately manner. The author deliberately neglected the smoothness of the resulting cross curve of the age distribution of fertility rate for the latest (furthest from the onset of the SDT) hypothetical generations, i.e. different types of functions were used for different ages to best suit the model and the observed trends.

31. Some functions for several single years of age were selected deliberately in arbitrary decisions, in addition to the accounting value of the coefficient of determination R^2, because the higher coefficient of R^2 in several cases was caused by better description of the onset of the STD; while the resulting curve looked increasingly unlikely further, not resembling any of real individual countries trajectories. To mothers aged 14-18 and 26-27 years, the author has chosen an exponential function, for 19-25 and 28 years - the function of the natural logarithm, and square polynomials appeared to be most relevant for other ages. At least until 2050, it has given a relatively plausible and "smooth" age-fertility curve.

32. Thus, a model of the fertility age profile transformation over time has been created. Annual fertility rates were approximated by the above-mentioned functions, which are shown in Figure 11.

33. Accordingly, a value field of fertility age curves for each conditional generation of women can be seen in Fig. 12.

34. The resulting model of ongoing STD in fertility has been used to project future fertility dynamics in Russia in the MEDIUM variant with RAPID process of the STD. For this purpose it was necessary to merge the actual data on the birth rate in Russia with the resulting averaged model for the developing countries together. At the time of the initial calculations relevant data for 2013 was available and had been used. For 2014 the

[12]This technique of modeling the trajectories of demographic indicators and the introduction of the conventional time scale from the beginning of irreversible changes was used for the first time in domestic practice by Zakharov while modeling the First Demographic Transition (the transition from high to low fertility) in Russia and in Europe and during the simulation of the SDT thereafter. In the second case, in contrast to the approach under consideration in the article, the start of decreasing of the birth rate in the 15-19 years age group for conventional generations (Zakharov, Demographic transition in Russia and evolution of regional demographic difference, 1991) (Zakharov, La Transition demographique en Russie et l'evolution des disparites demographiques regionales, 1992) (Zakharov S., 1996) had been taken as a onset of the SDT.

assumption about expected TFR for the first months of the year in the range of ~ 1.76 was made. It was also assumed that fertility aging will continue at the same pace as in the latest years[13].

35. Further, the next method of bringing actual Russian annual fertility rates to the resulting averaged model for developed countries in a whole was used: for the first three years relative dynamics of change of the ASFR's (their rate of change) was set to approach to the model by 1/3 per year, and then for the next10 years absolute levels of fertility in each year of women's age were set to converge with model coefficients, by 1/10 in a single year. The overall averaged model for the developed countries was used in subsequent years for Russia.

36. Examples of fertility rates calculation for ages 25 and 35 illustrated in Fig. 13, 13a and 14 plus 14a.

37. Despite big number of calculation stages, the author was not completely satisfied with the result, which was the reason for creating also a LOW fertility forecast with slightly different method, which is described below.

IV. Main projection scenario for Russia for the period up to 2050 according to the historical analogues method using cohort fertility (the MEDIUM option with the RAPID fertility aging)

38. Fig. 13 and 13a illustrate the difficulty of forecasting "young" fertility in Russia: its level in the age between 25 and 30 years continues to grow, while in most developed countries and, respectively, on average for all developed countries, it declines. Subsequently, the trend of fertility growth at these ages, according to the medium projection scenario, will turn into decline as a result of approximation to the average level for developed countries in a whole. This will lead to relatively rapid ageing of fertility, i.e. to the accelerated increase of the MAB. Hence is the name of this option.

39. Fig. 15 combines total fertility figures for calendar years (PTFR) and for cohorts (CTFR), with the latter figure moved by 28 years on the time scale. 28 years is the Mean Age at Birth in Russia, which is almost equal to the average length of a generation, both for 2013-2014 and for the whole period on average. Painted field at both sides of time axis shows tempo of fertility rejuvenation (above the x-axis) or ageing (below the x-axis), in this case calculated as

$PTFR_x - CTFR_{x-28}$,

where 'x' is the calendar year.

40. According to the model, the speed of the fertility aging should increase to bring Russia to the average European level sooner, so this scenario is called "with ACCELERATED fertility aging." According to this variant of the projection, the age profile of fertility in Russia will quickly move closer to the European one: modal age of childbearing will grow from 25 in 2012, 26 in 2013-2014 and 27 in 2015 year to the age of 31 year by 2050, and the MAB will be 31.7 years by that time (Fig. 16, tab. 3) in comparison with 27.85 in 2012, 27.97 in 2013, 28.12 in 2014 and 28.24 in 2015. Birth rates at younger age will decline, and at older – will grow, while mode will become more pronounced, like that is observed now in the continental Europe.

41. According to this model, the PTFR will stay between 1.7 and 1.8 children per woman in the medium term and will tend to grow to the value of 1.88 by 2050 thereafter,

[13] The data for 2014 and 2015 confirmed the validity of the adoption of such assumption for fertility in Russia: both the level and the age profile continued to change in accordance to the dynamics in 2012-2013.

which probably could help maintaining or increasing population in Russia (after decline of 2020s), counting sizeable and steady immigration influx. Therefore this version of projection is moderately optimistic and could be named as the MIDDLE one, or the base option of the three.

42. This scenario assumes an increase of the excess kurtosis of the age-fertility function, which is more typical for continental Europe. However, there is a high probability that the kurtosis will remain lower than average in Europe, more reminiscent of the fertility age profile in the United States and England; moreover, the downward trend of the kurtosis of the distribution is still present in the meantime.

V. LOW fertility scenario with a SLOW fertility aging

43. Development of this variant mostly based on previous one (MEDIUM), but with significant differences.

44. Period fertility has been used instead of cohort one. This made calculations shorter as for ASFR1 cohort indicators haven't much significant difference from period ones and there was no need to move fertility curves to the unified zero-year of the onset of the SDT.

45. As a result, there was no need for move in time for ASFR.

46. The opportunity to use weight indices for different countries in calculation of average indicators has emerged.

47. 4 values has been taken for counting the relative weights used to calculate the degree of similarity between the properties and dynamics of the fertility parameters in every single developed country in comparison with Russia:

a) the absolute level of the TFR in 2013;

b) the MAB[14] in 2013;

c) the value of excess kurtosis distribution of age-fertility function in 2013;

d) the relative change in the level of fertility at ages younger than 30 years for the ten-year period from 2003 to 2013 ($PTFR\text{-}30_{2013} – PTFR\text{-}30_{2003}$).

48. The latter value is used as a parameter for the following reason: during last decade or so the level and dynamics of the "young" fertility in several countries, including Russia, was parted from the bulk of the developed countries (see Fig.5). In contrast, the birth rate over the age of 30, as has been shown above (see Fig.6), is growing ubiquitously.

49. After the difference between Russia and each country for every 4 parameters have been calculated, it should be normalized. Normalization process included calculation of maximum possible deviations for each of the 4 parameters, by looking for extremes in the whole observed period in all observed countries. For example, to calculate maximum possible deviation of TFR, cases of Albania in 50's (TFR above 6 children per woman) and Taiwan in 2010 (TFR below 0.9) have been used, creating the difference of more than 5 children per woman. To normalize deviations for the TFR, they were divided by this maximum possible deviation. All deviations in 4 parameters were normalized that way:

$DN_{Pn} = |D_{Pn}|/(Pn\_max - Pn\_min)$,

where

D – difference or deviation between Russia and each particular country by 1 of the 4 parameters P, and

DN – normalized deviation.

[14] Calcuation based on ASFR's rather than on absolute birth numbers.

50. The only question arose was about the normalization of the TFR deviations. Historical variation of this parameter is much bigger than any current difference between any country and Russia. Counting this, 2 variants of normalization was prepared: with or without normalization of the TFR difference. Surprisingly, the difference between them appeared to be minor.

51. After all relative deviations from Russia for each country were calculated, these newly normalized numbers were put into a formula of Euclid distance:

Distance = $\sqrt{(DN_{P1}^2+DN_{P2}^2+DN_{P3}^2+DN_{P4}^2)}$,

52. The last stage of the calculation was to find relative weights for each country:

Relative weight = $1/(\text{Distance})^2$

53. Final result of one variant of the calculation is shown in the Table 2. The difference between two variants is relatively minor: in both cases 5 closest countries to Russia in terms of 4 fertility parameters are Belarus, Ukraine, Bulgaria, Romania and Lithuania. In each variant England, Latvia and Bosnia are in the top 10. Most distant countries from Russia are states of Eastern Asia.

54. Described method could be an alternative to the procedure of clasterization in general.

55. After all single ASFR's for each country and each calendar year were merged using calculated weights, a second field of combined ASFR's for each 1-year age group and each calendar year have emerged. Resulting lines were not perfect and also needed to be smoothed by approximizing functions. In this variant they all appeared to be exponential. This type of function showed highest value of R^2 almost for all ages.

56. Merging of Russian fertility dynamics with the model's one was performed the following way: a pessimistic scenario for 2014 has been taken (TFR~1.74), for 2015 model tempo changes of ASFR's were applied to Russia, and for the following 10 year absolute levels for Russia approached model's with steps of 1/10 of the difference for each year.

57. According to this variant of projection, both period and cohort TFR will return to the level of approximately 1.6 children per woman. SLOW age transformation of fertility means that neither MAB, nor modal age at birth will reach 30 years by 2050.

VI. HIGH fertility scenario with the MEDIUM rate of fertility aging

58. To develop high scenario a combination of low and medium versions has been taken, united as follows: maximum annual ASFR's were taken in the choice between two. Thus, at HIGH scenario fertility falls very slowly in young ages as in the LOW scenario, and grows rapidly in older ages as in the MEDIUM one.

59. Methodological justification for such acceptance is based on the analysis of the changes in Russian fertility age profile during the XXI century. Transformation of the age-fertility curve occurred particularly in this manner so far in this century (Fig. 1 and 2). In recent years, the birth rate in Russia almost did not change for women aged less than 25 years old, steadily grew at the age of 25 - 30 years, and the growth has been rapid and continuous above the age of 30. Thus, the high scenario of future changes in fertility is an extrapolation of current positive trends, adjusted for realistic assumptions about possible limits of future growth. It is obvious that the current rate of fertility growth can not last long, because fertility level in developed country with effective contraception should be limited by the mass idea of the perfect family size. Therefore, the result obtained by this method should be used with caution, especially in the long term.

60. According to the HIGH scenario the TFR will rise to 2.05 children per woman by 2050. At the same time the MAB will rise to 30.9 years. Such a rate of increase made this scenario named as with MEDIUM rate of fertility aging.

VII. Comparison of all 3 variants

61. All 3 variants place fertility in Russia below replacement level (TFR~2.1) until the end of projection period (2050). However, HIGH scenario projects TFR to approach this threshold by 2050 (Tab. 3), with the level of fertility theoretically providing replacement value (Net Reproduction Rate, NRR) of 0.98. At the other end of spectrum, LOW variant provides generation replacement only by ¾. It's worth noting that both average models, used in LOW and MEDIUM scenarios, result in linear growth of fertility and should not be extrapolated in the future unlimitedly. Ideal family size, mentioned above, is around 2 children or slightly less (but nowhere more than 2.5) in all European countries (Sobotka T. B., 2014), so it's unlikely that Period or Cohort TFR will exceed 2 by much.

Sources list

Alkema, L. R. (2010, January 28). *Probablistic Projections of the Total Fertility Rate for All Countries.* (U. o. Washington, Ed.) Retrieved from https://www.csss.washington.edu/Papers/wp97.pdf

Billari F.C., L. A. (2006). The Postponement of childbearing in Europe: Driving Forces and Implications. *Vienna Yearbook of Population Research*, 1-17.

Eurostat Database. (n.d.). Retrieved from http://ec.europa.eu/eurostat/web/population-demography-migration-projections/births-fertitily-data/database

Expert group meeting on below-replacement fertility. (1997, November 4-6). *Future Expectations for Below-Replacement Fertility.* Retrieved from Population Division, DESA, UN Secretariat, New York: http://www.un.org/esa/population/pubsarchiv/belowrep/belowrep.htm

Human Fertility Collection. (n.d.). Retrieved from Human Fertility Collection: www.humanfertilitycollection.org

Human Fertility Database. (n.d.). Retrieved from Human Fertility Database: www.humanfertility.org

Keilman, N. D. (1998, November). *Predictive Intervals for Age-specific Fertility.* Retrieved from Statistics Norway, Department for social Statistics: https://www.ssb.no/a/histstat/doc/doc_199818.pdf

Keilman, N. D. (2004). *Time Series Based Errors and empirical errors in Fertility Forecasts in the Nordic countries.* Retrieved from International Statistical Review: http://isi.cbs.nl/ISReview/abst721-07.pdf

Ministry of Health, Labor and Welfare of Japan. (n.d.). Retrieved from http://www.mhlw.go.jp

Myrskyla, M. G.-H. (2012, February). *New cohort Fertility Forecasts for the developed World.* Retrieved from Max Planck Institute for Demographic Research: http://www.demogr.mpg.de/papers/working/wp-2012-014.pdf

Raftery, A. A. (2014). *Bayesian Population Projections for the United Nations.* Retrieved from Statistical Science: http://arxiv.org/pdf/1405.4708.pdf

Sobotka, T. (2003, April 4). *Tempo-Quantum and Period-Cohort interplay in Fertility Changes in Europe. Evidence from the Czech Republic, Italy, the Netherlands and Sweden.* Retrieved from Demographic Research: http://core.ac.uk/download/pdf/6487407.pdf

Sobotka, T. (2004, 30 (2)). Is lowest-low fertility explained by the postponement of childbearing? *Population and Development Review*, 195-220.

Sobotka, T. B. (2014, September). Two is best? The Persistence of a Two-Child Family Ideal in Europe. *Population and Development review, 3*(40), 391-419.

United States National Vital Statistic System. (n.d.). Retrieved from http://www.cdc.gov/nchs/births.htm

Wilmoth, J. (2015, august 10). *Global population projections by the United Nations.* (P. division, Ed.) Retrieved from Joint Statistical Meetings, Session 151: "Better demographic forecasts, better policy decisions": http://www.un.org/en/development/desa/population/about/director/pdf/2015.08.10_JSM_slides.pdf

Zakharov S., I. E. (1996). Fertility decline and Recent changes in Russia: On the Threshold of the Second Demographic Transition. In J. DaVanzo, *Russian Demographic "Crisis"* (pp. 36-82). Santa Monica: RAND.

Zakharov, S. V. (1991). Demographic transition in Russia and evolution of regional demographic difference. *Demographics and Sociology. Family and family policy.*, 87-102.

Zakharov, S. V. (1992). La Transition demographique en Russie et l'evolution des disparites demographiques regionales. *Modeles de la demographique historique.*, 353-370.

Zakharov, S. V. (1999). Fertility Trends in Russia and the European Newly Independent States: Crisis or Turning Point? *Population Bulletin of the United Nations*(Special issue No. 40-41), 292-317.

Захаров. (2014). Рождаемость. In О. р. Вишневский, *Население России 2012. Двадцатый ежегодный демографический доклад.* (pp. 106-110). Москва: Издательский дом ВШЭ.

Захаров, С. В. (1997). Рождаемость и брачность в России. *Социологические исследования*(7), 70-80.

Росстат. (n.d.). *Демографический прогноз суммарного коэффициента рождаемости на период до 2050 г.* Retrieved from http://www.gks.ru/free_doc/new_site/population/demo/progn6.xls

Соботка, Т. Л. (2011). Коэффициент суммарной рождаемости даёт политикам дезориентирующие сигналы: не следует ли отказаться от использования? *Экономический журнал Высшей Школы Экономики, 15(4)*, 444-471.