Modelling the link between later childbearing ages and the change in childlessness

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October 31, 2019

Abstract

Late childbearing is on the rise across low fertility countries, and the increase has been particularly strong in the last two decades. Many women now start trying to have children or still want children above age 35-40, i.e. at ages where childbearing is under strong normative, social and biological constraints. In this paper, we estimate how these constraints may lead to an increasing number of childless women. We use birth cohort data on first birth available in the Human Fertility Database for 8 European countries. We forecast first birth rates of the cohorts not fully observed using two alternative methods. First, we complete unconditional first birth rates over age and birth cohort, assuming a certain degree of smoothness and coherence to observed trends over these two dimensions. Second, we perform a counterfactual scenario: for uncompleted cohorts we impose to late childbearing ages the mean age-pattern of earlier completed cohorts computed from equal fertility levels. Whereas the first approach can be considered a simple extrapolation of past trends, the second measures late fertility releasing the age constraints due to postponement. Difference between these two approaches in terms childlessness quantifies the effect of postponing childbearing towards really old ages. Our study suggests that by the 1985 birth cohort and depending on the country, 0.5 to 2.1 additional percent of women will be childless due to age-related constraints if no change in the use of Assisted Reproductive Technology or in the norms surrounding very late fertility takes place.

Keywords: childlessness · age-related infertility · low fertility countries · statistical estimation · forecasting

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1 Introduction

Already in the 1980s, Menken (1985) posed a question which is now more relevant than ever before: "Age and Fertility: how late can you wait?" This issue has become prominent for individuals as well as for countries, as European societies have witnessed uninterrupted increase in the age at childbirth for more than four decades. With the delay in age at first birth, more people plan and have children after age 35. Although later childbearing schedules are not necessarily linked to lower fertility across countries (Goldstein, 2006; Toulemon and Mazuy, 2001), having children late can be subject to biological, social and cultural age limits, some of them incompressible. te Velde et al. (2012) found using microsimulation that the postponement of childbearing between 1985 and 2007 contributed to the increase in childlessness by 3-4% in six European countries. Assisted reproduction could not fully counterbalance these effects, but its more widespread use may partly offset them (Leridon, 2005; te Velde et al., 2012).

Childlessness has been on the rise in the last decades in all European countries. It displays some signs of stabilisation in the West and the North of Europe, but does not seem ready to slow down in Italy and Spain (Sobotka, 2017). In the meanwhile, having children after age 35 is becoming common in Europe, and a substantial share of women still wishes children at age 35-39 (Sobotka and Beaujouan, 2018). Signs of increasing attempts, but also failure, to have children late notably appear in the large share of conceptions via assisted reproduction starting at ages 35-40 (Beaujouan and Sobotka, 2019), and the take off of extremely late births (48+) observed in the last decade (Beaujouan, 2018). This very recent increase in the share of the population approaching age limits at childbearing would then result in more people foregoing childbirth and a smaller completed family size. Particularly, this would certainly result in increasing the share of women "involuntarily childless" (Esteve and Treviño, 2019; Fiori et al., 2017; Miettinen, 2010; Toulemon, 1996).

In this paper, we inspect the possible consequence of the recent trend towards late and very late first birth for childlessness. More specifically, we investigate empirically whether having a first birth in the older ages at childbearing today seems more constrained than was having it in the older ages at childbearing of the past, and the incidence of the arising age-related limitations on childlessness levels.

2 Background

"Childbearing postponement" went together with decreasing family size, and with increase in the proportion of childless women (D'Albis et al., 2017; Jalovaara et al., 2018; Sobotka et al., 2012; Šprocha et al., 2018). However, nothing says so far that it was constraints at late ages, met due to the shift in birth calendars, that prevented women from "recuperating" their "missing births" (Caltabiano, 2016; Castro, 2014). It is more likely that large changes in values and emerging structural constraints drove these three trends in parallel but (almost) independently. In fact, given that most first births still take place before age 35 (see also Figure 1 in the method part), changes in childlessness are mostly driven by conjunctural changes that hit at earlier ages. The remaining share of first birth after age 35 having for long been minimal, the margin on which the constraints at later ages could play were remaining small. However, in an increasing group of countries recently, particularly large shares of first births are taking place after age 35, up to one fourth in Spain or Italy (Sobotka and Beaujouan, 2018). In 2014, between 2 and 6% of women had their children at age 40 and over in the low fertility countries (Beaujouan and Sobotka, 2019). This gives increasing margin for the bio-social constraints to childbearing to act. Notably, Goldstein (2006) explored by how much mean age at first birth could still increase, and found that the maximum cohort mean age at first birth would be around 33 years. He concluded that postponement, and the associated depressed fertility levels, could continue for years.

2.1 Past research and research question

We can report two in-depth investigations of the impact of postponement on fertility levels due to age-related constraints. The first one, whose results were reported above, used microsimulation to evaluate the rise in "involuntary childlessness" following childbearing postponement (Leridon, 2004; te Velde et al., 2012). Based on distribution of age at first births in two periods and on probabilities of live birth by age of the woman, they evaluated the proportion of births that did not take place in the 1985-2007 period due to the shift in age profiles towards later ages. In the second one, Toulemon (2002) was making scenarios based on the shift in conditional first birth rates by age of the 1950 birth cohort towards later ages, also taking into account risks of sterility by age. When shifting them by 4 years (i.e. a later age at first birth of around 3 years), childlessness increased by 3.5 percentage points, in line with the increase found by te Velde et al. (2012). An increase by 3 years in the mean age at first birth corresponds to what was observed between the 1945 and the 1975 birth cohorts in most Western European countries (own calculations from the Human Fertility Database).

Finally, though they were less focused on giving an evaluation, Myrskylä and Goldstein (2013) had to correct their forecast of Dutch cohort fertility rates based on the observation in past cohorts that later births seemed constrained at later ages. Indeed, their Gomperz diffusion model deviated from linearity starting at age 30 and showed an accelerated decrease. Suspecting this was linked to physiological reasons, they constructed an "infecundity correction". With ever later ages at first birth, an increasing number of women thus seem to be constrained in their childbearing at later ages. In the last cohorts where they are fully observed, age-specific (non-conditional) first birth rates do not display striking discontinuity or deep fall when reaching age 37 for instance (Nathan and Pardo, 2019). However, we suggest that *less visible changes* in the shape of the curve at late childbearing ages translate into inflated childlessness levels in most low-fertility countries. While age-specific first birth rates increase after age 30 because of childbearing postponement, levels at ages subject to bio-social constraints should become more and more deflated *relative to* the previous ages. Thus, by relying on 1st birth rates profiles of those who had children "later" in past birth cohorts, who were less constrained because even if late they were still younger, we can evaluate an alternative share of childless women. We can consider that it represents the women who would have been childless in the absence of age-related constraints. In countries where childbearing postponement is well advanced and rates at later ages substantial, we expect this proportion to be lower than the proportion of childless women observed, resulting in "excess childlessness". Of course, recourse to Assisted Reproductive Technologies (ART) could increase the chances of having children at late reproductive ages, and contribute in reducing this excess childlessness. In countries at less advanced stages of postponement or where rates at later ages are negligible, postponement could still go together with relaxing constraints at older ages (for instance norms about age at childbearing), and thus not necessarily result in "excess childlessness".

We present here an alternative way of evaluating the possible consequences of age-related fertility constraint for overall childlessness levels, based on empirical data and theoretical reasoning rather than on statistical models and microsimulations. We select eight countries with long series of cohort age specific first birth rates (ASFR1) in the Human Fertility Database. In a context of delayed first births, we calculate the impact of bio-social constraints on childlessness in the future and in countries at different stages of fertility postponement. Our simple assumption is that, if childbearing recuperation is not prevented, then the shape of age-specific first birth rate profiles at later ages will remain unchanged across birth cohorts – even if the level can change, since overall fertility levels do change across cohorts. Taking as reference 1966, the last birth cohort with fully observed ASFR1s across countries, we investigate prospectively (until the 1978 and 1985 birth cohorts) whether childbearing postponement mechanically will result in significant "excess childlessness" in the future.

2.2 Country differences

We study three Nordic countries (Denmark, Norway and Sweden), one East European country (Hungary), one Western European country (the Netherlands), one Southern European country (Italy), the US and Japan. Though not always fully representative of their region, these countries have characteristics that make them worth studying. They display varying levels of childlessness, with different trends in the last 15 birth cohorts (described in Sobotka (2017) but also available in Figure 5 in the results part). In the 1962 birth cohort, childlessness was highest in Japan, Italy and the Netherlands, and lowest in Hungary. The studied countries have reached various stages of childbearing postponement. Hungary, the latest, has reached recently a mean age at first birth of 28 years, 3 years behind the earliest of the low fertility countries, Italy (31 years). In most of these countries as well (all but Hungary, Italy by analogy with Spain), recent research finds that the dispersion of ages at first birth has stopped or very much slowed down its progression in the last 10 years (Nathan and Pardo, 2019; Philipov, 2017). Though this certainly means that women now endorse a "later fertility" schedule after a phase of dispersion linked to the double speed of postponement (Burkimsher, 2017), possibly age profiles start "not being able" to shift much further without narrowing their age range. The share of late first births also varies across these countries, between 2 and 5% contribution of first births at ages 40 and over to TFR1 in 2014. Those with highest mean age at first birth and late childbearing (Italy, the Netherlands, the Nordic countries) are good candidates for having more women trying to have a first child at late ages, and thus more women failing. This means that it is likely that the share of childless women there will be the most affected by postponement in the coming birth cohorts.

3 Data

Data are retrieved from the Human Fertility Database (2019, HFD) for Denmark, Norway, Sweden, Hungary, the Netherlands, Italy, the US and Japan. In terms structure, for a given population, first birth counts $b_{x,c}$ and female population exposure $e_{x,c}$ are arranged in two matrices $\boldsymbol{B} = (b_{x,c})$ and $\boldsymbol{E} = (e_{x,c})$. Each matrix has dimensions $m \times n$, where rows are classified by m single ages $x = [12, 13, \ldots, 54]$, and columns by n single birth cohorts $c = [1950, 1951, \ldots, 1985]$, respectively. Age-specific first birth rates are simply the ratio between birth counts and exposure: $f_{x,c} = b_{x,c}/e_{b,c}$.

The illustration of the matrix $\boldsymbol{B}$ is useful to directly grasp the structure of cohort data. Unlike the age-period data, here the matrices $\boldsymbol{B}$ and $\boldsymbol{E}$ contain missing data, corresponding to periods beyond the last available year of data collection. Let's take Italy for illustrative purposes. For this population, 2016 is the last available year of collected data. This implies that: (i) data are fully observed for the age-groups $x = 12, \ldots, 31$ for all cohorts, (ii) cohorts $c = 1950, \ldots, 1962$ are fully observed for all ages, and (iii) for the cohorts $c = 1963, \ldots, 1985$, data are increasingly missing from age 54 downwards. Here we illustrate the $\boldsymbol{B}$ matrix denoting by "na" the missing data:

$$\boldsymbol{B} = (b_{x,c}) = \begin{bmatrix} b_{12,1950} & \dots & b_{12,1962} & b_{12,1963} & b_{12,1964} & \dots & b_{12,1985} \\ b_{13,1950} & \dots & b_{13,1962} & b_{13,1963} & b_{13,1964} & \dots & b_{13,1985} \\ \vdots & \dots & \vdots & \vdots & \vdots & \dots & \vdots \\ b_{31,1950} & \dots & b_{31,1962} & b_{31,1963} & b_{31,1964} & \dots & b_{31,1985} \\ \vdots & \dots & \vdots & \vdots & \vdots & \iddots & na \\ b_{52,1950} & \dots & b_{52,1962} & b_{52,1963} & b_{52,1964} & \iddots & \vdots \\ b_{53,1950} & \dots & b_{53,1962} & b_{53,1963} & na & \dots & na \\ b_{54,1950} & \dots & b_{54,1962} & na & na & \dots & na \end{bmatrix} . \quad (1)$$

For other populations, last available last available year of data collection would be different and consequently last available age for the cohort 1985. Moreover, for Denmark, Norway, Sweden and Japan, first available completed cohorts is 1956, 1955, 1958, 1956, respectively. Figure 1 presents an overview of the data by plotting age-specific first birth rate $f_{x,c}$ for all cohorts and populations. Country-specific data availability can be clearly detected by looking at the gray areas in each panel.

4 Methods

In this section, we present two different approaches for completing partially observed cohorts. Taking Italy as illustrative example, we aim to complete first birth rates for the cohorts $[1963, 1964, \dots, 1985$. Whereas with the first approach we propose a novel methodology for forecasting fertility, with the second method, we perform a conventional demographic projection by imposing to uncompleted cohort previously observed age-patterns.

4.1 Forecast uncompleted cohort

In the recent years, several methodologies have been proposed for forecasting uncompleted cohorts and age-period fertility experiences. See Bohk-Ewald et al. (2018) and references in there. Here we propose a new approach adapting for fertility CP-splines proposed in mortality forecasting by Camarda (2019). In few words, forecasting uncompleted cohorts can be viewed as a missing-value problem within a smoothing framework. However, knowledge about past fertility experience should guide this pure data-driven approach. To incorporate demographic information, we first compute relative derivatives over both age and cohorts from smooth observed cohorts, both fully and partially completed. These relative derivatives contains information about fertility shape, regardless of its level. We thus smooth and forecast uncompleted cohorts enforcing future relative derivatives to be within the observed ones.

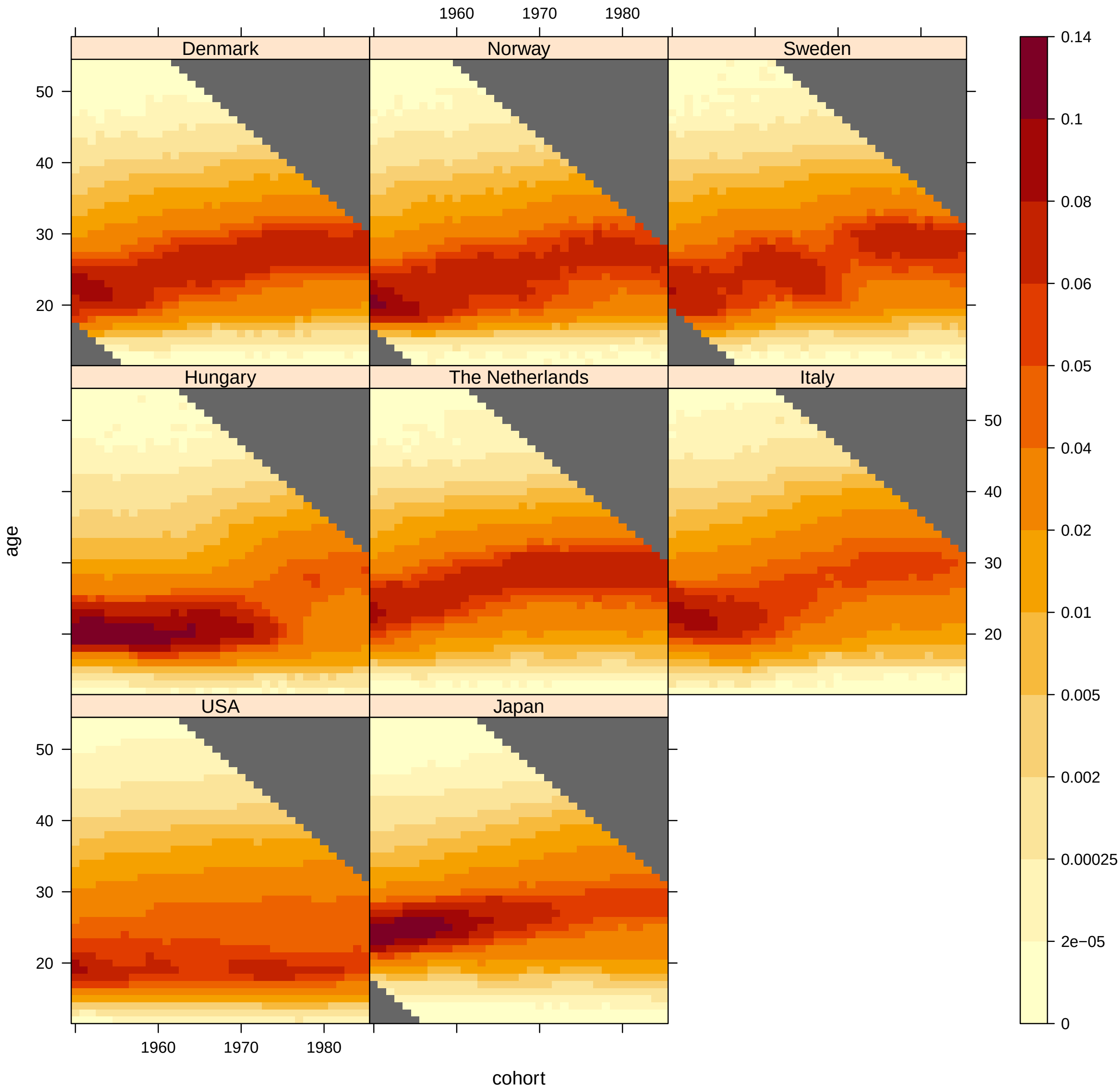

Figure 1: Overview of the data. Age-specific first birth $f_{x,c}$ for all cohorts and populations. Not available data are depicted by gray areas.
Note: Authors' calculation from Human Fertility Database.

Figure 2 presents relative derivatives with respect to age and cohort for Italian data computed from a smooth surface over age and cohort estimated by means of P-splines (Camarda, 2012; Currie et al., 2004). In general, values above zero correspond to fertility increase and, conversely, ages with fertility reduction coincide with negative values of the relative derivatives. A general view on the interpretation of derivatives applied in a fertility context can be found in Shang (2019).

In the top panel the classic fertility age-pattern emerges clearly: large positive values for younger ages which correspond to an increasing first birth rates for young Italian women, values about zero between age 20 and 30 which indicates zero velocity of the fertility function (a maximum has been reached) and finally negative values denoting the decreasing fertility age-pattern. Obviously each cohort behaves differently and speed in the increasing and decreasing pattern as well as the age in which fertility reaches its maximum varies over cohort (see colored lines within the red area underneath). Nevertheless, information about fertility age-pattern is condensed in the relative derivatives over age and we enforce uncompleted cohorts to lie within them.

Bottom panel in Figure 2 shows age-specific rate of change over time by plotting the relative derivatives over cohorts. Each line represents a given cohort and width of the red area denotes the variability over cohort of a specific age, i.e. whereas younger ages present a large variability with mainly negative values, older ages show less fluctuation and positive relative derivatives. This means that ages before (after) 25 show a decreasing (increasing) trend over cohorts regardless their actual level. Also in this case, we impose to uncompleted cohort to follow this information.

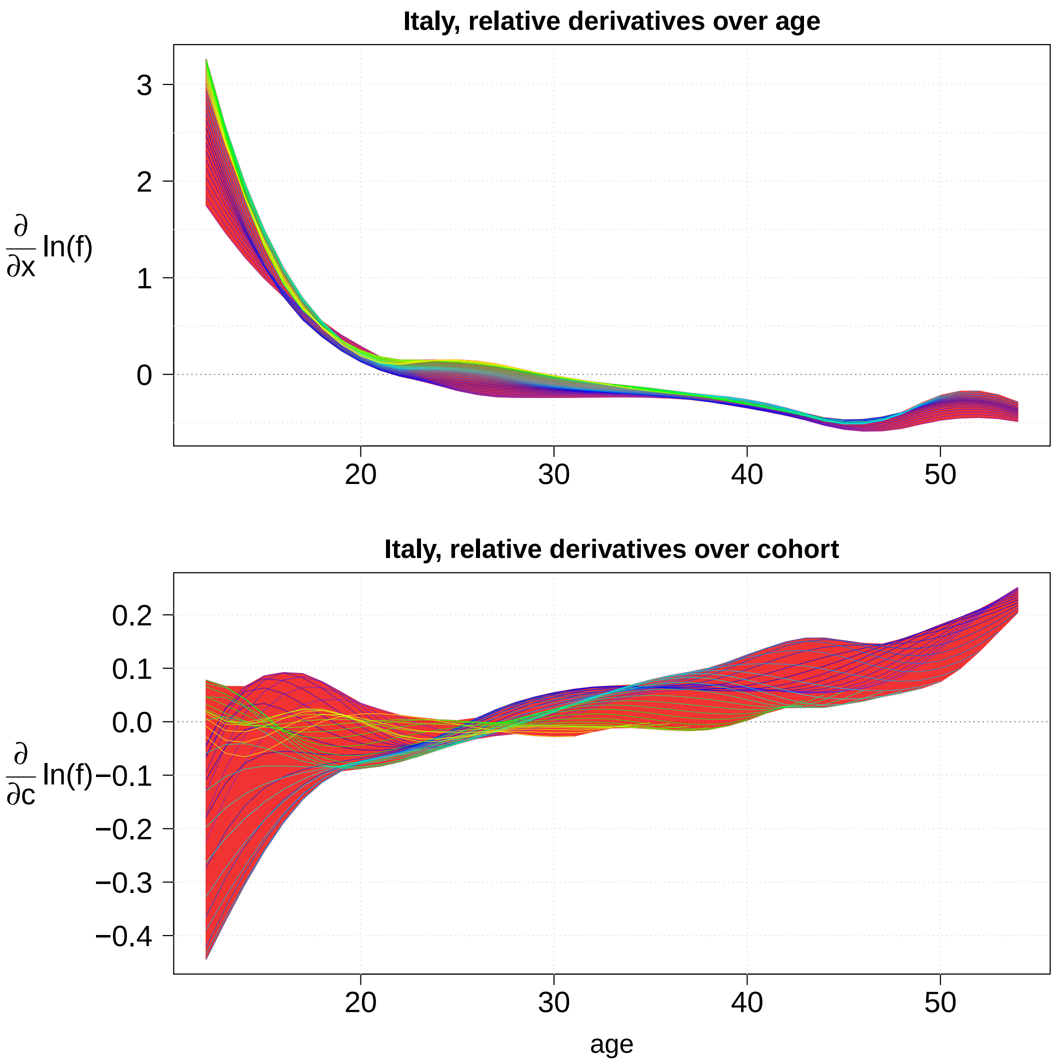

Figure 2: Relative derivatives of smooth observed data with respect to age (top panel) and cohort (bottom panel). Italy, ages 12-54, cohorts 1950-1985.
Note: Authors' calculation from Human Fertility Database.

Without going into details, once previously presented relative derivatives are computed, CP-splines allow us to enforce relative derivatives of first birth rates for uncompleted cohorts to lie within the range of values obtained from observed ages and cohorts. Asymmetric penalties by (Bollaerts et al., 2006) are employed to incorporate this information within a P-spline setting. This approach is thus free on any parametric assumption about fertility development over age and/or cohort and it combines powerful statistical methodology and prior demographic information.

Figure 6 presents the results of a CP-spline approach on our uncompleted cohort problem for Italy. Both observed, estimated and forecast first birth rates are plotted for selected cohort over ages. Outcomes are reasonable and no rigid model structure is imposed to obtain them, i.e. we simply impose that in future years, uncompleted cohorts must behave as observed cohorts in terms of shape and rate of change. In the appendix, Figure 6 shows the same results for all 8 populations by means of shaded contour maps.

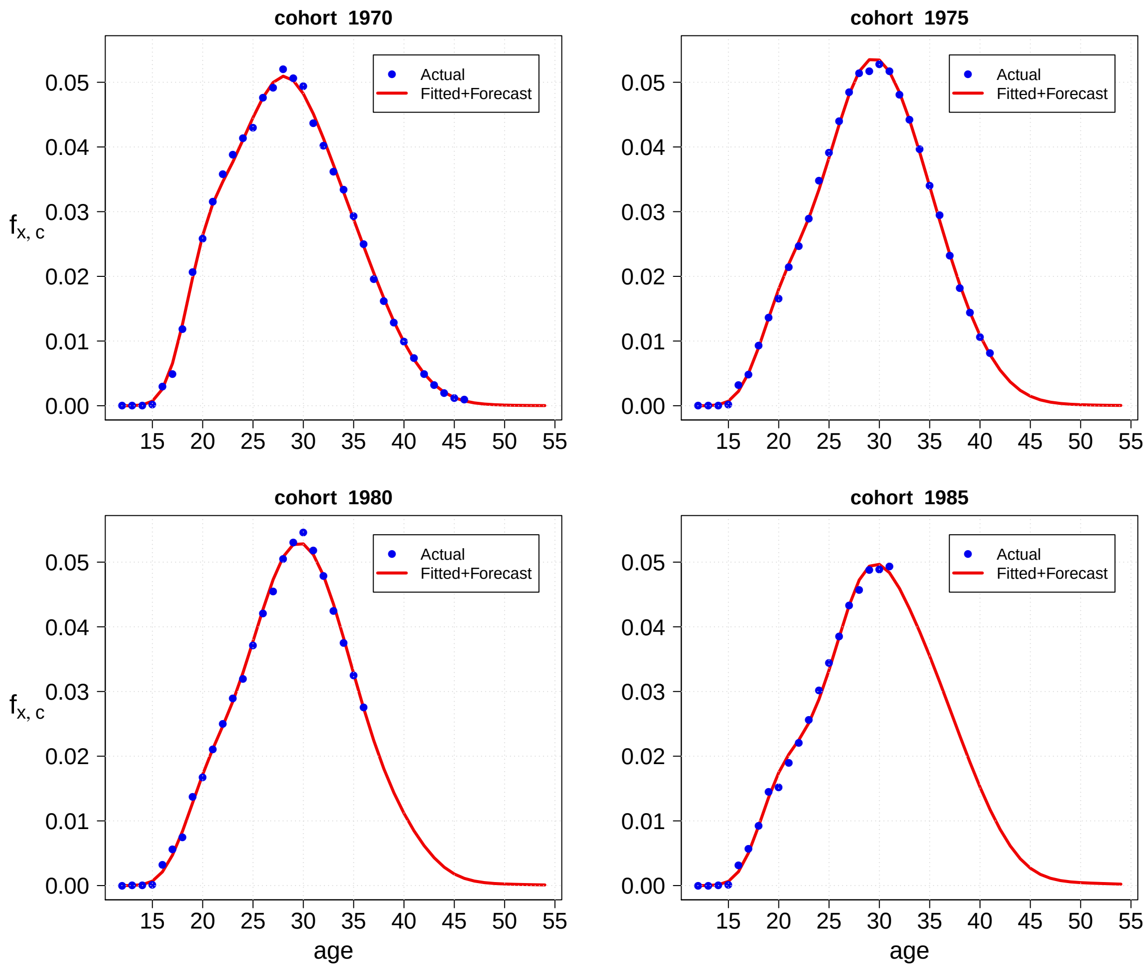

Figure 3: Overview of the data. Age-specific first birth $f_{x,c}$ for all cohorts and populations. Not available data are depicted by gray areas.

Note: Authors' calculation from Human Fertility Database.

4.2 Counterfactual scenario

In order to perform a scenario that would impose to uncompleted cohort previous fertility experience, we first take all completed cohorts from each population. By means of P-splines we smooth them. This allows us to evaluate fertility at any finer grid of the age axis, practically at a continuous level. We use an extremely small amount of smoothness over both dimensions since we simply aim to reproduce observed fertility experience.

In this exercise we complete each uncompleted cohort independently and we select a certain late fertility age x_1. In all uncompleted cohorts for ages below x_1 we use first birth rates as forecast in Section 4.1. For ages above x_1, we take the last available fertility level $f_{x_{1+},c}$ and we collect all age-patterns from completed cohorts starting from this level. Since we can operate on completed cohort as they were continuous curve, we are able to extract age-patterns from completed cohorts exactly at $f_{x_{1+},c}$. From the series age-patterns, we compute the mean and we shifted this mean at the last available age of the uncompleted cohort. In this way, we reconstruct uncompleted cohorts as they would have followed, from either a_1 or last available age, the mean age-pattern of the completed cohorts when they were at that fertility level.

Figure 4 gives a schematic view of the procedure we follow to produce our counterfactual scenarios. In this example we take $x_1 = 37$ which is the age use in this expected abstract, and an uncompleted cohort where x_1 is the last available age. Moreover, Figure 4 presents both counterfactual scenario and an hypothetical outcome from the forecast approach. In this way it is easy to depict the difference that it is expected by simply forecasting previous trends or imposing old patterns on younger uncompleted cohorts: See orange areas in Figure 4.

We then compute for all cohorts, and for both approaches, childlessness levels CL_c as follows:

$$CL_c = 1 - \sum_x f_{x,c} \quad c = 1950, 1951, \ldots, 1985$$

Description

- we use the following age range 12-54 - below we present the cohorts for the Swedish case

Exercise 1 (forecast)

Underlying reasoning: forecast fertility just assuming that it cannot have abrupt changes and what has been observed can eventually happen again. In a two-dimensional setting we forecast fertility rates over age and cohort for the uncompleted cohorts (1963-1985). We assume a certain degree of smoothness over both dimensions. Additionally we constrain both age-patterns and cohort-trends to lay within all observed age-patterns and cohort-trends from previous cohorts (both completed and uncompleted). Relative derivatives from smooth age/cohort trends and asymmetric penalty within a 2D P-spline approach are used.

Exercise 2 (counterfactual)

Underlying reasoning: what would happen if, above age 37, uncompleted cohort (1963-1985) would have behaved as the older completed cohorts (1950-1962)? First we compute relative derivatives over age for the completed cohort (1950-1962). Then we take each cohort independently and we complete fertility rates over age for the uncompleted cohorts (1963-1985). We assume that above age 37 all uncompleted cohorts would have followed within the observed age patterns from the completed cohorts. These patterns are computed from the relative derivatives starting from the closest age to the observed fertility rate at age 37 for the cohort 1963-1979. For the uncompleted cohort 1980-1985, we take the rates at age 37 from the previous exercise. For the unknown rates below age 37 in the uncompleted cohort 1980-1985, we follow an approach similar to Exercise 1 (they are solely constrain to be within all observed age-patterns at the corresponding ages). Again a combination of a P-spline approach (in a uni-dimensional framework) and asymmetric penalties are employed.

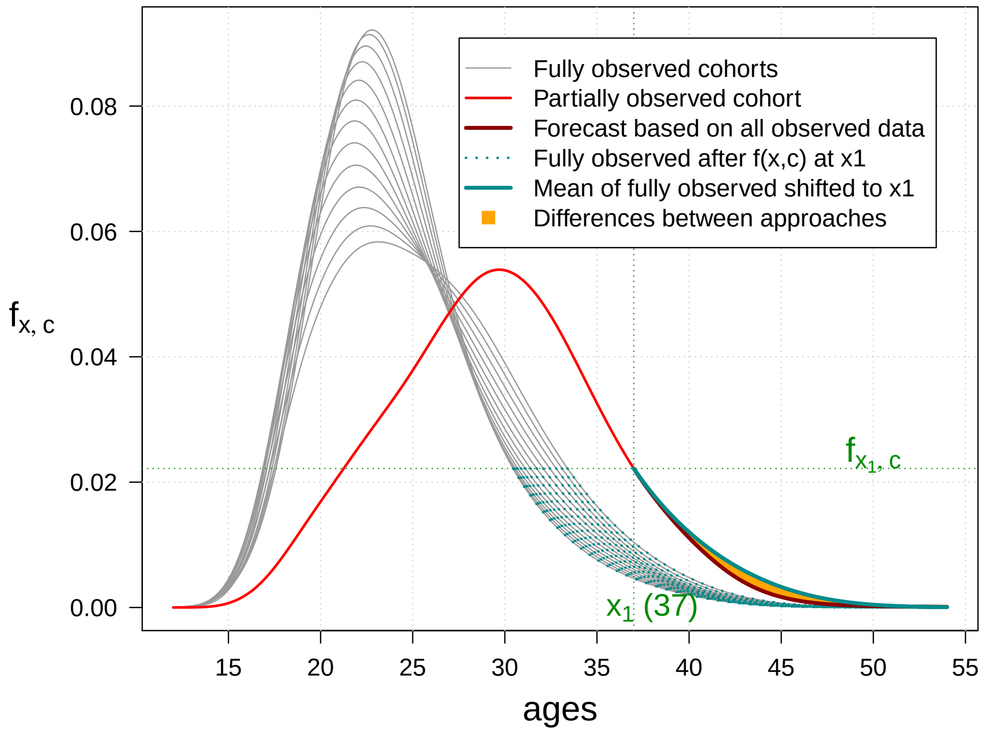

Figure 4: Schematic view of our approach.

5 Results

5.1 Childlessness forecasts

Figure 5 shows the share of women childless in the 1950-85 birth cohorts in the eight countries selected, according first to the HFD data and gradually to our forecasts. Note that our childessness rates in the 1970 birth cohorts correspond well to the childlessness rates presented in Sobotka Sobotka (2017), and those in the 1976 birth cohort (observed up to age 40) to the childlessness rates of the last available European Demographic Datasheet (Sobotka et al., 2018). Between the last birth cohort observed up to age 55 in most countries (1962) and the 1985 birth cohort (forecasted mostly from age 32), the share of childless women has followed very different paths depending on the country. In Hungary, Italy and Japan it quickly increased, but from around 7% in Hungary, 16% in Italy and 19% in Japan. Then they started to reverse, first in Japan in the cohorts born in 1970 after reaching a peak of more than 28% of women childless, then in Italy and Hungary in cohorts born in the first half of the 1980s where about a quarter of all women where childless. In the other countries rates decreased, drop that had actually often started around the 1962 birth cohort after the original strong increase, from levels ranging between 12 and 18%. Only in the US the decrease started for women born around 1955, from a level of 16.5%. In all these countries except the Netherlands, a new increase started among women born at the beginning of the 1970s, and mostly reached in the 1985 birth cohort levels equal or higher to the previous levels. In the US again, the last increase was less substantial. We can thus distinguish two main types of countries, those where childlessness started rising early but would eventually reach levels rarely higher than 15%, after several ups and downs. And those where childlessness started rising later but to extremely high levels.

5.2 Counterfactual application

We examine now the levels childlessness would have reached in the 1979 and 1985 birth cohorts if the first birth rates at ages 37+ had been set to correspond to the average of the 1950-62 birth cohorts when they had reached equivalent first birth rates (Table 1). In other words, we evaluate the effect on childlessness of the difference in bio-social age constraints in the cohort under study and in the past cohorts where latest fertility was still taking place at earlier ages (and thus was less constrained). In all countries and for 1979 and 1985, the counterfactual share childless was lower than the forecasted one, because individuals were less constrained in the past than in recent cohorts everywhere. In general, the difference ranged between .2 and 1.6 percentage points in the 1979 birth cohort, and between .5 and 1.4 percentage points in the 1985 birth cohort. In the 1979 birth cohorts the countries with the estimated largest bio-social constraint were Norway and Italy, and those with the lowest were Hungary and Japan. Denmark joined Norway in the 1985 birth cohort, while Japan did not display any sign of constraint in the settings we chose.

Table 1: Childlessness rates (1962 birth cohort), forecasted, counterfactual and difference (1979 and 1985 birth cohorts)

in % Country	Childlessness 1962	Forecasted 1979	Counterfactual 1979	Difference 1979	Forecasted 1985	Counterfactual 1985	Difference 1985
Denmark	14.6	13.4	12.6	0.8	13.6	12.4	1.3
Norway	12.1	11.8	10.4	1.4	12.0	10.7	1.4
Sweden	13.7	13.6	12.9	0.8	13.6	12.4	1.1
Hungary	7.2	22.0	21.7	0.2	23.6	23.1	0.5
Netherlands	17.7	16.2	15.3	0.9	14.3	13.1	1.1
Italy	16.2	22.4	20.8	1.6	22.8	21.7	1.0
USA	14.9	12.1	11.5	0.6	13.5	12.4	1.0
Japan	18.8	26.3	26.2	0.1	23.6	23.6	0.0

[a] For Hungary, Norway and Portugal last completed observed cohorts are 1967, 1964 and 1965, respectively. Consequently, for these countries, last cohorts with available data at age 37 are 1979, 1976 and 1977, instead of 1978

6 Discussion and Conclusions

We calculated possible limitations to first childbirth after age 37, and the amplitude varied across countries. The size of the constraint did not seem to depend on the childlessness level, since two countries with the largest shares of childless women displayed respectively no and the highest constraint. Rather, in countries where 1st birth rates were always comprised in a narrow age band like in Japan (Figure 6), the shift to later ages at first birth did not create very large shares of women at risk of foregoing childbearing. By contrast, in countries like Norway where first birth rates where more spread towards late ages, more women underwent some constraints on their childbearing. It is also possible that additional country specificities regarding the norms around late childbearing created a larger constraint in some countries than in others. The share of biological and of social effects in preventing late childbearing remains to be disentangled.

For the conference, we will also explore alternative scenarios, fixing the age limits from which socio-biological constraints may act earlier (35 years old) or later (39 years old). We will also discuss alternative specifications of the "age constraint".

Surely, the share constrained varies very much by socio-economic status, because women with high level of education tend to postpone first child birth much more than the others, and may thus also have to forego it more often. In the future, exploratiosn could be made in countries where age profiles of birth are available by level of education. The present study can be seen as a first step of a projection and analysis of constraints in total cohort fertility. This could be done by birth order rather than projecting all births together, because changes in birth levels differed hugely by parity in times of postponement, and because birth schedules differ by birth order, and so does the risk of being subjected to age-related constraints.

Acknowledgment

Eva Beaujouan's research was supported by the Austrian Science Fund (FWF), project "Later Fertility in Europe" (Grant agreement no. P31171-G29). The authors wish to thank Kryštof Zeman for valuable data support.

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Appendix

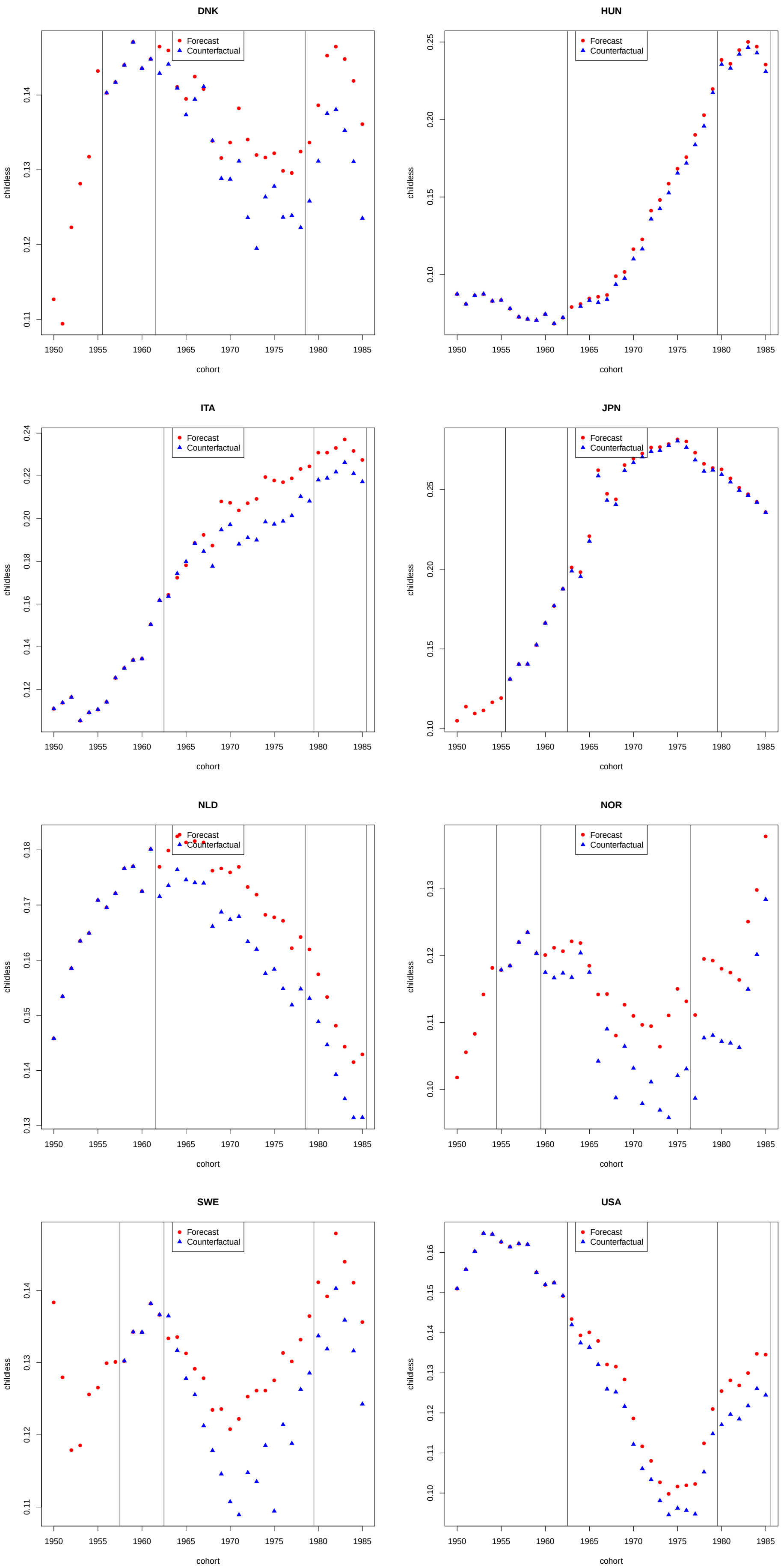

Figure 5: Observed, forecasted and counterfactual share of childless women in 8 low fertility countries

Note: Authors' calculation from Human Fertility Database.

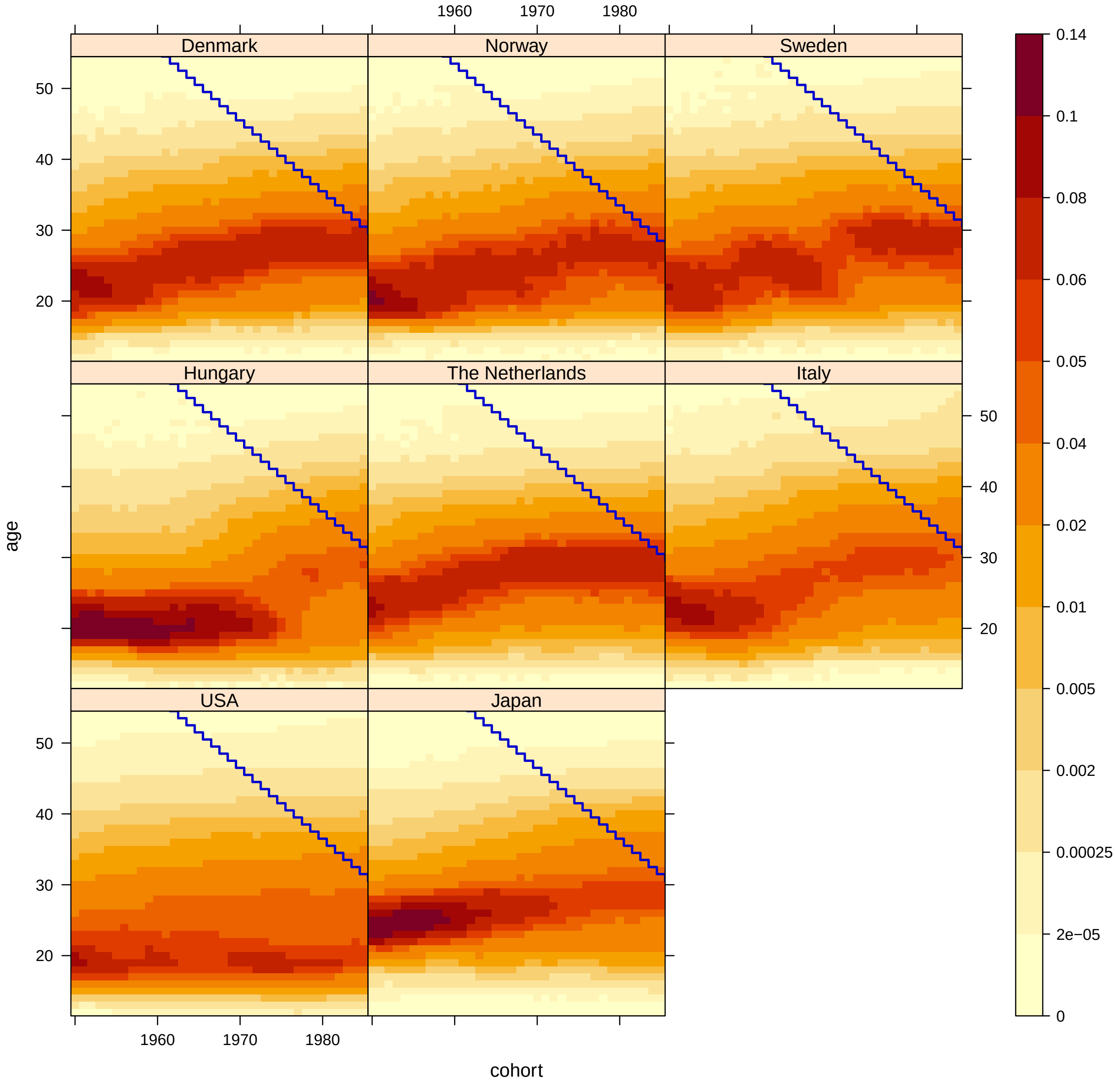

Figure 6: Observed and forecasted age-specific first birth $f_{x,c}$ for all cohorts and populations. Forecast uncompleted cohorts are presented above the blue lines.
Note: Authors' calculation from Human Fertility Database.