Estimating Indicators of Fertility Timing from Consecutive Census Data on Children Ever Born

FIRST DRAFT paper submitted for the EPC conference 2016, Mainz

Kryštof Zeman[1]

15.12.2015

1 Introduction

This methodological paper develops the method of estimating indicators of fertility timing from time-static census data on children ever born. The idea is to compare consecutive census data and retrieve timing information from the difference in fertility levels recorded in them. We call this method and the derived indicators "intercensal". The method was first introduced in the 1970s-1980s (Arretx 1973, UN 1983, Coale 1985), but not used since that time.

Our objective is to find method that can estimate fertility timing by highest educational attainment of mothers. Education of mothers has been argued to be the most important demographic dimension of fertility behaviour after age and gender. While age and gender are the two fundamental demographic dimensions, there are many other biological and socio-economic characteristics that affect demographic behaviours. Among these, educational attainment has been argued to be the single most important one (Lutz et al., 1998; Lutz, 2010). Educational attainment captures the social and economic dimension of fertility, adding the "quality" dimension. Education is frequently regarded as one of the most important factors in fertility decline in recent decades (Skirbekk, 2008; Lutz and KC, 2011). The negative relationship between women's education and family formation is one of the most consistently reported findings in the literature (e.g. Blossfeld and Huinink, 1991; Hoem, 1986; Kravdal, 2004; Kreyenfeld, 2006; Liefbroer and Corijn, 1999; Marini, 1984; Rindfuss et al., 1980; Rindfuss and Brewster, 1996; Skirbekk, 2008).

However, the timing of fertility by highest attained education level of mothers is usually not available from vital statistics or other direct demographic methods. Because the tempo of fertility is crucial for understanding the changes in fertility by education, we discuss several indirect methods of deriving it, and we further develop the intercensal method, which yields

[1] Wittgenstein Centre for Demography and Global Human Capital (IIASA, VID/ÖAW, WU), Vienna Institute of Demography/Austrian Academy of Sciences

most stable results and is relative robust against the shortcomings addressed later on (causality, differential migration and mortality, prolonged educational enrolment and late transitions to higher education levels). Two variants of the method are presented, one looking on the fertility timing from the period perspective and another from the cohort perspective. This will allow us to respond the following question: How has the timing (*tempo*) of fertility changed, and what was the role of educational expansion?

We use census data from the Czech Republic, Austria, South Korea, and Brazil, always for three census data points (around 1991, 2001 and 2011). The regional variation helps us to evaluate the universal validity of the method in different socio-economic settings. We analyse the total fertility, however the method is applicable also to the fertility by birth order, most importantly on first births.

The preliminary results presented here are just for the Czech Republic, as other countries will follow. Even these results show important shifts in the level and timing of fertility between the 1990s and the first decade of 21st century. We found broad differences in fertility level between educational groups, along with a strong postponement of births among better educated. Educational differences of fertility have even increased comparing the two intercensal periods, but also towards younger cohorts of women.

2 Data

All the data used for fertility analysis in this article come from the official population censuses[2]. We use data from the censuses around 1991, 2001 and 2011, specifically the tabulation of women by birth cohort, highest educational level attained, and number of children ever born[3]. The overview of the data is given in Table 1. All data are available in the online Cohrt Fertility and Education database at http://www.cfe-database.org (Zeman et al 2014).

The countries cover the wide range of regions, including Central-Eastern Europe (Czech Republic), West Europe (Austria), East Asia as a region of lowest-low fertility (South Korea) and Latin America as a region of still higher, but rapidly declining fertility (Brazil). We do not feature any country of the thirld world, but the method is generally replicable for any country.

The definitions of the highest attained educational level have been harmonised to ensure comparability across censuses and also to avoid too small educational groups. Initial educational

[2] Except of Austrian Mikrozensus 2012.

[3] The question according to the UN recommendation (to all women at age 15+) says: “How many children have you ever born alive?”

categories were merged using the 1997 International Standard Classification of Education (ISCED97) into following four groups:

1. Primary education: ISCED codes 0–2 (No education, primary and unfinished secondary school)
2. Secondary education: ISCED codes 3–4 (Apprenticeship training, Secondary technical without certificate, Vocational school with certificate, Higher general or technical secondary school with certificate, Post-secondary non-tertiary)
3. Tertiary education: ISCED codes 5–6 (Higher technical school, University with bachelor, masters or doctoral degree)

Once completed, education is a time-constant variable — it captures the cultural and human capital, and earning potential, but not the actual socio-economic status (Hamplová, 2003). We do not dispose with detailed data on educational enrolment[4], and there was no information collected on educational histories in the featured censuses.

Table 1 Overview of used census data

Country	1990s	2000s	2010s
Czech Republic	1991	2001	2011
Austria	1991	2001	Mikrozensus 2012
South Korea	1990	2000	2010
Brazil	1991	2000	2010

3 Methods

Completed cohort fertility (CFR) is the most frequently used and the best directly accessed aggregate indicator of cohort fertility. The average number of children to women aged 50 or more gives us very accurate indicator of their total fertility. At high ages, especially above age 85, the numbers begin to be less reliable, due to small numbers (depending on the population), and due to the increasing selection attributable to mortality and migration (United Nations, 1983). However, the CFR conveys no information about birth timing (United Nations, 1983) and there is no direct way how to derive fertility tempo indicators from census-based cross-sectional data. Some population censuses and large-scale surveys asked, apart of the

[4] From the Czech Republic 2011 Census data on parity of women by economic activity we can estimate that while non-students had on average 0.4 children at age 25, 1.0 child at age 30 and 1.6 children at age 35, for students the respective completed fertility was 0.0, 0.2 and 0.6.

number of children, also about the date of birth of these children[5], allowing the use of full timing information. However, this was not case in the countries of our interest[6]. Because the tempo of fertility is crucial for understanding the changes in fertility by education, we discuss several indirect methods of deriving it, and we further develop the *intercensal* method.

When both vital statistics and census data are available, one would incline to combine them in a way that the occurrences from the vital statistics (births by age of mother and her educational attainment, optionally by birth order) are related to the exposures from the census (women by age and educational attainment, optionally by parity), as applied by Handcock et al. (2000) for England and Wales, Oliveira (2009) for Spain, Zeman (2007) for Czech Republic, and Šprocha and Potančoková (2010) for Slovakia. Currently there are efforts of Eurostat to produce harmonised fertility rates by educational attainment for the countries of EU (Corsini, 2012). Some of these data estimated from Labour Force Survey were used to determine the total fertility rate by educational attainment for number of European countries (Lanzieri, 2013). While the completed cohort fertility approach works with real cohorts and synthesises their fertility over long period of women's fertile life, the vital statistics period approach works with synthetic cohort representing single year, the year of the census.

However, such approach poses considerable challenges. The most serious is the numerator/denominator bias, the mismatch of occurrences and exposures at young ages. At the age group 15–24 the intensive education enrolment and school graduating leads to swift changes in numbers and proportions of women by education between single years of age, but also during the single years of age. Mainly due to this problem, these results show unstable and inconsistent patterns (see e.g. Lanzieri, 2013, Table 6).

Many studies on estimating fertility indicators from census data, especially in developing countries, utilise the own-child method (Grabill and Cho, 1965). In developed countries, the own-child method was recently used in several papers. Retherford et al. (2004) analysed trends in fertility by education in Japan, and Cicali and Santis (2002) in Italy. Davie and Mazuy (2010) use the French annual census surveys 2004–2009. However, their analyses relied on detailed survey data providing information on the number of children living in the household, different from our data. Besides, the own-child method itself suffers important

[5] Austria 1984, Switzerland 2000, Poland 2002, Belgium 1991 and 2001, France annual census surveys 2004–2009, Spain 1991, or large-scale surveys in Britain (General Household Survey) and France (Family History Survey linked with the 1999 census).

[6] Brazilian censuses ask for whether child was born to a woman in the last 12 months.

problems, especially the omission of children living in other households, or those who have died (United Nations, 1983).

The so-called *P/F* method estimates current period TFR as based on current numbers on births, and census-derived parity composition of women (United Nations, 1983; Hobcraft et al., 1982). However, this method is not suitable for populations that face rapid postponement of fertility, where period fertility levels are strongly affected by tempo distortions and therefore they substantially differ from cohort fertility levels.

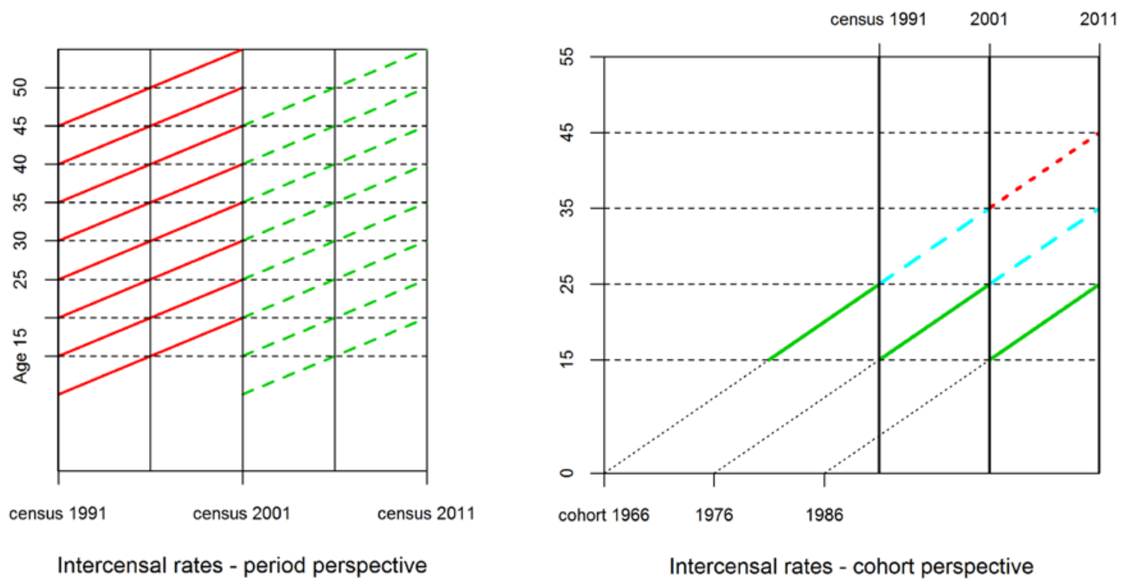
Finally we found the method of intercensal fertility to best suit our needs, which is to estimate at least crude indicators of fertility timing by education, based on census data on parity. Intercensal method capture the behaviour in restricted periods, delimited by the two neighbouring censuses. This is especially useful in analysing fertility in the Central Eastern Europe for example, where we can distinguish between the period of fast development of free society and capitalism 1991-2000, and the most recent period of 2001-2011, characterised by more stable institutional structure of market democracy and civil society and also by rapidly increasing educational level of the younger population. Contrary to previously discussed approaches, this method is regarded robust to changing fertility (United Nations, 1983, p. 59).

The method was first developed by Arretx (1973) (cited and formalised in United Nations, 1983, Chapter II.C.), and later extended by Coale et al. (1985). The estimation is based on the increment of cohort parities between two censuses. While Coale compared parities at the same age (but of different cohorts), and incorporated the rate of fertility increase between the censuses into the estimation, we concentrate on cohorts, and on the cohort parity distribution, as described in United Nations (1983). In fact we use two different approaches, which both proceed from cohort parity comparisons. Figure 1 illustrates the time-space covered by the intercensal approaches. The left diagram illustrates the approach from the period perspective. Age profile of fertility rates for intercensal period between censuses *T* and *T'* is derived from cohort parity increments *CFR(c)* and transformed to one-year dimension rates that represent transversal intercensal period rates *iASFR*:

$$iASFR(c, T \to T') = \frac{CFR(c,T') - CFR(c,T)}{(T' - T)} \tag{1}$$

$$iTFR(T \to T') = \sum_{c=(T-50)}^{(T'-15)} iASFR(c) \tag{2}$$

Figure 1 Lexis diagram of the time space covered by intercensal approach



The right diagram of Figure 1 illustrates the approach from the pure cohort perspective. Chosen cohorts *c* (around 1965, 1975 and 1985) are followed through their lifetime. In 10-year periods (in census years *T*) we record their cumulated fertility *CFR*, which gives us the quantum of fertility realised at age (*a*) 15–24, 25–34, and 35–44, which further gives us crude picture about the tempo of fertility:

$$CFR(T, a = 45, c) = [CFR(T - 20, a = 25, c)] +$$

$$+[CFR(T - 10, a = 35, c) - CFR(T - 20, a = 25, c)] +$$

$$+[CFR(T, a = 45, c) - CFR(T - 10, a = 35, c)] \qquad (3)$$

We evaluate the accuracy of this approach by a simple experiment: We compute one set of intercensal fertility rates for the whole population (disregarding education), and second set using conventional vital statistic-based fertility rates for the years between the two censuses. The comparison for 2001–2011 intercensal period in Czech Republic reveals very close agreement of the two sets of fertility rates, with a slight underestimation (about 4 percent) of rates after age 35. This result gives a strong indication that the method accurately estimates the real period fertility levels.

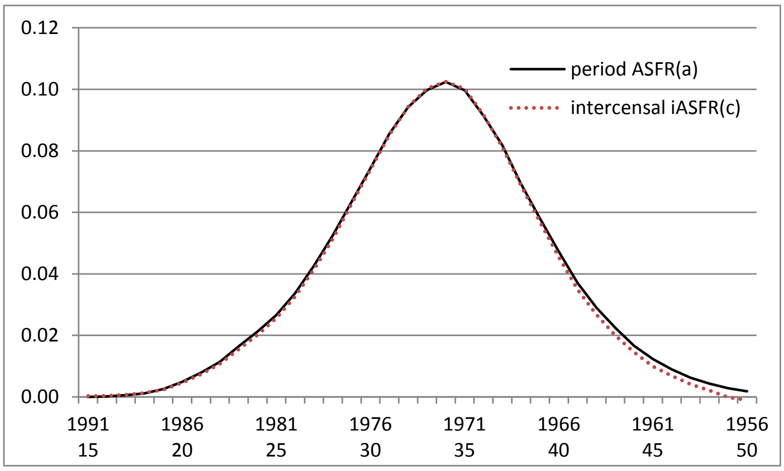
When adding the dimension of education, there arises the problem of changing level of education at young ages. We argue that this potential source of mismatch is relaxed by three effects: First we compare real cohorts, where there is no danger of mixing up the effect of changing parity distribution with period effects. Second, we compare mean parities, i.e.

averages, where the effect of education is already accounted for. And third, the problem of changing level of education is significant only at young age group 15–24, and does not affect estimation for older age groups 25–34 and 35–44.

Another potential drawback of this method is that it cannot capture the exact timing of the events and thus gives only a crude indication of the changes in birth timing. For example we know how many children were born to women of the cohort 1976 between censuses 1991 and 2001, but we don't know the distribution of births during these ten years, i.e. between ages 15 and 25. But we still can derive useful information from this approach, and we can especially concentrate on comparing behaviour in different educational categories, and its evolution over time.

There is also a problem of causality (i.e. whether women do not progress into higher education because they are pregnant, or if they become pregnant at young age because they are of low education)[7]. However the objective of this paper is not to study the causality, but to use education as a kind of proxy of socio-economic status. Finally, differential migration and mortality is disregarded in this paper. Earlier studies have identified higher mortality of women with lower education (Zeman, 2006; Bartoňová, 2007). However in the life stage of our interest (age 15–45), the mortality in countries under study is generally negligible.

Figure 2 Validation of intercensal method by comparison with vital statistic-based age-specific fertility rates, Czech Republic, 2001–2011



[7] Since educational enrolment and childcare are generally incompatible in the Czech Republic (Kantorová, 2004), we assume that most women completed their education before giving birth to their first child. In 1991-2005, only 5–7 percent of women with a higher education and 17 percent of those with a primary education at the time of entering motherhood further progressed in education before having a second child (Zeman, 2007).

4 Preliminary results (just Czech Republic now, will be extended for Austria, Brazil and South Korea)

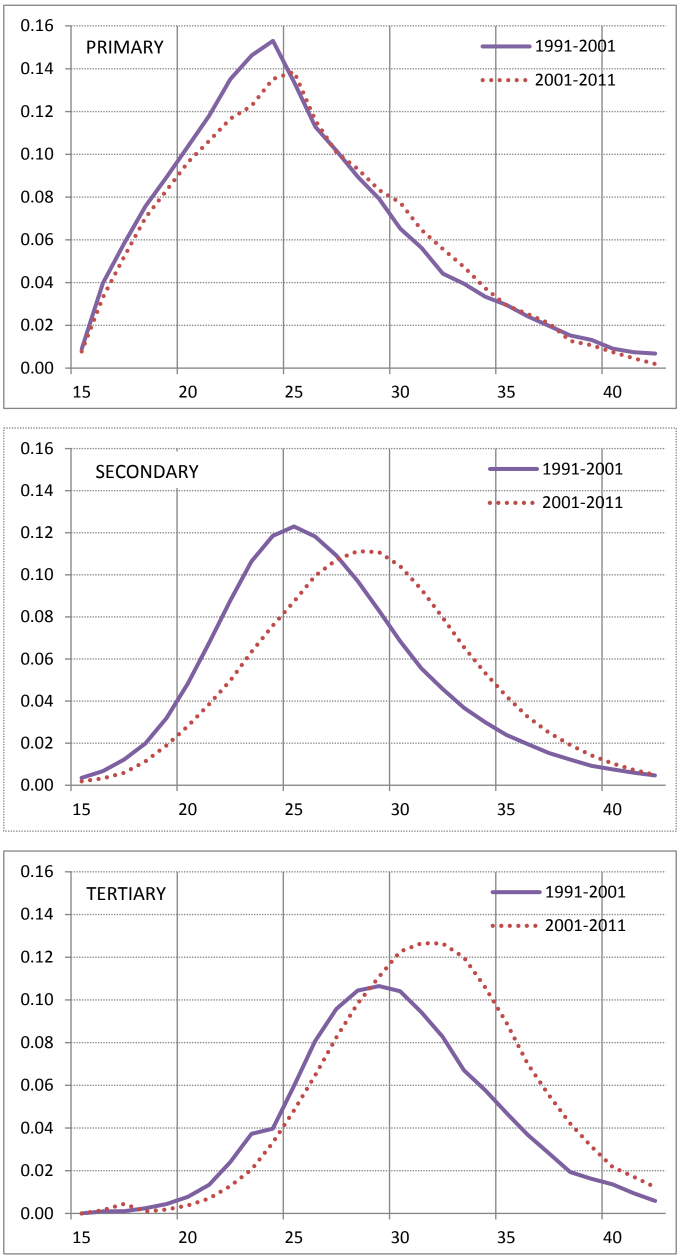
Here we first interpret the results of intercensal fertility rates from period perspective. Below we will look at the results from cohort perspective. The period perspective allows us to analyse fertility behaviour in two different period of time, namely in the 1990s and in the first decade of tour millennium. In the Czech Republic, this is especially useful allocation, as we can distinguish between the period of fast development of free society and capitalism in 1991-2000, and the most recent period of 2001-2011, characterised by more stable institutional structure of market democracy and civil society and also by rapidly increasing educational level of the younger population.

The results, summarised in Table 2, and displayed in Figure 3, show rapid development between the 1990s and 2000s, in terms of fertility decline and postponement of fertility to higher ages. More importantly, the development shows broad differences between the educational groups. Among primary educated, there was no important change between the periods — fertility level remained high, around 1.7-1.8, with relative low mean age at birth and the maximum of fertility levels around age 25. In contrast, secondary and university educated women experienced increase in the mean age at birth, by about 1–1.5 years per decade. Proportion of births realised after age 30 (denoted as *iASFR30p*) increased substantially: While in the 1990s, 27 percent of secondary educated and 51 percent of tertiary educated had their birth after age 30, in 2001–2011 it was already 40 percent of secondary educated and three quarters of university educated. When we compare these indicators with primary educated women we see huge differences: Almost 80 percent quarters of primary educated have their child before age 30.

Table 2 Intercensal fertility indicators

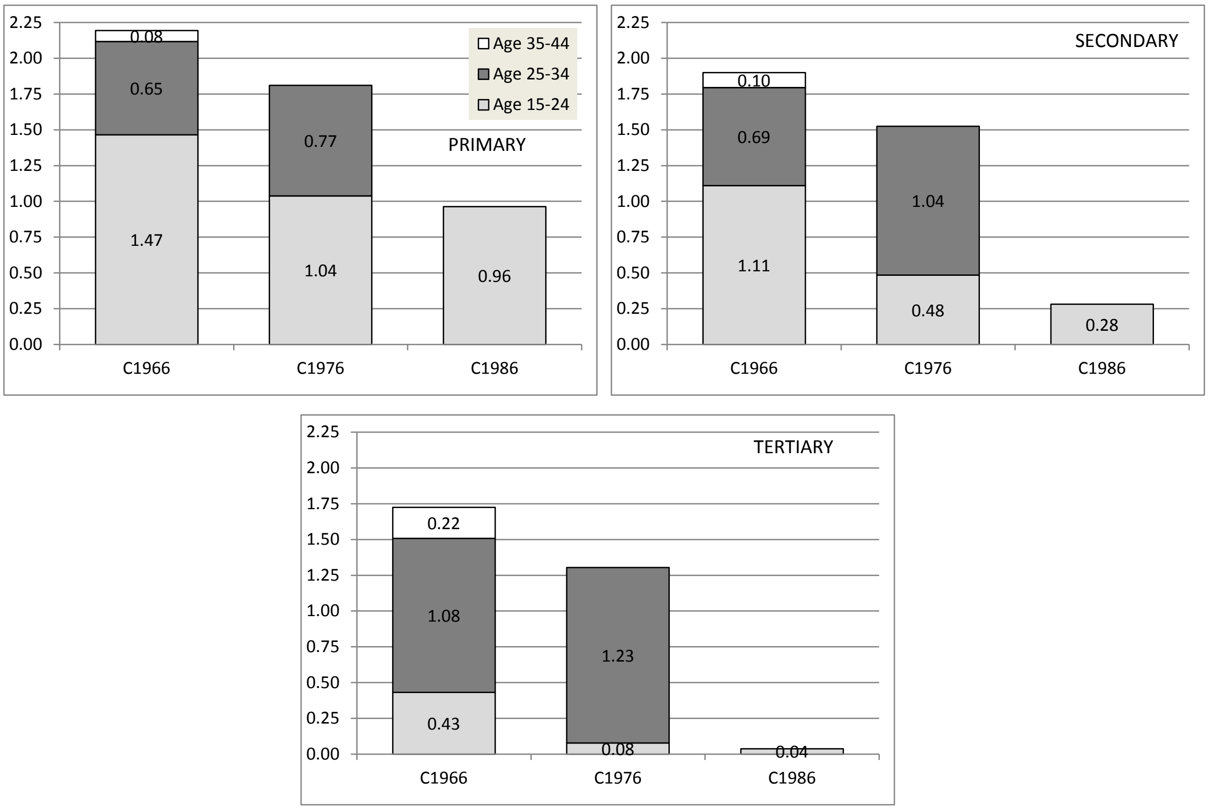
Period	Education	iTFR	iMAB	iASFR30p
1991–2001	Primary	1.88	26.0	23%
2001–2011		1.71	24.9	21%
1991–2001	Secondary	1.41	27.2	27%
2001–2011		1.37	28.4	40%
1991–2001	Tertiary	1.18	30.1	51%
2001–2011		1.47	31.6	67%
1991–2001	TOTAL	1.34	26.9	27%
2001–2011		1.28	28.4	43%

Figure 3 Intercensal age-specific fertility rates – Period perspective. Primary, secondary, and tertiary educated, respectively



When we turn to the cohort perspective, the Figure 4 displays the completed fertility of cohorts 1966, 1976 and 1986 by broad age groups of mothers (15–24, 25–34, 35–44), which refers to the intercensal periods 1991–2001 and 2001–2011. What is apparent at the first glance is the decline in completed fertility. In a more detailed view, we see postponement of fertility from young age 15–24 to the more mature age group 25–34.

Figure 4 Intercensal completed fertility rates – Cohort perspective. Primary, secondary, and tertiary educated, respectively



The change is clearly manifested in the cohort 1976, and even more so in the 1986 cohort. Focusing on the change between the cohorts 1966 to 1976, overall drop in fertility from 1.9 to 1.5 varied strongly between education groups. Primary educated saw rather moderate drop from 2.2 to 1.8, measured at age 35. On the other side of educational spectrum university educated women experienced a fall of the cumulated fertility at age 35 from 1.5 to 1.3. How much of the so-far not realised fertility is in fact *postponed* and can still be achieved? In cohort 1966 the sum of fertility rates at age 35-44 was 0.2. From combining vital statistics and census data we estimate the figure for university educated at younger cohort can be as high as 0.4. Even if this number would not further increase, the completed cohort fertility of university educated women born in 1976 would reach 1.7, the same level as for those born in 1966. Despite massive decline of period fertility, when women lived most of their fertile span in the period of lowest-low fertility, we still expect that their completed fertility will range between 1.7 among the university educated up to 2 among the primary educated, and about 1.8 in total.

Acknowledgements

This research was supported by the European Research Council under the European Union's Seventh Framework Programme (FP7/2007–2013) / ERC Grant agreement 284238 (EURREP).

References

Arretx, C. (1973). Fetility estimates derived from information on children ever born using data from censuses. In *International Population Conference, Liège, 1973*, Volume 2, pp. 247–261.

Blossfeld, H.-P. and J. Huinink (1991). Human capital investments or norms of role transition? How women's schooling and career affect the process of family formation. *American Journal of Sociology 97*(1), 143–168.

Cicali, D. and G. D. Santis (2002). Estimating cohort fertility levels and differentials by socio-economic characteristics with the own-children method and pseudo-panels. *Genus 58*(2), 35–61.

Coale, A. J., A. M. John, and T. Richards (1985). Calculation of age-specific fertility schedules from tabulations of parity in two censuses. *Demography 22*(4), 611–623.

Corsini, V. (2012). Fertility rates by educational attainment in the EU: first steps towards comparable data. In *Paper presented on the European Population Conference 2012*.

Grabill, W. H. and L.-J. Cho (1965). Methodology for the measurement of current fertility from population data on young children. *Demography 5*, 50–73.

Hamplová, D. (2003). Marriage and educational attainment: A dynamic approach to first union formation. *Czech Sociological Review 39*(6), 841–863.

Handcock, M. S., S. M. Huovilainen, and M. S. Rendall (2000). Combining registration-system and survey data to estimate birth probabilities. *Demography 37*(2), 187–192.

Hobcraft, J. N., N. Goldman, and V. Chidambaram (1982). Advances in the P/F ratio method for the analysis of birth histories. *Population Studies 36*(2), 291–316.

Hoem, J. M. (1986). The impact of education on modern family-union initiation. *European Journal of Population 2*, 113–133.

Kantorová, V. (2004). Education and entry into motherhood: The Czech Republic during the state socialism and the transition period (1970–1997). *Demographic Research Special Collection 3*(10), 245–274.

Kravdal, Ø. (2004). An illustration of the problems caused by incomplete education histories in fertility analyses. *Demographic Research: Special Collection 10*(3), 135–154.

Kreyenfeld, M. (2006). *Family Formation in East and West Germany before and after Unification*, Chapter 9, pp. 225–236. Springer.

Lanzieri, G. (2013). Towards a 'baby recession' in Europe? Differential fertility trends during the crisis. *Statistics in Focus 13*, 1–14.

Liefbroer, A. C. and M. Corijn (1999). Who, what, where and when? Specifying the impact of educational attainment and labour force participation on family formation. *European Journal of Population 15*, 45–75.

Lutz, W. (2010). Education will be at the heart of 21st century demography. *Vienna Yearbook of Population Research 8*, 9–16.

Lutz, W., A. Goujon, and G. Doblhammer-Reiter (1998). Demographic dimensions in forecasting: Adding education to age and sex. *Population and Development Review 24*, 42–58.

Lutz, W. and S. KC (2011). Global human capital: Integrating education and population. *Science 333*, 587–592.

Marini, M. M. (1984). Women's educational attainment and the timing of entry into parenthood. *American Sociological Review 49*(4), 491–511.

Oliveira, I. T. d. (2009). Fertility differentials and educational attainment in Portugal: A non-linear relationship. *Canadian Studies in Population 36*(3–4), 347–362.

Retherford, R. D., N. Ogawa, R. Matsukura, and H. Ihara (2004). *Trends in fertility by education in Japan, 1966–2000*. Nihon University Population Research Institute, Tokio and East-West Center, Honolulu.

Rindfuss, R. R. and K. L. Brewster (1996). Childrearing and fertility. *Population and Development Review 22*(Supplement), 258//289.

Rindfuss, R. R., L. Bumpass, and C. S. John (1980). Education and fertility: Implications for the roles women occupy. *American Sociological Review 45*(3), 431–447.

Skirbekk, V. (2008). Fertility trends by social status. *Demographic Research 18*(5), 145–180.

Šprocha, B. and M. Potančoková (2010). *Vzdělanie ako diferenčný faktor reprodukčného správania. [Education as a factor of fertility behaviour]*. INFOSTAT.

United Nations (1983). *Manual X: Indirect Techniques for Demographic Estimation*. United Nations.

Zeman, K. (2007). Transition of nuptiality and fertility onset in the Czech Republic since the 1990s: The role of women's education and its expansion. *MPIDR Working Paper 2007*(017), 1–28.

Zeman, K., Z. Brzozowska, T. Sobotka, E. Beaujouan, and A. Matysiak (2014). Cohort Fertility and Education database methods protocol. Available at www.cfe-database.org (last accessed on 15.12.2015). Technical report, Vienna Institute of Demography.