LSE Research Online

Karel Neels, Michael J. Murphy, Máire Ní Bhrolcháin and Éva Beaujouan

Rising educational participation and the trend to later childbearing

**Item type
Article (Accepted version)
(Refereed)**

http://eprints.lse.ac.uk

Rising Educational Participation and the Trend to Later Childbearing

Karel Neels [ID]

Michael Murphy [ID]

Máire Ní Bhrolcháin [ID]

Éva Beaujouan [ID]

HOW FAR CAN THE shift to later childbearing in developed countries be accounted for by the growth in educational participation? A move to later childbearing has been a conspicuous feature of fertility trends in developed countries for many decades, and over that same period educational participation rates have risen substantially (OECD 2014, 2016a). The rising age at birth is often described as fertility postponement and is primarily due to a progressively later start to childbearing. Fewer women have been starting a family in their teens and early 20s and more have been delaying the start of parenthood to their late 20s and 30s (d'Addio and Mira d'Ercole 2005; OECD 2016b). The consequence is a decline in the first birth rates of childless women at younger ages, followed, in most cases, by a rise in parity-specific rates at older ages, resulting in a general shift up the age scale in the timetable of parenthood. In the West, the mean age at first birth began rising in the 1970s; in Eastern Europe, the trend began in the 1990s, following political and societal transformation (see Figures 1a and 1b). Later childbearing is emerging more recently as a feature of population trends in Southeast Asia and Latin America (Rosero-Bixby et al. 2009; Frejka et al. 2010).

The postponement of childbearing in developed countries has been sizable and sustained. This has demographic importance for a number of reasons. Change in the mean age at first birth makes time trends in fertility harder to interpret. The indicator most widely used to measure such trends, the period total fertility rate (TFR), is influenced by shifts in fertility tempo. Tempo change increases the difficulty of assessing the extent to which trends in the TFR reflect change in the level of fertility or only in its timing, or in some combination of the two. Considerable technical ingenuity and debate have been devoted to this problem in the last two decades (see especially Bongaarts and Feeney 1998 and associated commentary; Schoen 2004; several chapters in Barbi et al. 2008; Ní Bhrolcháin 2011). The postponement

FIGURE 1a   Period mean age at first birth, Western Europe and other developed countries, 1960–2014
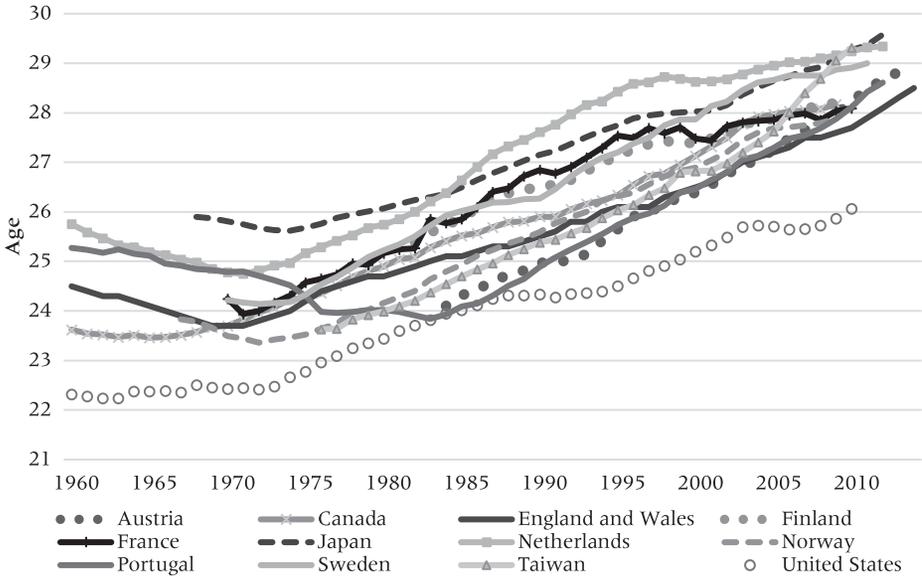
FIGURE 1b   Period mean age at first birth, Eastern Europe, 1960–2014
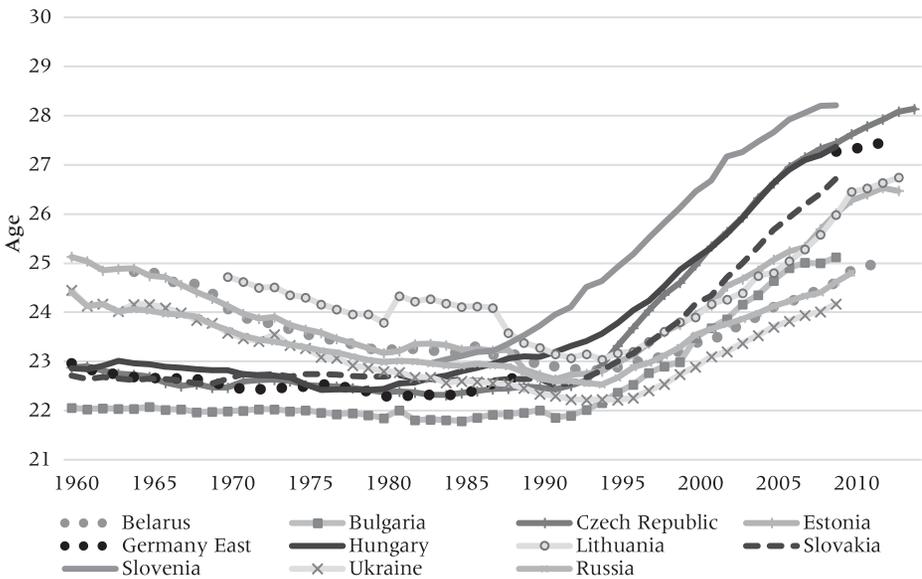
NOTE: Figures show the standardized period mean age at first birth, termed MAB1 in the Human Fertility Database (Jasilioniene et al. 2015).
SOURCE: Human Fertility Database. www.humanfertility.org (data downloaded 15 January 2016).

of fertility also raises practical issues. Forecasters, policymakers, and planners need an assessment of how long the postponement phenomenon is likely to continue and its implications for long-range levels of fertility, considered from either a period or a cohort perspective. Social commentators and medical professionals have raised concerns about the implications of a delayed start to childbearing for women's ability to have children at later ages (Menken 1985; Billari et al. 2007; te Velde et al. 2007; Schmidt et al. 2012). Delayed childbearing also has implications for intergenerational support: for example, children born later are less likely to have surviving parents at any given age, and surviving parents are likely to be in poorer health (Murphy et al. 2006).

A wide array of potential causes of the shift to later childbearing have been proposed. For example, a recent review (Mills et al. 2011: 848) summarized the principal factors influencing aggregate postponement as: "effective contraception, increases in women's education and labour market participation, value changes, gender equity, partnership changes, housing conditions, economic uncertainty and the absence of supportive family policies" (see also Blossfeld and Huinink 1991; Lesthaeghe 2001; Billari et al. 2006). While there has been no shortage of candidate causal factors, with educational expansion prominent among them, there have been fewer attempts to quantify the contribution of specific determinants to aggregate change in fertility timing (but see Rindfuss et al. 1996; Bergouignan 2006; Neels 2009; Neels and De Wachter 2010; Ní Bhrolcháin and Beaujouan 2012).

A strong link at the individual level between education and family formation has been documented in several decades of demographic research. In particular, copious micro-level evidence has been available for several decades that better-educated women in developed countries start childbearing at later ages than the less well educated (Martin 2000; Gustafsson et al. 2002; Rendall et al. 2005; Kravdal and Rindfuss 2008). Although the effect of childbearing on finishing education is likely to contribute to the negative association between education and timing of parenthood (Cohen et al. 2011; Gerster et al. 2014), the frequency with which the end of education coincides with a first birth is limited, indicating that other mechanisms are at play. Education has mostly been interpreted as influencing family formation either through economic processes—the career incentives and opportunity costs of childbearing that result from higher attainment—or through cultural ones—via the acquisition of knowledge and attitudinal and value change that accompany educational participation. But the time cost of educational participation and its impact on the age at leaving full-time education, as distinct from attainment per se, is a further mechanism by which education may have an effect on the timing of life-course transitions (Hogan 1978; Marini 1985; Blossfeld and Huinink 1991; Oppenheimer 1994).

Up to the 1980s, most of the empirical evidence related to the link between education and family formation was based on measures of educational attainment, such as highest level of qualifications or years of education. This may have been partly because attainment was the principal information collected on education in demographic surveys and that questions were not usually asked on the age at leaving school or college/university. In addition, conventional regression methods are not well suited to examining the statistical effects of attributes that vary within an individual life course, such as educational enrollment, employment status, and the like. With the advent in the 1980s of methods of event history analysis that allowed the investigation of time-varying covariates, it became possible to examine the effect of time spent in education per se as distinct from ultimate attainment or highest level of qualifications.[1] Numerous studies have investigated the rate of transition to adult statuses—cohabitation, marriage, first birth—using this methodology. Probably the most consistent finding is that first birth rates are substantially lower when women are enrolled in education (Blossfeld and Huinink 1991; Blossfeld and Jaenichen 1992; Kravdal 1994; Liefbroer and Corijn 1999; Santow and Bracher 2001; Winkler-Dworak and Toulemon 2007). By contrast, the statistical effect of educational attainment on rates of first birth is much weaker or often absent when enrollment status is taken into account (Blossfeld and Huinink 1991; Santow and Bracher 2001; Lappegård and Rønsen 2005). The question arises therefore as to the extent to which the link between educational attainment and adult transitions is attributable to i) variation in time spent in education and the corresponding effect on the age at which people leave full-time education and ii) to other aspects of educational attainment, such as its impact on earning power, attitudes and values, and participation in the labor force (Marini 1985). We examine the first of these issues in this article, evaluating the extent to which the changing age at first birth is linked to the change over time in educational enrollment and to the resulting upward shift in the age at leaving education.

One cannot infer from the consistent evidence of an individual-level link between education and birth timing that the growth in educational participation explains the trend over time to later childbearing. The micro-level link may not be a causal one, and so even if both education and birth timing change over time in a corresponding direction, this may not be due to a causal process. And even if education is a cause of fertility delay at the micro level, the causal effect may not be strong enough to account for any observed aggregate change in birth timing. Although rising education levels have often been suggested as a potential cause of fertility postponement, only a handful of studies have investigated the degree to which changing educational composition accounts for delayed marriage or first birth in developed countries. Using standardization, Rindfuss et al. (1996) found that

the changing distribution by educational attainment did not explain the rise in age at first birth in the US. Their results appear anomalous, given the data and differentials reported.[2] By contrast, two standardization analyses of Belgian data have shown that rising attainment accounts for 37–54 percent of the cumulated deficit in the proportion of women having a first child by age 25 in the cohorts born between 1951 and 1975 relative to the 1946–1950 birth cohorts. Similarly, adopting a period perspective, two-thirds of the rise in mean age at first birth between 1970 and 2000 is accounted for by rising levels of educational attainment over the period considered (Neels 2009; Neels and De Wachter 2010). Only two studies have analyzed the effects of compositional change in educational enrollment or the age at completing education on delaying the entry to parenthood, both using standardization. Bergouignan (2006) reported that about half of the increase across the female French cohorts of 1960 and later in the proportions childless at ages 25 and 30 was attributable to the rise in the age at leaving education. Ní Bhrolcháin and Beaujouan (2012), adopting a period life table approach to standardize for changing structure by age and by educational enrollment/duration, estimated that around three-fifths of the rise in the 1980s and 1990s in the period mean age at birth in Britain, and four-fifths in France, was attributable to later ages at completing education and, thus, to rising educational enrollment. Over the same period, the increase in the time to first birth after completing education was found to be greater among better-educated women than among the less well educated.

We extend the investigation of Ní Bhrolcháin and Beaujouan in several ways. The standardization for enrollment and duration since leaving education is more comprehensive than in the earlier study. We improve on the previous estimates by adopting a modeling approach to smooth the estimated rates. We examine the contribution of these structural factors to change in the mean age and to shifts in age-specific first birth rates. In addition, we separate the overall structural contribution to period change in first birth timing into two components—one due to rising enrollment at each age, the second to the changing composition at each age by duration since leaving education. We add a further data source for the UK, allowing us to make estimates back to the 1970s. Finally, we add an additional country to the cross-national study, using large-scale data from the Belgian census of 2001.

Data

For the United Kingdom we used two survey sources: (a) a pooled series of General Household Survey (GHS) rounds from 2000 to 2009, on which the Ní Bhrolcháin and Beaujouan (2012) analysis was based; this is a subset of a larger harmonized time-series data file of GHS surveys from

1979 to 2009 compiled by the Centre for Population Change (Beaujouan et al. 2014a); (b) to this dataset we added the first (2009) round of the UK Household Longitudinal Study (UKHLS), also known as Understanding Society, a prospective longitudinal study linked with and incorporating the British Household Panel Survey (Knies 2015). Both surveys collected fertility histories, the GHS for women aged 16–59 and UKHLS for women aged 16+. Both also fielded questions on the age at which respondents completed their education, discussed further below. Data from the two sources were pooled to form a single database and validated against period fertility rates derived from the national vital statistical system and against national statistics on educational participation. We confine analysis of GHS data to the later rounds, 2000–2009, because the information on the age at finishing education was found to be defective before the 2000 GHS round (Beaujouan et al. 2014a, Appendix G).[3]

For France, we used the same large-scale survey data as in the earlier study, the Family History Survey (FHS/EHF) linked with the French census of 1999 (Cassan et al. 2000). This self-completion survey collected details on the fertility histories of women aged 18 and above and on the age at completing education, discussed further below. The FHS/EHF, the main source of data on parity-specific fertility in France, has been validated and weighted by INSEE and INED (Mazuy and Toulemon 2001).

Finally, we use the fertility histories of women aged 14+ together with information on age at achieving highest qualification collected in the 2001 Belgian census (Deboosere and Willaert 2004), on which the analyses by Neels (2009) and Neels and De Wachter (2010) were based. Validation against vital registration has shown that period and cohort indicators estimated retrospectively from the 2001 census agree well with national statistics on period fertility trends between 1960 and 2000 and with independent estimates of cohort fertility patterns for women born after 1930 (Neels and Gadeyne 2010).[4]

Month and year of the woman's first birth were available in all four data sources used. Both month and year of first birth were collected in the UK and French surveys, but since only the year of first birth was available in the Belgian census we assigned a birth month of June to all first births in this source.

Data are available up to 2000 for the UK and Belgium. The FHS took place in 1999 but for technical reasons the French data are available only up to 1998. We chose 1970 as a starting point both because it precedes by a few years the start of the lengthy rise in age at first birth in all three countries and because UK data before about 1970 become increasingly selected since they are mainly based on retrospective information from respondents alive in 2000–2009 and, in the case of the GHS, aged under 60. We therefore confine analysis to the period 1970–1998/2000.

Age at completing education

The age at which individuals complete their education is not readily defined. People may leave school, engage in some other activity such as employment or family formation, return later to full-time education, and exit again. Thus, they may leave full-time education several times during their lives. We therefore defined our key variable as the age at which a person first left continuous, full-time education and attempted to construct this. The indicator remains fixed throughout a person's lifetime, unlike educational attainment or total years spent in education. That in turn makes it much less prone to problems of endogeneity and reverse causation than highest educational qualification or years of education (Kravdal 2004; Hoem and Kreyenfeld 2006). Accurate measurement of our key indicator would require a near-complete dated history of the start and end of spells of full-time education. Such information was not available to us and is rarely collected. Details of how the indicator was constructed in each dataset are given in the online Appendix.[5] For economy we refer to this variable throughout as age at leaving education or age at completing education.

Methods

Our fertility indicators are annual age-specific first birth rates among childless women aged 15–39 who were in education while below age 26, or reported leaving full-time education between ages 15 and 26, and the period life table mean ages at first birth derived from these schedules. To measure the propensity to leave school by age in a calendar year, we use a period life table mean age at leaving education, calculated analogously to the period life table mean age at first birth. Both of these measures are independent of the age structure in a given year and are therefore free of the distortions to which crude period mean ages are subject when age structure varies over time. We refer to these measures throughout as period mean age at first birth and period mean age at leaving education.

   We decompose age-specific first birth rates in a given year into the weighted sum of i) the age-specific first birth rates of women enrolled in education, and ii) the age-specific first birth rates of women who have left education. Moreover, since the fertility behavior of the latter women is also determined by the duration since leaving education,[6] we additionally disaggregate the age-specific rates of women who are out of education into a weighted sum of age-duration-specific first birth rates. Details of the decomposition are provided in the online Appendix.

   We use indirect standardization to assess the extent to which changing educational participation accounts both for the rise in the mean age at first birth and for the change in the first birth rates of childless women at each age. In each case, we estimate two distinct but related structural effects:

(i) We evaluate the impact of *changing enrollment* on change in the mean age at first birth and on change in age-specific first birth rates, by standardizing for age-specific enrollment.

(ii) Change in educational enrollment at each age results in a change in the distribution of ages at leaving education, and this in turn results in change in the composition of each age group by duration since leaving education. We estimate the impact of *changing duration* by standardizing jointly for enrollment and duration since leaving education,[7] and taking the difference with (i).

Our preferred standard schedule of rates is the average of the annual age-specific rates of women in education and the average of the annual age-duration-specific rates of women who left education across the 29/31 years from 1970–1998/2000. We consider this the most appropriate standard for the present purpose as it minimizes the deviations from the actual values and, given significant changes in rates across the period analyzed, alternative standards could differ substantially from some observed values. However, because results can vary with the standard employed, we also use two other standards—rates in 1970, the start of the period, and rates at the end of the period, 1998/2000—to assess the sensitivity of the estimated effects. Details of the standardization are given in the online Appendix.

The standard schedules used in the indirect standardization were smoothed using generalized additive models (details of the generalized additive model (GAM) fitting process are given in the online Appendix; see also Wood 2006). The smoothed rates improve on the unsmoothed estimates when samples are restricted in size. Further details are given in the online Appendix.

Results

Between 1970 and 1998/2000 the mean age at first birth increased substantially in Britain, France, and Belgium. The period mean age at first birth in 1970 was similar in the three countries: 23.9 years in France and Belgium and 24.7 years in Britain. By the turn of the century the figure had risen to 27.2 (UK), 27.5 (France), and 27.1 (Belgium). Thus, the period mean age at first birth rose by 2.5, 3.6, and 3.2 years in the final three decades of the twentieth century. These substantial increases reflect the postponement of family formation that was such a striking feature of childbearing trends in the late twentieth century and that continues up to the present.

In parallel with these shifts was a substantial expansion in educational participation, with young women in all three countries completing their education at progressively later ages between 1970 and the turn of the century. The period mean age at first leaving continuous full-time education was 17.6 in the UK in 1970 and had risen to 19.6 by 2000. In France and Belgium, the corresponding increases were somewhat larger, with the

period mean age at completion rising, respectively, from an average age of 18.8 in 1970 to 21.5 in 1998 and from 18.9 in 1970 to 21.4 in 2000. During the final decades of the twentieth century, then, young people were staying on longer in full-time education and, as a result, leaving education at progressively later ages. The increases in the age at leaving education—with young women being between 2.0 and 2.7 years older on leaving education at the turn of the century compared with three decades earlier—are sizable enough in principle to lead to substantial shifts in the timetable of childbearing. Given the well-established restriction in birth rates during periods of educational enrollment, and the individual-level link between educational attainment and later childbearing reviewed earlier, the question arises whether the growth over time in educational participation can account for the aggregate trend to later childbearing and, if so, to what extent.

The beginnings of an answer to this question can be seen graphically, in the contrast between the left and right columns of Figure 2. The left-hand plots show smoothed age-specific first birth rates of childless women from the 1970s to the late 1990s for the three countries (original unsmoothed values are also plotted). In each case, we see a rightward shift in the curve of first birth rates by age. That is, across these decades the schedule of entry to parenthood moved up the age scale. An alternative perspective is given by the right-hand graphs, showing the smoothed first birth rates of childless women by time since leaving education, again from 1970 onward (we do not consider births while in education for reasons set out in endnote 6). First birth rates are closely related to time since leaving education, gradually rising to a peak and falling again. But the plots by time since leaving education display much less rightward movement over the three decades than do plots by age. That is, there is much less change over time in the timetable of first births relative to the end of education than there is relative to age. The contrast between these two sets of plots suggests that the upward trend in age at leaving education has played a part in the aggregate shift to later ages at first birth.

Both sets of graphs also show a progressive lowering of the schedules of rates, indicating a decline in the overall level of period fertility. A conspicuous feature of the trends during the 30-year period covered is not only a delay in motherhood, but also a decline overall in the propensity to start a family. However, because our focus is on explaining the change in first birth timing, we do not attempt to account for the changing level of period fertility.

We use indirect standardization to assess the extent to which compositional change by education can account for the upward shift in ages at first birth. We standardize for education in two stages. First, we standardize for educational enrollment to evaluate the impact of the additional time spent in full-time education. Second, we standardize for both enrollment and duration since leaving full-time education. This second stage is

FIGURE 2   Schedules of first birth rates for women aged 15–39 who have left education, by age (left-hand side) and by duration since leaving education (right-hand side), United Kingdom 1970–2000, France 1970–1998, and Belgium 1970–2000
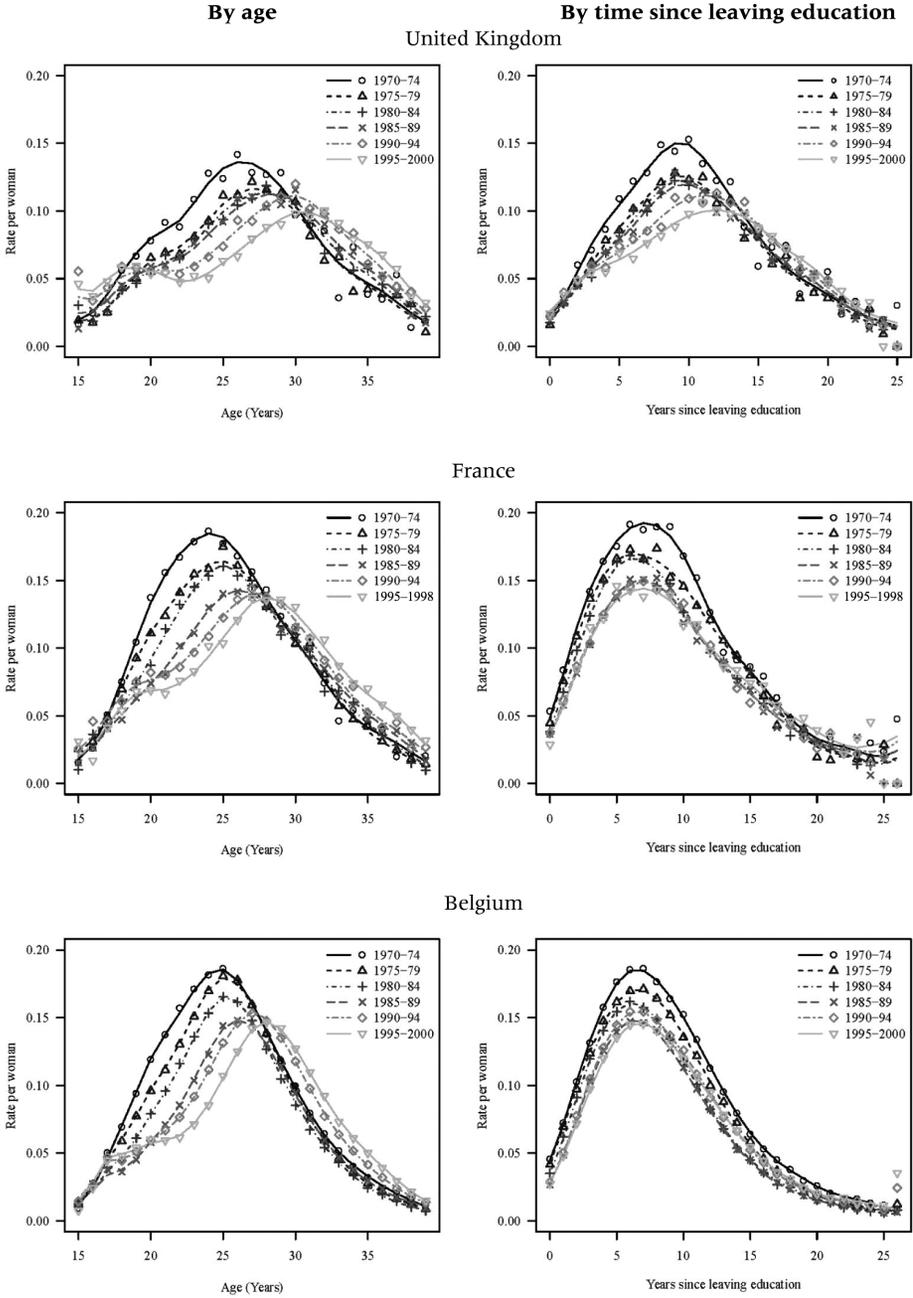
NOTE: Schedules are smoothed using generalized additive models (see online Appendix).
SOURCE: General Household Survey and Understanding Society (UK); Family History Survey and 1999 census (France); 2001 census (Belgium).

essential to evaluating the total impact of change in educational participation. The reason is twofold: (1) rising enrollment results in a shift to later ages at leaving education, and this in turn results in a change in the composition of each age group by duration since completing education (or, equivalently, by age at leaving education); and (2) first birth rates are closely linked to time since leaving education, as we saw in Figure 2.

Results are summarized in Table 1. Between 1970 and 1998/2000 the period mean ages at first birth rose by 2.5, 3.6, and 3.2 years, respectively, in the UK, France, and Belgium. We focus mainly on the decomposition based on our preferred standard, the average 1970–1998/2000 rates in the second panel of the table (see Methods section). If age-specific and age-duration-specific first birth rates of childless women had been fixed at their average values throughout the period, but full-time educational enrollment rose as observed over the period, the mean ages at first birth would have risen by 0.7, 1.4, and 1.0 years in the UK, France, and Belgium. That is, the increase in time spent in education accounts for 26.9, 39.0, and 30.9 percent, respectively, of the change in the mean age at first birth over the period in the three countries. Beyond time spent enrolled in education, the changing composition by duration since leaving education accounts for a further and substantial 1.1, 1.0, and 0.8 years of the rise in mean age, that is 46.8, 27.3, and 25.9 percent of the increase in the UK, France, and Belgium. The total structural effect, encompassing changing composition in both respects, accounts for an increase of 1.8, 2.4, and 1.8 years in the mean ages at birth. That is, structural factors are responsible overall for 73.7, 66.2, and 56.8 percent of the aggregate postponement of first births from 1970 to 1998/2000. Rising educational participation has clearly had a substantial impact on the timetable of childbearing in the final decades of the twentieth century in these three European countries.

How robust are the estimates? The third and fourth panels of Table 1 show the results of using two alternative standards—1970 rates and 1998/2000 rates—in the indirect standardization. The 1970 standard gives a somewhat smaller role to structural change than does the average standard, while the 1998/2000 standard gives it a slightly larger role (except in France). The range of the estimated structural effect across all three standards is 47–66 percent in France and 42–67 percent in Belgium, in both cases indicating a very sizable effect: at a minimum, structural factors account for close to half of the timing shift in the two countries. The range of the estimates in the UK, 56–89 percent, is somewhat wider. This may be due to the much more pronounced change in the shape of the first birth schedule in the UK seen in Figure 2 and may indicate that standardization is not as effective a method of arriving at a decomposition for the UK as it is for France and Belgium. However, for reasons we set out earlier, the average of rates across the period is our preferred standard.

TABLE 1 Contribution of rising enrollment and changing distribution of duration since leaving education to change in period mean age at first birth, estimated by indirect standardization: United Kingdom 1970–2000, France 1970–1998, and Belgium 1970–2000

	United Kingdom	France	Belgium
Period mean age at first birth			
1970	24.7	23.9	23.9
1998/2000	27.2	27.5	27.1
Change 1970–1998/2000	2.5	3.6	3.2
Structural effects based on average 1970–1998/2000 standard			
Change in mean age due to			
Enrollment	0.7	1.4	1.0
Duration since leaving	1.1	1.0	0.8
Enrollment + duration	1.8	2.4	1.8
Percent of overall change explained by			
Enrollment	26.9	39.0	30.9
Duration since leaving	46.8	27.3	25.9
Enrollment + duration	73.7	66.2	56.8
Structural effects based on 1970 standard			
Change in mean age due to			
Enrollment	0.7	1.2	0.9
Duration since leaving	0.7	0.5	0.5
Enrollment + duration	1.4	1.7	1.4
Percent of overall change explained by			
Enrollment	26.8	33.1	28.8
Duration since leaving	28.8	13.6	13.0
Enrollment + duration	55.6	46.7	41.8
Structural effects based on 1998/2000 standard			
Change in mean age due to			
Enrollment	0.9	1.2	1.0
Duration since leaving	1.3	1.1	1.2
Enrollment + duration	2.2	2.3	2.2
Percent of overall change explained by			
Enrollment	36.1	33.1	31.7
Duration since leaving	53.2	31.2	34.9
Enrollment + duration	89.3	64.3	66.6

NOTE: Period mean ages at first birth are life-table adjusted mean ages; the indicator is thus standardized for age, to abstract from the change over time in the age distribution of the population at risk of first birth.
SOURCE: General Household Survey and Understanding Society (UK); Family History Survey and 1999 census (France); 2001 census (Belgium).

Components of changing age-specific first birth rates

The mean age at first birth, though indispensable as an indicator of fertility timing, conveys limited information. A fuller picture is given by examining the entire schedule of first birth rates by age. Figure 3 decomposes change between 1970 and 1998/2000 in first birth rates at each year of age into

FIGURE 3   Change between 1970 and 1998/2000 in age-specific first birth rates: Observed change, overall structural effect, and rates effect, United Kingdom, France, and Belgium
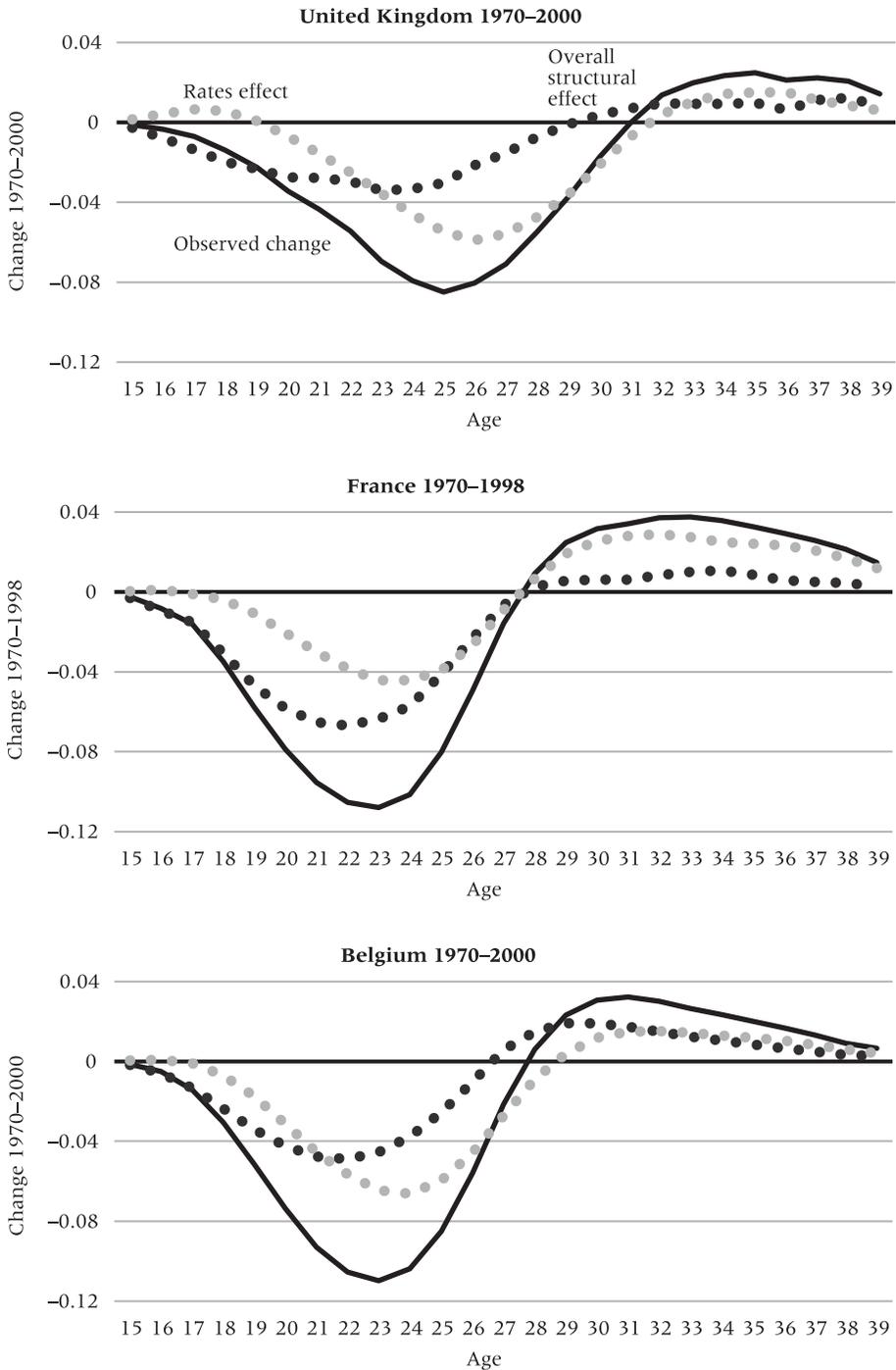
NOTE: A detailed discussion of the calculation of the observed change, the overall structural effect, and the rates effect is provided in the online Appendix.
SOURCE: General Household Survey and Understanding Society (UK); Family History Survey and 1999 census (France); 2001 census (Belgium).

structural and rates components, using the same indirect standardization approach as for the analysis of mean age.

The shift up the age range of the first birth schedules seen in Figure 2 results from a decline in fertility rates at younger ages and an increase at older ages. This differential pattern by age is evident for all three countries in Figure 3, which shows substantial declines in rates at younger ages and modest increases at older ages. The decomposition reveals that the changing structure by enrollment and by duration since leaving education contributed to both of these shifts in all three countries. The structural effect is decidedly negative at younger ages and turns positive at older ages. The three countries present a similar picture, although the precise ages affected by compositional change, and the size of the structural effects at each age, differ somewhat between countries.

Figure 4 shows the enrollment and duration effects separately by age. As would be expected, the enrollment effect is prominent and negative at younger ages—teens and early 20s—the ages at which educational participation increased the most.[8] The restraining effect of the duration component is at its strongest around the mid-20s. The duration effect then turns positive from the late 20s (France, Belgium) or early 30s (UK) through the late 30s. Because they left education at later ages, women in their late 20s and 30s in 1998/2000 were out of education for a shorter time than their counterparts in 1970. First birth rates are, as we saw in the right-hand graphs in Figure 2, closely tied to duration since leaving education. Women at these later ages in 1998/2000 were thus subject to the higher birth rates associated with shorter average durations since leaving education compared with women of the same age in 1970. Again, the precise ages affected differ somewhat between countries, but the broad picture is similar in all three.

Compositional factors do not account for the whole of the movements in age-specific rates in any of the countries studied. Changing status-specific rates, reflecting changing behavior influenced by factors other than educational participation and time since leaving, also play a sizable role (Figure 3). In France and Belgium, the rates effect is negative at younger ages. Thus, as well as changing structure (composition), a declining propensity to start a family among women at an equivalent stage of their (post) educational trajectory has contributed to the decline in first birth rates at younger ages in these two countries. In the UK, by contrast, the rates effect is estimated to be positive at ages under 21. At older ages the effect due to the rates effect is, like the structure effect, positive in all three countries. Hence the upward shift in first birth rates at older ages is due not only to structural factors but also to a rise in the propensity to start a family at these ages. This may, in turn, be partly attributable to lesser selectivity in the later period. When, as in 1998/2000, childbearing starts later, those still childless in their late 20s and 30s are a larger fraction of the cohort than when, as in 1970, childbearing starts earlier. And, because older childless women are a

FIGURE 4   Decomposition of the age-specific overall structural component into duration and enrollment effects: United Kingdom, France, and Belgium, 1970–1998/2000
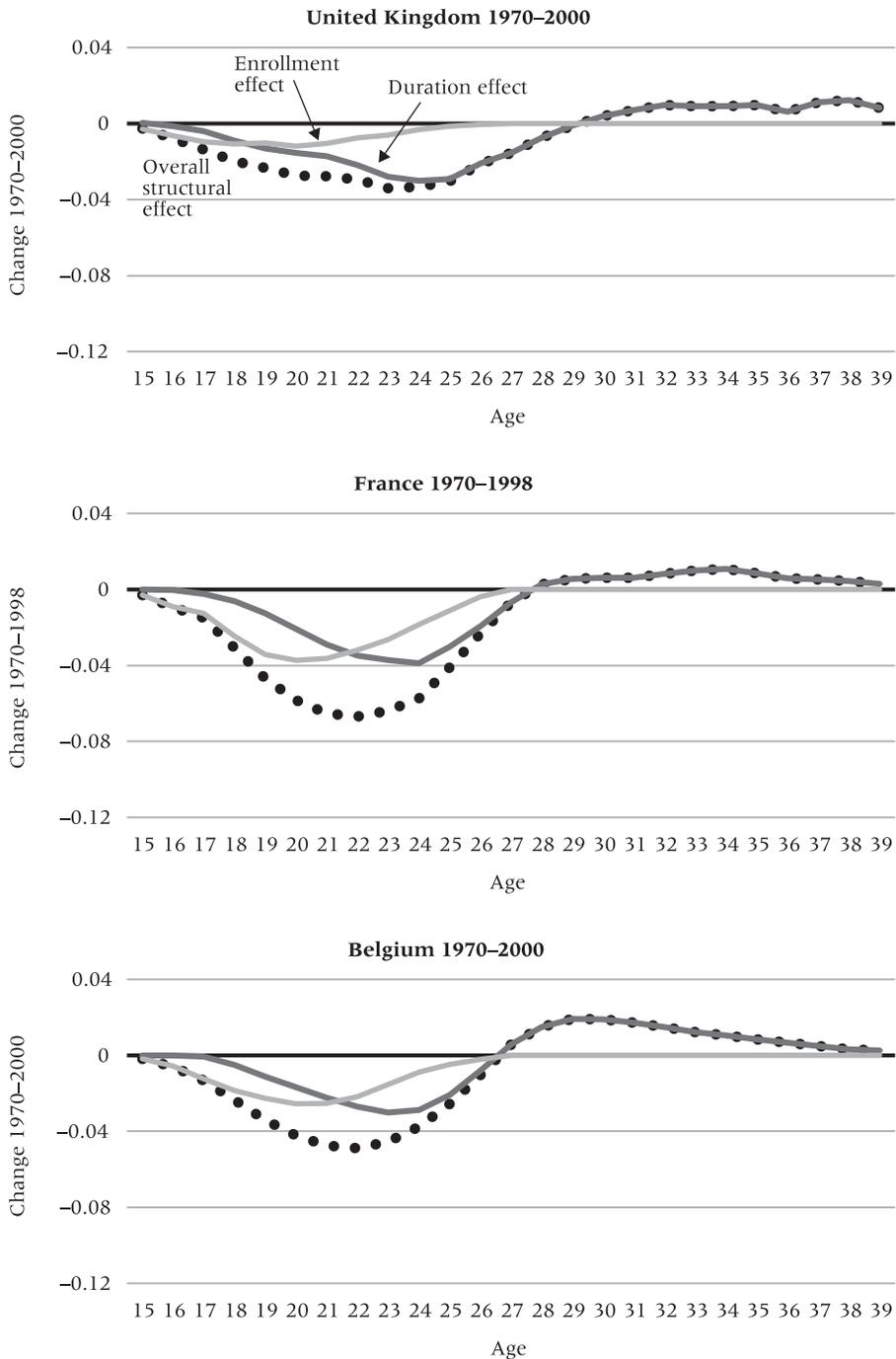
NOTE: A detailed discussion of the calculation of the observed change, the overall structural effect, and the rates effect is provided in the online Appendix.
SOURCE: General Household Survey and Understanding Society (UK); Family History Survey and 1999 census (France); 2001 census (Belgium).

less select group in 1998/2000 than in 1970, proportionately fewer of them would be expected to have problems of fecundity than in the earlier period.

The age profiles of the structural and rates effects are distinctive to each country, and result from the extent of shifts in enrollment by age, the level of rates at each age in 1970, and change in age- and status-specific rates. While further analysis of these differences is beyond the scope of this article, the rates component in all three countries tends to follow the structural component with a lag of a few years of age (Figure 3). At younger ages, the rates component tends to reach its largest negative value about two years of age after the structural component does so; at older ages, the rates effect tends to reach its maximum positive impact a few years after the structural effect peaks. This may be purely a statistical effect, due to the fact that birth rates are rising during the teenage years and falling during the 30s. First birth rates are therefore lower in the early than in the later teens, and the absolute size of the rates effect is more constrained at the youngest ages than a few years later; similarly, the lower rates at older ages toward the end of the fertility schedule leaves more scope for a larger rates effect. On the other hand, there may be a substantive basis for the finding, since first birth rates also vary with duration spent in states that young adults typically experience upon leaving education, such as entry into the labor market or into a co-residential union. Hence, the lag may reflect economic and cultural consequences of rising educational attainment, and particularly variation in associated labor market, economic, and cultural contexts.

Discussion

We estimate that the rise in educational enrollment accounts for between 57 percent and 74 percent of the increase in the mean age at first birth in the UK, France, and Belgium from 1970 to 1998/2000. Although sensitive to the standard employed, the results indicate that compositional change due to educational expansion has had a sizable effect on the postponement of first births. The structural effect we estimate for the UK, at 74 percent, is substantially higher than the 57 percent estimated by Ní Bhrolcháin and Beaujouan (2012), and our current estimate for France (66 percent) is somewhat below the earlier 79 percent estimate (the earlier study covered the period 1980–84 to 1995–99). For Belgium our figure of 57 percent falls between the structural components of 37–54 percent and 66 percent from the analyses of Neels and De Wachter (2010) and Neels (2009), respectively, employing somewhat different indicators and approaches. Overall, however, while precise estimates, methods, and, in some respects, data, differ, our findings corroborate those of these earlier studies—that increasing educational participation is the primary factor underlying delayed childbearing from 1970 to 1998/2000, accounting for at least half of the fertility postponement over those decades. The observed change in educational participation, combined

with fixed first birth rates at equivalent stages of the educational trajectory, explains over half of the postponement observed.

We extended our earlier investigations by separating the structural effect into two subcomponents—time spent in education and duration since leaving education—and quantifying their contribution, and also by applying the decomposition to changes in rates at single years of age. Educational expansion has had an effect on first birth rates not only via the additional time spent in full-time education, but also by delaying the transition to adult statuses and in the process altering the distribution of the duration since leaving education at each age. Finally, we have shown that compositional change due to rising education has contributed not only to fertility postponement but also to fertility recuperation at older ages.

Causation

To what extent do the structural effects of rising educational participation reflect a causal influence on the aggregate postponement of fertility? And, if a causal process is involved, through what mechanisms does it operate? Several kinds of evidence are available on the causal link between education and fertility timing, including both experimental randomized controlled trials (Mason-Jones et al. 2016) and observation-based studies. Using longitudinal data, a number of studies have shown that the link between education and later childbearing remains when controlling for family environment and parental characteristics (Marini 1978, 1985; Rindfuss et al. 1988; Thornton et al. 1995). More explicit evidence of causation is given by several demographic and econometric analyses of natural experiments, designed to remove the potential endogeneity of education in relation to fertility. These studies cover a range of countries and exploit a variety of conditions—administrative rules regarding school entry, changes in the length of compulsory schooling, change in the duration of vocational education, and the timing of college entry. These studies are near unanimous in reporting that additional schooling or a later age at completing education has a causal effect either in delaying the first birth or, equivalently, in lowering the probability of a teenage birth (Skirbekk et al. 2004; Black et al. 2008; Monstad et al. 2008; Geruso et al. 2011; Silles 2011; Cygan-Rehm and Maeder 2013; Gronqvist and Hall 2013; Humlum et al. 2014; Wilson 2017).[9] The estimated causal effects reported in these studies are sizable. Skirbekk et al. (2004), using a natural experiment framework for Sweden (discussed further below), found that an 11-month earlier age at leaving education gave rise to an average 4.9-month earlier age at first birth. A range of econometric studies found that an additional year of schooling reduced the likelihood of a teenage birth by between 3.7 and 8.8 percentage points in the United States and Norway (Black et al. 2008; Monstad et al. 2008), by 5.7 percentage points in Germany (Cygan-Rehm and Maeder

2013), and by between 4 and 6.1 percentage points in the UK (Silles 2011). A recent Cochrane review of randomized controlled trials of school-based interventions related to sex education found that intervention to retain young people in secondary school reduced adolescent pregnancy, providing strong evidence for a causal relationship (Mason-Jones et al. 2016).

Another approach to investigating causality in the relationship between education and age at first birth is through family-based designs, especially twin studies. These examine the extent to which unobserved family-level factors, environmental and/or genetic, influence both education and fertility, without a direct link between the two, and whether there is a direct link from education to age at first birth, independent of such unmeasured factors. A number of twin and family studies have examined the relationship between education and fertility. Several of these report that the link between education and fertility timing is either wholly or largely attributable to family background or genetic influences (Neiss et al. 2002; Rodgers et al. 2008; Tropf and Mandemakers 2017). However, these three studies have weaknesses in both methodology and data. Neiss et al. (2002) use the National Longitudinal Study of Youth to analyze sibling rather than twin pairs; in addition, the study infers sibling relationships retrospectively from reports of household membership, includes pairs of siblings thus identified regardless of sex, and finds no difference between the age at first birth of brothers and sisters. The quality of data in this study appears insufficient to bear the weight of the conclusions drawn. The type of twin-based analysis used by Rodgers et al. (2008) cannot identify a direct effect from education to fertility and so cannot illuminate the issue of causation between education and fertility timing. Finally, Tropf and Mandemakers (2017) do not correct for measurement error, which can account for a sizable fraction of the within-pair variance in twin studies; their estimate of the effect of education on age at first birth is therefore likely to be biased toward zero (Kohler et al. 2011: 102–104; Amin and Behrman 2014: Section 4.3).[10] In contrast, and consistent with the evidence from natural experiments, two recent twin studies—Nisen et al. (2013) and Amin and Behrman (2014)—find a direct causal link from education to later childbearing among female co-twins, net of family and genetic effects. Using a sample of 628 identical twin pairs from the Minnesota Twin Registry born 1936–55, Amin and Behrman (2014) found a substantial causal effect, with one year of additional education leading to fertility postponement of around one year, a fixed-effects estimate that was no different from the OLS model.

Some evidence of reverse causation or a feedback effect from fertility to education has been reported. Cohen et al. (2011) and Gerster et al. (2014) focus on completed fertility rather than on fertility timing. Furthermore, their results relate to Nordic populations in which educational careers can be much more extended than in our countries. The age distribution of full-time students in tertiary education extends to much later

ages in Nordic countries than in the UK, France, and Belgium; the 85th percentile age of full-time students in tertiary education in Nordic countries was between 29.0 and 33.8 in 2006 compared with a range of 23.2–26.4 in the UK, France, and Belgium; medians are 22.9–24.9 compared with 19.9–20.7 (Eurydice/Eurostat 2009: Figure C17).

In all, a range of investigations, while not unanimous, provide strong evidence of a sizable causal effect of education on fertility timing. Further, the effect sizes estimated in these studies are large and consistent in magnitude with the substantial aggregate effect we report in the present study.

Mechanisms

We suggest that education affects first birth rates at each age in three ways: (1) the direct impact of factors that inhibit fertility during full-time educational enrollment; (2) the displacement to later ages of the timetable of transition to adulthood; and (3) effects of educational participation on factors such as earning power, labor force participation of women in particular, attitudes, values and preferences, social learning, and on knowledge of and access to contraception, beyond the role such factors may have in the first two pathways. Our estimates are confined to the first two of these mechanisms, with the first accounting for between 27 and 39 percent of the postponement of first birth between 1970 and 1998/2000 in the three countries considered, and the second accounting for 26 to 47 percent of the rise in the mean age at first birth. But educational expansion may clearly also have effects on birth timing via processes of the third kind mentioned above. Our estimates suggest that these other paths through which rising education may have independently influenced birth timing account for, at most, between 26 and 43 percent of the change in age at first birth over the period (i.e. the complement of the overall structural effect). However, it could reach those levels only if educational expansion were responsible for 100 percent of the upward shift in mean ages at first birth.

A first route through which education affects birth timing is via time spent in full-time education. We noted earlier that micro-level analyses using time-varying covariates have consistently found that first birth rates are substantially lower during periods of enrollment. Economists use the term "incarceration effect" to describe this (see e.g. Black et al. 2008; Monstad et al. 2008), but the term seems inaccurate. Young people are no more incarcerated as full-time students than they are as full-time employees. Instead, the enrollment effect is likely to operate through a mix of social and interpersonal processes including social and economic dependency, expectations that the student role is a transitional pre-adult status, societal and peer-group expectations regarding the normal sequencing of adult transitions, and the age stratification and time-criticality of educational

participation (Marini 1985; Hogan and Astone 1986; Liefbroer and Billari 2010). The limited resources of young people in education may also have an effect, as suggested by Spéder and Bartus (2017). That educational participation inhibits not only birth rates but also conception rates is suggested by Geruso et al. (2011), who find that the raising of the school-leaving age in the UK in 1974 caused a decline in teenage birth rates but did not result in increased abortion rates at the ages affected.

The second causal pathway is through the impact of age at leaving full-time education on the scheduling of adult transitions (see especially Oppenheimer 1994; Oppenheimer et al. 1997; Robert-Bobée and Mazuy 2005; Bergouignan 2006). On leaving education, young people begin the process of finding employment, becoming financially independent, accumulating experience, skills, and earning power, forming their own households, finding a partner, and eventually starting a family. The later the age at leaving education, the later this series of transitions begins; and the shorter the time out of education, the less advanced individuals are in these transitions, including the transition to parenthood. Figure 2 showed that first birth rates are strongly associated with duration since leaving education, rising initially and then falling back. We show elsewhere (Beaujouan et al. 2014b) that this duration outperforms age as a predictor of first birth rates and makes a significant improvement to statistical models including age terms only.

The findings of Skirbekk et al. (2004) reveal the impact of duration since leaving education on first birth timing. They exploited a natural experiment created by Sweden's primary school enrollment laws. These mean that, on average, people with December birthdates are 11 months younger at completing their education, whether compulsory or post-compulsory, than those born a month later in January. As noted above, they are also an average of 4.9 months younger on becoming a parent than those born the following month.[11] Skirbekk et al. suggest that the mechanism is what they term "social age," defined as the average age of a person's school cohort. However, their results suggest that the link between school-leaving age and first birth timing is better explained via duration since leaving education than by social age. They find that those born late in the year give birth to their first child at a younger age than those born early in the year. This can be explained via the duration effect as follows. All members of a calendar-year cohort enter school and reach school-leaving age at the same time. Because of this, at any given duration since leaving, those born in December will be younger than those born in January of the same calendar year. As a result, they are subject to any given duration-specific first birth rates at a younger age than those born early in the year; this overrides the difference in age and results in a younger age at first birth for those born late rather than early in the year. A similar explanation, via duration effects rather than social age, can account for the detailed pattern of differentials by

birth month in age-specific birth rates at younger and at older ages reported in that study (Skirbekk et al. 2004: 557).

Concluding comments

While our analysis has been confined to three European countries, there are ample reasons for thinking that a broadly similar picture holds in other developed societies. We saw in Figure 1 that the trend to later first birth was common to a wide range of European and other developed countries. A steady and continuing increase in educational participation has also been taking place throughout the developed world. In view both of the sizable causal effects of education on fertility timing reported above, and of the range of countries in which such effects have been found, it would be surprising if our findings did not hold much more widely. Large datasets that combine precise, long-run information at the individual level on both the ages at participation in and leaving education and the age at first birth are, however, scarce, and so confirmation of generalization to other contexts is not yet possible.

A final question is what accounts for the rise in educational participation. Change in statutory compulsory schooling has played some role. Since the 1960s most European countries have enacted legislation to increase the number of years of compulsory schooling (Garrouste 2010: Figure 3.1; Murtin and Viarengo 2011). During the decades covered by this study, European governments have continued to extend the compulsory requirement for education and training (Eurydice/Eurostat 2012). In Belgium, the minimum age at school leaving was extended from 14 to 18 years in 1983, a reform which, however, followed a gradual development already taking place. Minimum school-leaving age was extended from 14 to 16 years in France in 1967 and from 15 to 16 years in the UK in 1973; compulsory participation to the age of 18 was introduced in the UK in 2013. The actual change in enrollment over the period covered in this article is larger than the change induced by compulsory schooling legislation. There is evidence that compulsory schooling laws have the effect of increasing participation even beyond the statutory provisions (Oreopolous 2009). Education expansion over the period analyzed here has occurred in the context of concerted government effort to broaden access and increase participation (Green 1999; Smith and Bocock 1999; Hansen and Vignoles 2005). Policy initiatives, in addition, appear to have had some success (Machin and Vignoles 2006; Braga et al. 2013). Policy is driven, in turn, by changes in the labor market, with the decline in unskilled jobs and the increasing demand for an educated and skilled work force. Thus, rising education is propelled in part by macro-economic forces that not only influence governments to act but also motivate individual decisions to participate. We conclude that both macro-economic factors and policy interventions that have promoted

the substantial rises in educational enrollment are major contributors to the fertility postponement seen across this period.

Notes

1 Educational attainment and highest level of qualifications can, of course, be analyzed as time-varying covariates where detailed data are available, but before the development of event history methods they were generally treated as fixed covariates.

2 The reason for the absence of a structural effect in Rindfuss et al. (1996) is unclear. Given the well-documented rise in educational attainment in the US over the period covered, and the data presented on differential timing of fertility, a sizable compositional component to changing tempo would be expected.

3 Further details of the GHS as a source on fertility are given in Ní Bhrolcháin et al. (2011) and Ní Bhrolcháin and Beaujouan (2012).

4 GHS weights were normalized by survey round, and UKHLS were normalized. For details of the weights used for the GHS data series, see Beaujouan et al. (2011). Weights for the French Family History Survey (FHS) were provided by INSEE. The Belgian census data did not require weighting.

5 Appendix is available at the supporting information tab at wileyonlinelibrary.com/journal/pdr.

6 Childbearing while in education is rare and its inclusion or exclusion makes little difference to the mean age. We estimate that the proportion of young women giving birth while in education was 1 percent in the UK, 2 percent in France, and 3 percent in Belgium.

7 This is equivalent to standardizing for enrollment and age at leaving education, as rates are specific by age.

8 The absence of an enrollment effect from the mid-20s is not only because continuous enrollment is rare at those ages but also because, in editing the data, the variable "age at first leaving continuous full-time education" was truncated at 26 years (see Methods section).

9 An exception to this general finding is the study of McCrary and Royer (2011). They use school entry regulations, meaning that children with a specific birthdate will have on average a year's more schooling than those with an adjacent birthdate, and find no causal effect on fertility timing. However, the additional year's education occurs in kindergarten, when children are very young. Furthermore, the groups contrasted do not necessarily complete their education at different ages, unlike e.g. in the Skirbekk et al. (2004) study, nor do they necessarily spend different amounts of time in education when in their teens, as occurs when compulsory schooling is extended. The finding's relevance to the link between education and fertility timing therefore seems limited.

10 There are further difficulties with the representativeness of the Tropf and Mandemakers results based on a sample of British twins born 1919–69 (TwinsUK). Their study estimated a coefficient of 0.44 for a linear regression of age at first birth on age at leaving education. Our analysis of British data based on the same cohorts of all women using the general population UK data employed in the present study, rather than just twins (and

including only cases where a birth was reported at least one year after leaving full-time education so as to exclude cases where the young woman left education owing to pregnancy), found a coefficient of 0.72 in an OLS model, two-thirds higher than the TwinsUK value. The reason for this discrepancy is unclear. The mean age at first birth in the TwinsUK sample is reportedly a year and a half older than in the general population (Tropf and Mandemakers: 81–82). The TwinsUK sample is self-selected and the analysis is restricted to cases where both twins have given birth. The sample may be unrepresentative not only of the general population but also of the twin population. Calculations based on assuming that results hold for the general population may be misleading. Finally, the ages at leaving full-time education in the TwinsUK sample extend to age 30 (Tropf and Mandemakers, Table 1). The measure is therefore unlikely to capture the age at first leaving full-time education. Late ages

at completing education more than likely reflect the resumption of education following a break. The education indicator and associated analysis are therefore potentially problematic, both in introducing non-negligible measurement error and in being subject to potential reverse causation, from birth timing to education.

11 Note that in the Swedish system a systematic difference in age at completing education occurs at the end of compulsory education without an additional year's schooling between those with adjacent birth months. Unlike most of the econometric studies on this subject, the Skirbekk et al. results do not relate to additional years of education, nor are they confined to compulsory schooling. They refer rather to exogenously determined differences in the age at leaving education, and show that these result in systematic differences in the timing of fertility, regardless of the educational level attained.

References

Amin, Vikesh and Jere R. Behrman. 2014. "Do more-schooled women have fewer children and delay childbearing? Evidence from a sample of US twins," *Journal of Population Economics* 27(1): 1–31.

Barbi, Elisabetta, John Bongaarts, and James W. Vaupel (eds.). 2008. *How Long Do We Live?* Berlin: Springer.

Beaujouan, Éva, Ann Berrington, Mark J. Lyons-Amos, and Máire Ní Bhrolcháin. 2014a. "User guide to the Centre for Population Change GHS database 1979–2009," Working Paper 47, University of Southampton, ESRC Centre for Population Change.

Beaujouan, Éva, James J., Brown and Máire Ní Bhrolcháin. 2011. "Reweighting the General Household Survey, 1979–2007," *Population Trends* 145: 119–145.

Beaujouan, Éva, Mike Murphy, Karel Neels, and Máire Ní Bhrolcháin. 2014b. "Alternatives to age in analysing early adult transitions," paper presented at British Society for Population Studies Annual Conference, Winchester, UK, 9 September. http://www.eurrep.org/wp-content/uploads/Beaujouan-Murphy-Neels-Ni-Bhrolchain_alternatives_to_age_online_BSPS_2014.pdf.

Bergouignan, Christophe. 2006. "Âge à la fin des études, destin social et arrivée du premier enfant," *Population et travail* (Actes du colloque de Aveiro, 2006) 11: 183–203.

Billari, Francesco C., Hans-Peter Kohler, Gunnar Andersson, and Hans Lundström. 2007. "Approaching the limit: Long-term trends in late and very late fertility," *Population and Development Review* 33(1): 149–170.

Billari, Francesco C., Aart C. Liefbroer, and Dimiter Philipov. 2006. "The postponement of childbearing in Europe: Driving forces and implications," *Vienna Yearbook of Population Research* 4: 1–17.

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2008. "Staying in the classroom and out of the maternity ward? The effect of compulsory schooling laws on teenage births," *Economic Journal* 118(530): 1025–1054.

Blossfeld, Hans-Peter and Johannes 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.

Blossfeld, Hans-Peter and Ursula Jaenichen. 1992. "Educational expansion and changes in women's entry into marriage and motherhood in the Federal Republic of Germany," *Journal of Marriage and the Family* 54(2): 302–315.

Bongaarts, John and Griffith Feeney. 1998. "On the quantum and tempo of fertility," *Population and Development Review* 24(2): 271–291.

Braga, Michela, Daniele Checchi, and Elena Meschi. 2013. "Educational policies in a long-run perspective," *Economic Policy* (73): 47–100.

Cassan, Francine, Francois Héran, and Laurent Toulemon. 2000. "Study of family history: France's 1999 family survey," *Courrier des statistiques, English series* 6. http://www-ehf.ined.fr/english/english/C_stat_en.pdf.

Cohen, Joel E., Øystein Kravdal, and Nico Keilman. 2011. "Childbearing impeded education more than education impeded childbearing among Norwegian women," *Proceedings of the National Academy of Sciences of the United States of America* 108(29): 11830–11835.

Cygan-Rehm, Kamila and Miriam Maeder. 2013. "The effect of education on fertility: Evidence from a compulsory schooling reform," *Labour Economics* 25: 35–48.

d'Addio, Anna Cristina and Marco Mira d'Ercole. 2005. "Trends and determinants of fertility rates in OECD countries: The role of policies," *OECD Social, Employment and Migration Working Papers*. Paris: OECD.

Deboosere, Patrick and Didier Willaert. 2004. "Codeboek algemene socio-economische enquête 2001," Working Paper 2004-1, Vrije Universiteit Brussel, Interface Demography.

Eurydice/Eurostat. 2009. *Key Data on Education in Europe 2009*. Brussels: EACEA/Eurydice.

———. 2012. *Key Data on Education in Europe*. Brussels: EACEA/Eurydice.

Frejka, Tomas, Gavin W. Jones, and Jean-Paul Sardon. 2010. "East Asian childbearing patterns and policy developments," *Population and Development Review* 36(3): 579–606.

Garrouste, Christelle. 2010. "100 years of educational reforms in Europe: A contextual database." European Commission Joint Research Centre, JRC 57357.

Gerster, Mette, Mette Ejrnæs, and Niels Keiding. 2014. "The causal effect of educational attainment on completed fertility for a cohort of Danish women—does feedback play a role?," *Statistics in Biosciences* 6(2): 204–222.

Geruso, Michael, Damon Clark, and Heather Royer. 2011. "*The impact of education on fertility: Quasi-experimental evidence from the UK*," Princeton University, mimeo.

Green, Andy. 1999. "Education and globalization in Europe and East Asia: Convergent and divergent trends," *Journal of Education Policy* 14(1): 55–71.

Gronqvist, Hans and Caroline Hall. 2013. "Education policy and early fertility: Lessons from an expansion of upper secondary schooling," *Economics of Education Review* 37: 13–33.

Gustafsson, Siv, Eiko Kenjoh, and Cecile Wetzels. 2002. "The role of education on postponement of maternity in Britain, Germany, the Netherlands and Sweden," in E. Ruspini and A. Dale (eds.), *The Gender Dimension of Social Change: The Contribution of Dynamic Research to the Study of Women's Life Courses*. Bristol: Policy Press, pp. 55–79

Hansen, Kirstine and Anna Vignoles. 2005. "The United Kingdom education system in comparative context," in S. Machin and A. Vignoles (eds.), *What's the Good of Education? The Economics of Education in the United Kingdom*. Princeton University Press.

Hoem, Jan M. and Michaela Kreyenfeld. 2006. "Anticipatory analysis and its alternatives in life-course research. Part 1: The role of education in the study of first childbearing," *Demographic Research* 15: 461–484.

Hogan, Dennis P. 1978. "The effects of demographic factors, family background, and early job achievement on age at marriage," *Demography* 15(2): 161–175.

Hogan, Dennis P. and Nan Marie Astone. 1986. "The transition to adulthood," *Annual Review of Sociology* 12: 109–130.

Humlum, Maria K., Jannie H.G. Kristoffersen, and Rune Vejlin. 2014. "Timing of college enrolment and family formation decisions," IZA DP No. 7905. Bonn: Institute for the Study of Labour.

Jasilioniene, A., D.A. Jdanov, T. Sobotka, E.M. Andreev, K. Zeman, and V.M. Shkolnikov. 2015. Methods Protocol for the Human Fertility Database. http://www.human fertility.org/Docs/methods.pdf.

Knies, Gundi. 2015. "Understanding Society. The UK Household Longitudinal Study. Waves 1–5. User manual." Colchester: University of Essex, Institute for Social and Economic Research.

Kohler, Hans-Peter, Jere R. Behrman, and Jason Schnittker. 2011. "Social science methods for twins data: Integrating causality, endowments, and heritability," *Biodemography and Social Biology* 57(1): 88–141.

Kravdal, Øystein. 1994. "The importance of economic activity, economic potential and economic resources for the timing of first births in Norway," *Population Studies* 48(2): 249–267.

———. 2004. "An illustration of the problems caused by incomplete education histories in fertility analyses," *Demographic Research*, Special Collection 3(6): 135–154.

Kravdal, Øystein and Ronald R. Rindfuss. 2008. "Changing relationships between education and fertility: A study of women and men born 1940 to 1964," *American Sociological Review* 73(5): 854–873.

Lappegård, Trude and Marit Rønsen. 2005. "The multifaceted impact of education on entry into motherhood," *European Journal of Population* 21(1): 31–49.

Lesthaeghe, Ron. 2001. "Postponement and recuperation: Recent fertility trends and forecasts in six Western European countries," *Interuniversity Papers in Demography*. Bruxelles: Interface Demography.

Liefbroer, A.C. and F.C. Billari. 2010. "Bringing norms back in: A theoretical and empirical discussion of their importance for understanding demographic behaviour," *Population Space and Place* 16(4): 287–305.

Liefbroer, Aart C. and Martine 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(1): 45–75.

Machin, Stephen and Anna Vignoles. 2006. "Education policy in the UK," *CEEDP 57*. London: London School of Economics Centre for the Economics of Education.

Marini, Margaret Mooney. 1978. "Transition to adulthood—sex-differences in educational attainment and age at marriage," *American Sociological Review* 43(4): 483–507.

———. 1985. "Determinants of the timing of adult role entry," *Social Science Research* 14(4): 309–350.

Martin, Steven P. 2000. "Diverging fertility among U.S. women who delay childbearing past age 30," *Demography* 37(4): 523–533.

Mason-Jones, A.J., D. Sinclair, C. Mathews, A. Kagee, A. Hillman, and C. Lombard. 2016. "School-based interventions for preventing HIV, sexually transmitted infections, and pregnancy in adolescents (review)," *Cochrane Database of Systematic Reviews* 2016, Issue 11. http://onlinelibrary.wiley.com/doi/10.1002/14651858.CD006417.pub3/abstract

Mazuy, Magali and Laurent Toulemon. 2001. "Étude de l'histoire famille: Premiers résultats de l'enquête en ménages," *Dossiers et Récherches*. Paris: INED.

McCrary, Justin and Heather Royer. 2011. "The effect of female education on fertility and infant health: Evidence from school entry policies using exact date of birth," *American Economic Review* 101(1): 158–195.

Menken, Jane. 1985. "Age and fertility: How late can you wait?," *Demography* 22(4): 469–483.

Mills, Melinda, Ronald R. Rindfuss, Peter McDonald, Egbert te Velde, on behalf of ESHRE Reproduction and Society Task Force. 2011. "Why do people postpone parenthood? Reasons and social policy incentives," *Human Reproduction Update* 17(6): 848–860.

Monstad, Karin, Carol Propper, and Kjell G. Salvanes.. 2008. "Education and fertility: Evidence from a natural experiment," *Scandinavian Journal of Economics* 110(4): 827–852.

Murphy, Michael, Pekka Martikainen, and Sophie Pennec. 2006. "Demographic change and the supply of potential family supporters in Britain, Finland and France in the period 1911–2050," *European Journal of Population* 22(3): 219–240.

Murtin, F. and M. Viarengo. 2011. "The expansion and convergence of compulsory schooling in Western Europe, 1950–2000," *Economica* 78: 501–522.

Neels, Karel. 2009. "Postponement and recuperation of cohort fertility," XXVI IUSSP International Population Conference, Marrakech.

Neels, Karel and David De Wachter. 2010. "Postponement and recuperation of Belgian fertility: How are they related to rising female educational attainment?," *Vienna Yearbook of Population Research* 8: 77–106.

Neels, Karel and S. Gadeyne. 2010. "Het effect van opleidingsniveau op tempo en kwantum van rangspecifieke vruchtbaarheid in België: 1960–2000," in K. Matthijs, B. Van de Putte, J. Kok, and H. Bras (eds.), *Leven in de lage landen: Historisch-demografisch onderzoek in vlaanderen en Nederland*. Leuven/Den Haag: ACCO, pp. 211–238.

Neiss, Michelle, David C. Rowe, and Joseph L. Rodgers. 2002. "Does education mediate the relationship between IQ and age of first birth? A behavioural genetic analysis," *Journal of Biosocial Science* 34(2): 259–275.

Ní Bhrolcháin, Máire. 2011. "Tempo and the TFR," *Demography* 48(3): 841–861.

Ní Bhrolcháin, Máire and Éva Beaujouan. 2012. "Fertility postponement is largely due to rising educational enrolment," *Population Studies* 66(3): 311–327.

Ní Bhrolcháin, Máire, Éva Beaujouan, and Mike Murphy. 2011. "Sources of error in reported childlessness in a continuous British household survey," *Population Studies* 65: 305–318.

Nisen, Jessica, Pekka Martikainen, Jaakko Kaprio, and Karri Silventoinen. 2013. "Educational differences in completed fertility: A behavioral genetic study of Finnish male and female twins," *Demography* 50(4): 1399–1420.

OECD. 2014. *Education at a Glance 2014: OECD Indicators*. OECD Publishing.

———. 2016a. "Indicator C1 Who participates in education?," in OECD (ed.), *Education at a Glance 2016: OECD Indicators*. http://www.keepeek.com/Digital-Asset-Management/oecd/education/education-at-a-glance-2016/indicator-c1-who-participates-in-education_eag-2016-23-en#page1.

———. 2016b. *SF2.3 Age of mothers* at childbirth and age-specific fertility. Paris: OECD https://www.oecd.org/els/soc/SF_2_3_Age_mothers_childbirth.pdf

Oppenheimer, Valerie Kincade. 1994. "Women's rising employment and the future of the family in industrial societies," *Population and Development Review* 20(2): 293–342.

Oppenheimer, Valerie Kincade, Matthijs Kalmijn, and Nelson Lim. 1997. "Men's career development and marriage timing during a period of rising inequality," *Demography* 34(3): 311–330.

Oreopoulos, Philip. 2009. "Would more compulsory schooling help disadvantaged youth? Evidence from recent changes to school-leaving laws" in J. Gruber (ed.) *The Problems of Disadvantaged Youth: An Economic Perspective*. University of Chicago Press: 85–112.

Rendall, Michael, Christine Couet, Trude Lappegård, Isabelle Robert-Bobée, Marit Rønsen, and Steve Smallwood. 2005. "First births by age and education in Britain, France and Norway," *Population Trends* 121: 27–34.

Rindfuss, Ronald R., S. Philip Morgan, and Kate Offutt. 1996. "Education and the changing age pattern of American fertility: 1963–1989," *Demography* 33(3): 277–290.

Rindfuss, Ronald R., S. Philip Morgan, and Gray Swicegood. 1988. *First Births in America*. University of California Press.

Robert-Bobée, Isabelle and Magali Mazuy. 2005. "Calendriers de constitution des familles et âge de fin des études," in C. Lefèvre and A. Filhon (eds.), *Histoires de Familles, Histoires Familiales*. Paris: Les Cahiers de l'Ined, pp. 175–200.

Rodgers, Joseph Lee et al. 2008. "Education and cognitive ability as direct, mediating, or spurious influences on female age at first birth: Behavior genetic models fit to Danish twin data," *American Journal of Sociology* 114(S1): S202–S232.

Rosero-Bixby, Luis, Teresa Castro-Martín, and Teresa Martín-García. 2009. "Is Latin America starting to retreat from early and universal childbearing?," in S. Cavenaghi (ed.), *Demographic Transformations and Inequalities in Latin America: Historical Trends and Recent Patterns*. Rio de Janiero: ALAP, pp. 219–241.

Santow, Gigi and Michael Bracher. 2001. "Deferment of the first birth and fluctuating fertility in Sweden," *European Journal of Population* 17: 343–363.

Schmidt, L., T. Sobotka, J. G. Bentzen, A. Nyboe Andersen, on behalf of ESHRE Reproduction and Society Task Force. 2012. "Demographic and medical consequences of the postponement of parenthood," *Human Reproduction Update* 18(1): 29–43.

Schoen, Robert. 2004. "Timing effects and the interpretation of period fertility," *Demography* 41(4): 801–819.

Silles, Mary A. 2011. "The effect of schooling on teenage childbearing: Evidence using changes in compulsory education laws," *Journal of Population Economics* 24(2): 761–777.

Skirbekk, Vegard, Hans-Peter Kohler, and Alexia Prskawetz. 2004. "Birth month, school graduation, and the timing of births and marriages," *Demography* 41(3): 547–568.

Smith, David and Jean Bocock. 1999. "Participation and progression in mass higher education: Policy and the FHE interface," *Journal of Education Policy* 14(3): 283–299.

Spéder, Zoltan and Tamás Bartus. 2017. "Educational enrolment, double-status positions and the transition to motherhood in Hungary," *European Journal of Population* 33(1): 55–85.

te Velde, Egbert, Dik Habbema, Henri Leridon, and Marinus Eijkemans. 2007. "The effect of postponement of first motherhood on permanent involuntary childlessness and total fertility rate in six European countries since the 1970s," *Human Reproduction* 27(4): 1179–1183.

Thornton, Arland, William G. Axinn, and Jay D. Teachman. 1995. "The influence of school enrollment and accumulation on cohabitation and marriage in early adulthood," *American Sociological Review* 60(5): 762–774.

Tropf, Felix C. and J.J. Mandemakers. 2017. "Is the association between education and fertility postponement causal? The role of family background factors," *Demography* 54(1): 71–91.

Winkler-Dworak, Maria and Laurent Toulemon. 2007. "Gender differences in the transition to adulthood in France: Is there convergence over the recent period?," *European Journal of Population* 23(3-4): 273–314.

Wilson, Tanya. 2017. "Compulsory education and teenage motherhood." University of Stirling Economics Discussion Paper 2017-SEDP-2017-01. Online at http://www.stir.ac.uk/management/research/economics/working-papers/

Wood, Simon. 2006. *Generalized Additive Models: An Introduction with R*. Chapman and Hall/CRC Press.