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Online Appendix

The Importance of Rising Educational Attainment for Cohort Fertility *Postponement* and *Recuperation*

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1 Issues, data and methods

Rising educational attainment, especially among women, has repeatedly been identified as the main factor driving the *postponement transition* (*Mills et al.* 2011; *Neels* 2010; *Gustafsson/Kalwij* 2006; *Lappegård/Rønsen* 2005; *Sobotka* 2004; *Rindfuss et al*. 1996; *Blossfeld/Huinink* 1991). Studies which focus on the period perspective commonly take the educational level into account as one of the covariates studied. Purely cohort-based studies are less frequent. Furthermore, they also often leave the influence of educational attainment unaddressed. One difficulty facing researchers who wish to address the impact of education on cohort fertility level and timing is data availability. In purely period-based studies, survey data provide useful input, even for women of younger childbearing ages. In cohort studies wishing to document complete or almost complete reproductive trajectories, there is a need to gather high-quality data on retrospective fertility, partnership, education and employment histories among the women in later reproductive years and those who are just past their reproductive period. Another potential complication is the possibility of reverse causation. This means that fertility early in life influences educational outcomes later in life, rather than the other way round as is usually assumed. Several recent studies have argued that this fertility –> education causation may be more important than the influence of educational qualifications on fertility (*Cohen et al.* 2011; *Gerster et al.* 2009).

Cohort-based studies focusing on the importance of education for fertility can be roughly divided into three categories. The first includes descriptive studies documenting trends and differentials in cohort fertility and parity distribution by level of education. *Andersson et al's* (2009) study of the Nordic countries is a very fine

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example of this approach. The second category consists of hazard models showing the importance of educational attainment for differentiating fertility trajectories, net of the impact of other important covariates. Such studies usually cover several cohorts, but they may also focus on a single unique cohort, such as in the case of studying rapid transformations in fertility among the 1971 cohort, whose behaviour was strongly affected by the unification of Germany in 1990 (*Huinink/Kreyenfeld* 2004). The third category enquires as to the influence that has been exerted by a change in the educational composition of the population on the trends observed in fertility level and quantum. This is the issue we aim to address in this supplementary appendix. As in the main body of the text, we divide the cohort reproductive trajectories into two distinct layers – one of declining fertility at lower ages (termed as *postponement*), and the other of a compensatory rise of fertility at higher reproductive ages (*recuperation*).

To illustrate the role of rising educational attainment, we use survey data as well as census data from Belgium to estimate stratified hazard models of first birth *postponement* and *recuperation*. The shift of childbearing into higher ages necessitates the inclusion of an age*cohort interaction in longitudinal hazard models spanning over many birth cohorts. We resolve this issue by stratifying the hazard models by age group so that the remaining age*cohort interaction within age groups is absorbed by the linking function performed by the model. The stratification by age also allows a more straightforward identification of factors that contribute to the *postponement* or *recuperation* of fertility. As an illustration, we estimate the effect of increasing educational attainment on the postponement of first births in selected European countries using data from round 3 of the *European Social Survey* (ESS), conducted in 2006. Similar to the relational model proposed by *Lesthaeghe* (2001), we analyse first birth hazards between ages 15 and 27 for women born between 1950 and 1979 relative to those of the 1946-1950 cohort that is used as a benchmark. The estimated hazard models are discrete time models using a logit link, allowing an interpretation of cohort differentials in terms of odds ratios relative to the benchmark cohort.

We also illustrate the impact of rising educational attainment on first birth *recuperation*, using as an example the 2001 census data for Belgium. The ESS data used for the analysis of educational influences on the postponement of first births could not be used for this purpose, as the sample of childless women aged 30+ was too small to derive stable, significant results. In analogy to the two models of fertility *postponement*, we also specify two hazard models for *recuperation*. Each model includes a quadratic effect of age, centered at the interval midpoint. These results, displayed in the first model, are referred to as *gross* cohort differentials. In the second model referred to as *net* cohort differentials, the stratified discrete-time model is extended to include the effect of education and an age*education interaction. Cohort differentials in this model account for the increase of educational attainment over subsequent birth cohorts.

2 Modelling first birth *postponement*

We examine the effect of rising educational attainment on first birth *postponement* in nine countries (regions) of Europe: Austria, Belgium, Eastern Germany, Western Germany, Hungary, Spain, the Netherlands, Sweden and Switzerland. All countries analysed in the main text, except for the Czech Republic and the United States, are included in this analysis.

Two models are estimated for each country: i) a model estimating *gross cohort differentials* relative to the benchmark cohort and ii) a model that reflects *net cohort differentials* that control for rising educational attainment over subsequent birth cohorts, as well as the interaction between education and the age-specific first birth hazard schedules (*Neels* 2009). The 1945-1949 birth cohorts are used as the benchmark for all countries.[1] The cohort differentials for each country are expressed as odds ratios relative to the benchmark. Therefore, the levels of odds ratios cannot be readily compared across countries, given that both their absolute levels, and the baseline hazard of the benchmark cohort, vary considerably from one country to another. Despite the relatively small sample sizes, validation indicates that the data provide reliable estimates of completed fertility.

Table A1 summarises the main results by country. For Belgium, the estimates of the impact of increasing educational attainment on first birth hazards are in line with results obtained by direct standardization of order-specific fertility schedules using census data (*Neels/De Wachter* 2010). Applying this model to other European countries shows that increasing educational attainment has had a strong effect on reducing first birth hazards among women aged 15-27 in Belgium, Western Germany, the Netherlands, Spain and Sweden. In these countries, first birth hazards at lower ages in the 1975-79 birth cohort fell to 14-48 % of the level of the benchmark cohort 1945-49, deep below the level implied by the hypothetical scenario of no change in educational attainment. For instance, in Sweden – the country where the impact of changing education on first birth rates was greatest –, women born in 1975-79 had a relative first birth hazard of 0.41 at ages below 28 when compared with the reference cohort of 1945-49. However, had educational attainment remained stable, first birth hazards in Sweden would remain considerably higher at younger ages, falling “only” to 0.77 relative to the benchmark cohort fertility. Surprisingly, in two former state-socialist regions, Eastern Germany and Hungary, changing education did not have much of an impact on the relative first birth hazards among the youngest cohorts analysed. In Hungary, this result may be explained in part by a peculiar progression of fertility postponement, with a slow onset in the 1950s cohorts, a reversal in the early 1960s cohorts and a vigorous “restart” of the postponement process among women born after 1965.

1 In contrast to the other parts of our study, we use an identical benchmark cohort for all the countries analysed. Model estimations and their comparisons across countries thus become more straightforward.

Tab. A1: Odds ratios of first birth between ages 15-27 in subsequent 5-year birth cohorts relative to benchmark cohort (ref.); gross differentials and differentials controlling for education in selected European countries. Birth cohorts 1945-1979

Country	Ratio of first birth hazard in subsequent 5-year cohorts relative to benchmark cohort:						
	C1945-49	C1950-54	C1955-59	C1960-64	C1965-69	C1970-74	C1975-79
Austria							
Gross cohort differentials[1]	ref.	.88ns	.62*	.73ns	.88ns	.49**	.41***
- Controlling for education[2]	ref.	.87ns	.65*	.80ns	.94ns	.56**	.49**
- % change in differential[3]	ref.	+ 0.7	- 4.9	- 8.8	- 6.1	- 11.5	- 15.5
Belgium							
Gross cohort differentials[1]	ref.	.75ns	.49**	.64*	.49**	.39***	.28***
- Controlling for education[2]	ref.	.92ns	.61*	.94ns	.75ns	.61*	.47*
- % change in differential[3]	ref.	-18.6	-19.8	-31.9	-35.3	- 36.1	- 39.5
Eastern Germany							
Gross cohort differentials[1]	ref.	.85ns	1.18ns	.75ns	.71ns	.31*	.24**
- Controlling for education[2]	ref.	.79ns	1.21ns	.75ns	.69ns	.29*	.23**
- % change in differential[3]	ref.	+8.3	+2.5	+0.1	+3.3	+5.8	+2.5
Western Germany							
Gross cohort differentials[1]	ref.	.90ns	.78ns	.53**	.48***	.43***	.30***
- Controlling for education[2]	ref.	1.15ns	.99ns	.69ns	.65*	.63ns	.41**
- % change in differential[3]	ref.	-	-21.3	-23.4	-25.7	-31.9	-28.2
Hungary							
Gross cohort differentials[1]	ref.	.76ns	.75ns	.78ns	1.14ns	.68ns	.69*
- Controlling for education[2]	ref.	.82ns	.85ns	.88ns	1.46ns	.76ns	.67ns
- % change in differential[3]	ref.	-6.5	-12.1	-10.5	+28.1	-11.6	+3.7
Netherlands							
Gross cohort differentials[1]	ref.	1.13ns	.92ns	.63*	.53**	.40***	.49**
- Controlling for education[2]	ref.	1.41ns	.96ns	.76ns	.75ns	.49**	.70ns
- % change in differential[3]	ref.	+24.8	-4.3	-16.8	- 29.4	- 16.7	- 30.6
Spain							
Gross cohort differentials[1]	ref.	.94ns	.60*	.65*	.30***	.22***	.15***
- Controlling for education[2]	ref.	1.25ns	.88ns	.90ns	.39**	.36***	.26***
- % change in differential[3]	ref.	-	-32.3	-27.5	-23.7	-40.7	-43.4
Sweden							
Gross cohort differentials[1]	ref.	.93ns	.65*	.50**	.54**	.38***	.41***
- Controlling for education[2]	ref.	.85ns	.77ns	.64ns	.72ns	.46**	.77ns
- % change in differential[3]	ref.	+9.0	-16.3	-22.2	-24.6	-16.8	- 46.6
Switzerland							
Gross cohort differentials[1]	ref.	.77ns	.75ns	.63*	.64*	.39**	.68ns
- Controlling for education[2]	ref.	.85ns	.79ns	.63ns	.70ns	.45**	.78ns
- % change in differential[3]	ref.	-9.5	-4.4	+1.0	-8.7	-13.7	-12.7

Notes: [1] Gross cohort differentials are drawn from discrete-time hazard models, including the linear (AGE_LIN) and quadratic (AGE_QUA) effects of age, as well as a cohort effect (COHORT). Given the limited age range, the inclusion of AGE_LIN*COHORT and AGE_QUA*COHORT interactions did not improve model fit in the countries considered. All models use a logit link. [2] Net cohort differentials are drawn from discrete-time hazard models, including the effect of education (EDUCATION), as well as the interaction between education and age (i.e. EDUCATION*AGE_LIN and EDUCATION*AGE_QUA. [3] Odds ratios (exp(β)) representing a negative effect are bound between values 0 and 1. The proportional reduction in the odds ratio was calculated as: $(1-((1/\exp(\beta_N)/(1/\exp(\beta_G)))*100$, where $\exp(\beta_G)$ represents the gross cohort differential and exp(βN) represents the net cohort differential controlling for education.

First birth hazards would fall substantially in all the countries considered here, even in the absence of changes in educational attainment. This would occur to a relatively moderate degree in the Netherlands, Sweden and Switzerland, and would be particularly marked in Eastern Germany and in Spain (by about three-quarters when compared with the benchmark cohort). Significant inter-cohort shifts and reversals in the development of first birth hazards persist in a number of countries, including Austria, Belgium, Germany (both regions) and Spain, after adjusting for educational attainment. This finding calls for alternative and complementary explanations of fertility postponement. This irregular pattern of *postponement* over subsequent birth cohorts – e.g., the 1955-1959 cohort in Belgium – suggests that period factors may greatly influence the progression of the postponement transition. It would therefore be worth elaborating the model to include period variation in contextual factors, such as the effects of business cycle and labour market trends (*Sobotka et al.* 2011; *Neels* 2010).

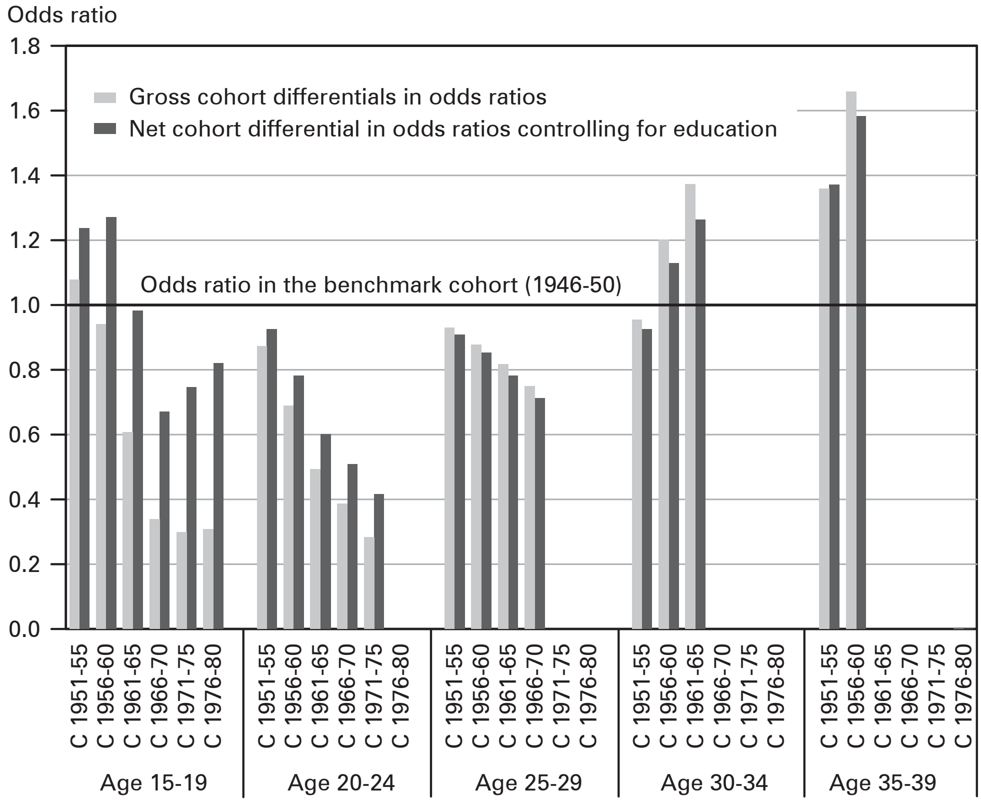
3 Analysing first birth recuperation in Belgium

To analyse the other side of the coin – the educational influences on the *recuperation* process we turn to a 1 % sample of the 2001 census data for Belgium. Such an analysis cannot be performed with the multi-country survey data used above, as the latter do not include a sufficiently large sample of childless women aged over 30. Besides providing a picture for one country only, the dataset for Belgium has another disadvantage: The data show only the early stage of the recuperation process up until 2001, when only women born before 1960 had reached the age of 40 and could be analysed through virtually the entire *recuperation* stage.

Figure A1 displays the results of two stratified models fit to the first birth hazards of Belgian women born between 1946 and 1980. The first model compares first birth hazards (odds ratios) at ages 15-39 among the cohorts born between 1951 and 1980 to first birth hazards of women born between 1946 and 1950 (benchmark cohort).[2] The second model (*net cohort differentials*) accounts for the effect of rising educational attainment over subsequent birth cohorts, and shows the hypothetical trend in first birth rates in the absence of changes in educational attainment. The results with respect to first birth *postponement* align well with the cross-country comparison carried out above. First birth hazards declined strongly at ages 15-24, and a large share of this decline, especially among teenage women, was driven by the rising educational attainment. The decline was more gradual at age 25-29, when the rise in the level of education actually slowed down the fall in first birth hazards. The *recuperation* becomes apparent after age 30, and even more so at ages 35-39, when first birth hazards increased by 35 and 65 % for women born between 1951-55

2 The analysis distinguishes between five educational levels: i) none and primary education, ii) lower secondary, iii) higher secondary, iv) short type tertiary education and v) long type tertiary education.

Fig. A1: Gross and net cohort differentials in first birth hazards (odds ratios) in the 1951-1980 birth cohorts relative to the cohort of 1946-1950. Belgian women, analysis stratified by 5-year age and cohort groups



Notes: *Gross cohort differentials:* Results of discrete time event history models estimated separately by 5-year age groups with cohort effect; controlling for linear and quadratic effects of age (centred at interval midpoint)

Net cohort differentials: Results of discrete time event history models estimated separately by 5-year age-groups; cohort effect controlling for linear and quadratic effects of age, education and an age*education interaction.

and 1956-60, respectively. The effect of increasing education was however rather limited in these cohorts, and much of the upward trend observed in the hazard rate would have occurred in the absence of changes in the educational composition of the female population as well. The rise in first birth hazards observed after age 30 was not sufficient to fully compensate for reductions in birth hazards at younger ages. The recuperation index (RI_c) at age 34 in the models considered nevertheless amounts to 0.66 and 0.69 for the 1956-1960 and 1961-1965 birth cohorts, respectively. Thus, the fertility *recuperation* was "incomplete" in the case of first births, implying an increase in the proportion of childless women.

Overall, these results show that other factors than rising educational attainment were often also of key importance in stimulating the fertility *postponement and recuperation* (*Lesthaeghe/Surkyn* 1988), and that the *postponement transition* has frequently proceeded unevenly, affected by economic and other influences, presumably operating as period effects (*Ní Bhrolcháin* 1992).

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