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Research Article

Education and second birth rates in Denmark 1981-1994

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Abstract

A high educational attainment is shown to have a positive effect on second birth rates for Danish one-child mothers during the period 1981-94. We examine whether a timesqueeze is a possible explanation: due to the longer enrolment in the educational system, highly educated women have less time at their disposal in order to get the desired number of children. Also, we examine to what extent the partnerŠs education can explain some of the positive effect. We find no evidence that the positive effect of education is due to a time-squeeze nor to a partner effect.

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1. Introduction

A large interest has been shown in the effect of education as well as other socio-economic factors on fertility in recent years. A number of studies have looked into the effect of education on entry into motherhood, some have focused on the effect of education on the completed fertility while others have studied the connection between education and parity-specific (higher-order) birth rates.

The aim of this study is to assess the association between women's educational level and their second birth rates in Denmark for the period 1981-1994. However, we start by briefly summarizing some findings on the effect of education on entry into motherhood and on completed fertility.

1.1 Education and fertility in general

A number of studies have shown that being in education has a delaying effect of entry into motherhood. Blossfeld and Huinink (1991) showed this for the case of the Federal Republic of Germany (FRG) and Liefbroer and Corijn (1999) showed that for Dutch and Flemish women, entry into parenthood was delayed among the better educated, presumably due to the longer enrolment in the educational system. Finally, in a study of the effect of education on timing of first birth in Norway, Lappegård and Rønsen (2005) also showed a negative effect of being enrolled in education on first birth rates, but that after having completed their training, the higher educated have higher rate of first birth than others. The latter was also found to be the case in the study by Blossfeld and Huinink (1991) (but not in the study by Liefbroer and Corijn (1999)). Lappegård and Rønsen (2005) referred to this phenomenon as a *catching-up-effect*.

It has also been shown that in the former German Democratic Republic (Kreyenfeld, 2006) as well as the former Czechoslovakia (Kantorová, 2006) there were almost no educational differences in the timing of first birth whereas during the 1990's these differences were increasing. Both authors argued that this is due to the family friendly politics of these countries.

In the above mentioned study by Lappegård and Rønsen (2005) they distinguished not only between the mere educational level of the women but also between the educational field thereby obtaining a very detailed description of the woman's education. They showed that even *within* the same level of education there were large differences in entry into motherhood according to field of education.

The effect of educational field as opposed to the mere level was also in focus in the two papers by Hoem et al. (2006) but here the fertility outcome was measured at the end of the fertile age range: in the first of the two papers the focus was on the effect of educational field on childlessness, in the second the focus was on ultimate fertility as measured by the cohort's Completed Fertility Rates (CFR); both used the Swedish cohorts of women born 1955-59. They argued that when modeling the effect of education on (completed) fertility it is important to take into account the educational attainment as measured not only by the level but also by the field, since there are substantial differences between women's ultimate fertility even within groups with the same educational level.

1.2 The effect of education on higher order birth rates

Several studies have been performed to assess the effect of education on both second and third birth rates for Scandinavia as well as for other countries in Western Europe. In a study on the effect of educational attainment on first, second and third births in Norway, Kravdal (2001) found significantly higher second and third birth rates for women with the highest educational level than for women with fewer years of education, net of age. For the case of Sweden, Oláh (2003) also found a positive effect of education on second birth rates, net of age, employment status and several other variables. She compared these results with results from Hungary (before as well as after transition) where no positive effect of education was found. Furthermore, in their study on third birth rates in Austria, Hoem et al. (2001) found a positive effect on education. Finally, Köppen (2006) and Kreyenfeld and Zabel (2005) showed higher second birth rates for highly educated women in West Germany comparing with France and Great Britain, respectively.

To our knowledge, no previous study has looked into the effect of education on second birth rates using Danish data. However, on the basis of the above mentioned results from Norway and Sweden, we expect to find a positive effect of education on second birth rates. This is because the Scandinavian countries share the same welfare-state system including family-friendly settings which facilitate that a dual-breadwinner family can have children.

1.3 The Danish Setting

For the period in question, 1981-1994, the Danish TFR reached its lowest in 1983 (1.38). It was 1.81 in 1994 which was the highest for this period (Statistics Denmark, 2002). Second-birth fertility has increased steadily from 1983 and throughout the rest of the study period (Strandberg-Larsen et al. (2007)). The Danish female labour force participation was among the highest in the world, in 1980 it was 65 per cent and in 1994 71 per cent (ages 16-66), cf. Knudsen (2002). The mean age at first birth grew from 24.8 in 1981 to 27.3 years in 1994.

From 1981 the maternity leave comprised 4 weeks prior to expected time of delivery and 14 weeks after delivery. From 1984 the 14 weeks were extended to 20 weeks which were later extended to 24 weeks. Also, some weeks could be taken by the father (Knudsen, 2002).

The day-care facilities in Denmark are well-established and for the period in question (1981-1994) the coverage was around 50 per cent for children below 3 years of age (day nurseries), 75 per cent for children in the age group 3-5 years (kindergarten) and for children aged 6-9 it was around 40 per cent (Knudsen, 2002). Hence, the Danish system should allow for a relatively high compatibility between female labour force participation and having children.

1.4 Research question

Based on the findings for the other Scandinavian countries, we expect to find a positive effect of education on second-birth rates. In order to look in more detail into a possible reason for this we will elaborate on a hypothesis suggested by Kreyenfeld (2002), who in her study of second birth rates in West Germany found a positive effect of education. As a possible explanation for this she suggested a so-called *time-squeeze hypothesis*: that women with a higher education postpone their first birth because of the longer enrolment in the educational system. Due to biological limitations they have less time at their disposal to get the second child and they therefore squeeze the births more closely together. We look into this hypothesis by asking the question *"Is there more to time-squeeze than age?"*.

That first and second births are indeed *squeezed* more together for older than for younger one-child mothers was shown by Strandberg-Larsen et al. (2007), who in their recent study of second-birth rates in Denmark for the period 1980-1994 addressed the question *Does the spacing between the first and second child depend on age at initiating childbearing?* Using basically the same study population as ours, they showed that women who are e.g. 40 years old had the highest rates of giving birth to the second child 2-3 years ago while for women who are eg. 25 years old the highest rate was 3-4 years after first birth. They pointed out that their findings “support the supposition that women who postpone childbearing have a speedy catch-up to reach the desired number of children”. Hence, a *squeezing pattern* concerning age has already been shown. As a first step it is therefore of interest to see whether this pattern is maintained when education is taken into account.

On the other hand, it might also be relevant to see if women with different educational attainments have the highest second birth rates at different durations (net of age at first birth), in particular whether the highly educated have the highest second birth rates at shorter durations than women with lower level education.

In fact, if there actually is *more to time-squeeze than age*, we would expect that the possibly higher second birth rates shortly after first birth for the “late starters” would be particularly pronounced for highly educated women. We therefore bring together the two viewpoints mentioned above, thereby allowing the combined effect of age at first birth and duration to vary according to different educational levels.

Finally, we also look into the effect of the partner's education on second birth rates. In a study on the effect of education on completed fertility in Norway, Naz et al. (2006) argued that *assortative mating in marriage markets* might explain some of the positive effect of women's education on fertility: in their study they found that the effect of female education disappeared when the partner's education was included in the model. They suggested that the explanation for this is that "Norwegian female's education does not affect fertility directly, but only through assortative mating". This refers to the fact that partners to a large extent have the same educational level or at least levels that are close to each other, which is also the case for our study population. Kreyenfeld (2002), in her paper on the effect of education on second birth rates, refers to this phenomenon as *educational homogamy*. For West Germany, Kreyenfeld (2002) found that the positive effect of women's education disappeared when the partner's education was taken into account, and she ascribed this to the West German Society being a "male breadwinner regime". However, we do not expect to find this effect as pronounced for the case of Denmark as it was shown for West Germany due to the high labour market participation of women with children.

1.5 Selection mechanisms

Several attempts have been made in order to deal with selection issues that might arise in studies of the effect of education on higher order birth rates.

focused on the conceptual content in controlling for age at previous birth, arguing that the social meaning might be enhanced by replacing the age at birth of the previous child by the relative age at birth of the previous child relative to the mean or median age at birth of the previous child within the relevant educational group. This approach puts priority to comparing the woman under study to her peers within the same educational group, but sacrifices comparison with women of the same current biological age in other educational groups.

Furthermore, Hoem's approach has not been fully developed for the situation (such as ours) where the age-dependency of educational status is directly implemented in the analysis. For these reasons we have refrained from implementing Hoem's approach in the present paper.

Both Kravdal (2001) and Kreyenfeld (2002) suggested a *selection hypothesis* as a possible explanation for the higher second birth rates for the highly educated. We will discuss this hypothesis later in the paper, however, we will not look more detailed into it in this study.

The paper is structured as follows: In Section 2. we describe the data used for our analyses, the register from which they originate, the independent variables that are included, and the statistical methods used. In Section 3. we describe the results of our analyses and in Section 3 we conclude on these findings.

2. Data and methods

2.1 The study population

The data used in this study are based on the Fertility of Women and Couples Dataset (FWCD). The FWCD originates primarily from the Fertility Database in Statistics Denmark (Knudsen, 1998). It includes annual information for the period of 1980-1994 on socio-demographic characteristics of all women in the fertile age (13-49 years) and on their co-resident male partners. It also contains information on any births of the women, stillbirths as well as live-births. Timing and number of births are identified from the Register of Population Statistics and from the Medical Register of Birth and Death Statistics. The information in these registers is of high quality (Eurostat / Statistics Denmark (1995), Knudsen and Murphy (1999)).

The population used for this study comprises all women of Danish origin who became one-child mothers in the period 1981-1994. Only live-born children are considered and women who gave birth to twins or triplets in their first birth are excluded, since we expect that these women have a second-birth pattern which substantially differs from that of one-child mothers. Unfortunately, also women who had twins or triplets in their second birth are excluded from the study population. Each woman entered the study population the year after which she had her first delivery. The women where chosen on the basis of their parity in the beginning of each year. Therefore, women who had their second child in the same calendar year as their first child do not enter the study population.

Due to low numbers of one-child mothers giving birth to their second child before the age of 17 years or after the age of 40 years, the study population was restricted to women who where $17 - 40$ at the time of first delivery. The final study population comprised information on 329440 one-child mothers who had 208390 second-child births occurring during the study period. The follow-up was until the end of 1994 or until the women turned 45, whichever occurred first.

2.2 Independent variables

For each one-child mother we had information on her age in completed years at the day of her first delivery and her age in completed years by the end of each calendar year. Also, information on the woman's educational attainment and whether she was registered as being in education by the end of the year was available. Finally, we had information on her partnership status (whether she was cohabiting or not and whether she was married or not) and the same educational information for the partner as we had for the woman was available. This was combined into the following independent variables, which will be described in more detail below: *duration since first delivery*, *educational attainment and in or out of education*, *age at first delivery*, *partnership status*, *calendar period* and finally *educational attainment and in or out of education of the partner (if any)*.

The dependent variable corresponded to the information that for each year, it was known whether the woman delivered her second child during that year or not.

2.2.1 Duration since first birth

The estimation of duration since first birth was for each calendar year calculated as the difference between the age last birthday of the one-child mothers at the end of the year and the age last birthday of the women at the time of their first birth. See the Appendix for details on these calculations.

2.2.2 Educational variables

The information on education is based on the following information from The Educational Classification Module of Statistics Denmark (Statistics Denmark, 1998): *education in progress*, *most recently completed level of general education* and *highest level of further education completed*. The latter includes any kind of further education, for example vocational training (skilled workers, education within trades, etc.) and also longer courses of further education eg. university degrees. There is one record of each of these three variables for each year. On this basis we construct an educational variable which is described in Table 1. Educational information is compiled each October on the basis of data from the educational institutions. The data from October in a given year enters the FWCD in the following year and so forth. Eg. if a woman is registered as enrolled in university as of October 1984 she will appear in the data with this record for the year 1985. However, among the 329440 women in the study population 36815 ($\approx 11\%$) change level of the educational variable at least once within the period 1981-1994. Most of these women change status only once during this period.

Table 1: Description of the way the educational information from FWCD is compressed into one variable

Educational variable	Description
In education	Any kind of education in progress
High further education	Long courses of further education, eg. university graduates
Short/medium further education	Short/medium length courses of further education, eg. nurses/school teachers
Vocational training	Eg. Skilled workers / shop assistants
No/low degree	$\leq$ 12 years of schooling / no detailed information

Table 2: The distribution the woman's educational attainment at the end of the year of first delivery

Education	Frequency	Percent
High further	9202	2.8
Short/medium further	57641	17.5
Vocational	104458	31.7
No/low degree	138898	42.2
In education	19241	5.8

The distribution of the woman's educational attainment by the end of the year of her first delivery is described in Table 2. Please note, that as the definition of the highest education is relatively narrow (it comprises primarily women who are university graduates) there are quite few women in this category. Also, the group "in education" comprises women in *any* kind of education. We expect that being in education has a strong impact on fertility by itself; however to keep things simple, there is no distinction between the educational attainments of the women within that group.

2.2.3 Age at first birth

We include age at first birth as an independent variable in our models, since this is an important determinant when modeling higher order birth rates and furthermore, it might be an important confounder for the effect of education (as already mentioned). Due to the low number of women who have their first child when in age group 36-40 and in education and also due to the low number of highly educated women who are younger than 23 when they have their first child we make coarser age groups when including interaction terms in our models, see below.

That is, when we fit models with only main effect the age groups are $17-23$, $24-27$, $28-31$, $32-35$ and $36-40$ whereas when we fit models with an interaction term between age, education and duration since first birth the age groups are $17-27$, $28-31$ and $32-40$.

A description of the distribution of age at first birth for the women in the study population is shown in Table 3.

Table 3: The distribution of age at first birth for the women in the study population

Age (first birth)	Frequency	Percent
$17-19$	19052	5.8
$20-23$	94100	28.6
$24-27$	126778	38.5
$28-31$	64336	19.5
$32-35$	19440	5.9
$36-40$	5734	1.7

2.2.4 Partnership status

The cohabitational status of the women has the following categories: 'married', 'not partnered' (which means that the woman has no co-resident male partner), 'cohabiting with a common child', 'cohabiting without a common child'. We distinguish between couples who are cohabiting and have a common child and couples who are cohabiting without having a common child, ie. the present partner is not the biological father of the first child. We do not have any further information about the women who are registered as 'not partnered', ie. we do not know whether they might be widowed or divorced. Table 4 shows the distribution of the women's cohabitational status in the year of the first delivery.

Table 4: The distribution of cohabitational status of women in the study population by the end of the year of their first delivery

Type of cohabitation	Frequency	Percent
not partnered	32932	10.0
cohab. w. common child	128303	39.0
cohab. wo. common child	20255	6.2
married	147950	44.9

2.2.5 Other independent variables

Finally, we include also the calendar period (in two-year intervals) and the educational level of the partner for those women who have a partner. This variable is defined in the same way for the partner as for the woman. The educational level for the woman is highly correlated with the educational level of her partner.

Eg. among the 296508 living with a partner in the year of first delivery $\approx 44\%$ are living with a partner of the same educational level. Table 5 shows the distribution of the education of the partner (among those women who have a partner) regardless of the woman's education; Table 6 shows the distribution of the partner's education according to the woman's education.

Table 5: Distribution of the educational level among partners regardless of the mother's educational level by the end of the year of the women's first delivery

Partner's education	Frequency	Percent
high further	18174	6.1
short/medium further	35428	12.0
vocational training	130544	44.0
no/low degree	90873	30.7

Table 6: Distribution of the educational level among partners in the year of the women's first delivery according to the education of the woman

Partner's education Mother's education	high further	short/med further	vocational training	no/low degree	under education	Total
high further	4442	1261	835	743	1224	8505
(per cent)	52.1	14.9	9.8	8.8	14.4	100
short/medium further	6991	15304	16989	9231	5765	54280
(per cent)	12.9	28.2	31.3	17.0	10.6	100
vocational	2050	9242	55656	27339	4141	98428
(per cent)	2.1	9.4	56.5	27.8	4.2	100
no/low degree	2155	7234	52964	50512	5830	118695
(per cent)	1.8	6.1	44.6	42.6	4.9	100
under edu.	2556	2387	4100	3048	4529	16620
(per cent)	15.4	14.4	24.7	18.3	27.3	100

2.3 Statistical methods

We assume that the hazard of giving birth to the second child for the ith woman is

$$\lambda_i(t) = \exp[\alpha_0(t) + \beta' \mathbf{x}_i(t)] \tag{1}$$

where the duration, t, is time since first delivery and the baseline log-hazard, $\alpha_0(t)$, is assumed piecewise constant within 1-year intervals (until 5 years of duration after which it is assumed constant for all higher duration values) and the time-dependent covariates, $\mathbf{x}_i(t)$, are assumed piecewise constant within one-year intervals.

Due to the discrete nature of the data, we model the conditional probability[5], P_{it}, of delivering the second child in the tth year after the first birth given that it has not already been born. This can be expressed in terms of the continuous time hazard via the *complementary* log-log-*function*:

$$\log\left[-\log(1-P_{it})\right] = \log\lambda_i(t) = \alpha_0(t) + \beta'\mathbf{x}_i(t), \tag{2}$$

(Allison (1982)). This means that the β-parameters should be interpreted as rate ratios, i.e. it is the rate according to which a woman with a given value of a covariate gives birth to her second child compared to a woman in the reference group for this covariate. The data are tabulated according to each combination of calendar year and other covariates, $k = 1, \ldots, K$, and the observed probability of giving birth to the second child is for each of these combinations given as follows:

$$P_k = \frac{x_k}{n_k}$$

where x_k is the number of second-child births and n_k is the number of one-child mothers at risk of delivering their second child in the kth cell of the table. The model was fitted using the **SAS** procedure "PROC GENMOD" with binomial distribution and the complementary log-log link function, cf. (2) (SAS Institute Inc., 1999).

As pointed out by Thygesen et al. (2005) when fitting models to data of a very large size which is the case here, almost any effect will be statistically significant. This, however, does not necessarily mean that the effect is substantively important. We here refrain from performing formal hypothesis tests but do quote the ratio deviance/degrees of freedom. If this number is close to 1 for the model, the fit is assumed to be satisfactory.

3. Analyses

First, we fit a number of models corresponding to (2) where t is duration since first birth. We successively include the covariates described in the previous section as main effects. Next, we look more into the time-squeeze hypothesis described in Section 1. by extending the model with relevant interaction terms. Finally, we discuss the effect of the partner's education in some detail. Below is a description of the main effects models and the conclusions drawn from those.

3.1 Main effects models

Table 7 shows the results from the models described below.

[5] This is sometimes also referred to as *the discrete time hazard rate*.

Model 1a includes *duration since first delivery*, *calendar period* and *age at first birth*. From this model we see a relatively strong positive effect of the mother's age at first delivery on the second birth rate. Women who are 17 to 23 years old when having their first child have a rate ratio of 1.24 compared to the reference group of women who are 28-31, whereas women who are 36-40 years old have a rate ratio of 0.36.

Model 1b extends **Model 1a** with *mother's education*. In this model there is a quite large effect of education, a woman with the highest education has a rate ratio of 1.41 compared to a woman in the reference group (vocational degree), net of age at first birth. Also for a woman with a short or medium further education there is a larger rate ratio of 1.29 compared to a woman in the reference group. The lowest rate is seen among women who are currently in education, for this group the rate ratio is 0.59 compared to women who have a vocational degree. The effect of age at first birth is positive as was also the case for Model 1a, but now the effect has become even stronger.

Table 7: Rate ratios from a stepwise modeling including main effects only (Model 1a-1d). †: Absolute risk per 1000 person-months, ie. this shows the absolute risk for a "reference woman", i.e. a woman who is in the reference group for all covariates

Independent Variable	**Model 1a**	**Model 1b**	**Model 1c**	**Model 1d**
Baseline duration†				
0-12 months	2.053	1.936	2.131	2.059
13-24 months	9.274	8.701	9.421	9.092
25-36 months	21.022	19.737	21.790	21.031
37-48 months	24.132	22.737	26.192	25.297
49- months	10.907	10.182	12.553	12.133
Calendar Period				
1981-82	0.627	0.624	0.589	0.589
1983-84	0.797	0.794	0.761	0.761
1985-86	0.950	0.947	0.929	0.928
1987-88	1	1	1	1
1989-90	1.034	1.037	1.066	1.067
1991-92	1.040	1.049	1.101	1.103
1993-94	1.042	1.055	1.130	1.133
Age at 1st birth				
17-23	1.244	1.467	1.700	1.748
24-27	1.255	1.339	1.360	1.380
28-31	1	1	1	1
32-35	0.623	0.611	0.613	0.609
36-40	0.361	0.350	0.356	0.354
Current education				
high further		1.410	1.467	1.288
short/medium further		1.286	1.341	1.276
vocational		1	1	1
no/low degree		0.873	0.967	0.971
in education		0.591	0.693	0.663
Partnership status				
cohab (no com. ch.)			0.783	0.785
cohab (com. ch.)			0.744	0.748
married			1	1
not partnered			0.240	0.246

Table 7: (continued)

Independent Variable	**Model 1a**	**Model 1b**	**Model 1c**	**Model 1d**
Partner's (if any) education				
high further				1.288
short/medium further				1.141
vocational				1
no/low degree				0.979
in education				1.056
Log-likelihood	−538434.3	−535180.6	−517617.1	−517177.4
Deviance/DF	52.9	12.6	5.3	2.2

Model 1c extends **Model 1b** with *mother's partnership status*. When this covariate is included the effect of education becomes somewhat stronger, the same applies for the effect of age at first birth. The rate of having a second child is the highest for women who are married compared to women who are cohabiting as well as to women who do not have a partner. Furthermore, there is no difference between the two groups of cohabiting women.

Model 1d extends **Model 1c** with *partner's educational attainment (if any)*. As expected the inclusion of the partner's education in the model removes some of the effect of the woman's own education. However, it is still present. We will return to this matter in Subsection 3.2.

The model fit is highly improved from Model 1a to Model 1d. Nevertheless, a ratio between deviance and degrees of freedom of 2.2 is not satisfactory from a conventional model fitting point of view.

3.2 The effect of the partner's education

In the following we will look more into the observation made in Subsection 3.1 concerning the effect of the partner's education and how introducing it into the model changes the effect of the woman's education (and vice versa).

3.2.1 Comparing marginal and conditional effects

Table 8 shows the effect of education for the mother and her partner both *marginally* and *conditionally*: the result in the uppermost left panel (A) is the effect of the woman's education when the partner's education is not included in the model (ie. the *marginal* *effect*), the result in the uppermost right panel (B) is the effect of the woman's education with the partner's education included in the model (ie. the *conditional effect*). Hence, these results correspond to the results from Model 1c and Model 1d, respectively, and are therefore the same as shown in Table 7. We include them again in order for the comparison to be more easy-to-read.

Table 8: Rate ratios from 3 different models: Panel A: The *marginal* effect of woman's education (Model 1c). Panel B: The *conditional* effect of woman's education (Model 1d). Panel C: The *marginal* effect of the partner's education (Model 1c'). Panel D: The *conditional* effect of the partner's education (Model 1d)

Educational level	**A: Woman, marginal**	**B: Woman, conditional**
high further	1.467	1.288
short/medium further	1.341	1.276
vocational	1	1
no/low degree	0.967	0.971
in education	0.693	0.663
Educational level	**C: Partner, marginal**	**D: Partner, conditional**
high further	1.385	1.288
short/medium further	1.206	1.141
vocational	1	1
no/low degree	0.975	0.979
in education	1.053	1.056

The rate ratio of having a second child for a woman with the highest educational level compared to a woman in the reference group changes from 1.467 marginally to 1.288 conditionally. The difference between a woman with a high further education and a woman with a short/medium further education vanishes when we condition on the partner's education. However, the effect of being in education does not become smaller when conditioning on the partner's education. In any case the rate ratio of having a second child is around 30% smaller for a woman in education than for a woman with a vocational degree.

The results in the two lowermost panels of Table 8 correspond to the *marginal effect* of the partner's education and *conditional effect* of the partner's education given the woman's education. That is, the latter corresponds to the result already shown under Model 1d in Table 7, whereas the former corresponds to a new model, Model 1c', in which all the same covariates as in Model 1c are included, except for the fact the instead of the woman's education we included the partner's education.

Now, if we compare the results in the two lowermost panels of Table 8 we see that also the effect of the partner's education becomes somewhat smaller when including the effect of the woman's education. But again, as for the women, the effect is still very much present.

3.2.2 Comparing the effects of the woman and her partner

If we make the comparison *vertically* in Table 8 we see that for the woman as well as for her partner there is a strong *marginal* effect of education on the second birth rate. Furthermore, we note that the marginal effect of the woman's education seems to be somewhat stronger than the marginal effect of her partner's education.

If we compare the conditional effect of the woman's education to that of her partner, we see that for the group with the highest education the rate ratio compared to the group with a vocational degree is excactly the same, namely 1.288. The rate ratio for a woman with a short/medium further education compared to a woman with a vocational degree is 1.276, whereas the corresponding number for men is somewhat smaller, namely 1.141. However, the only group where there is really noticeable difference between the conditional effect of the woman's education and that of her partner is for the group in education. Being in education lowers the rate with which she has her second child with approximately 34% for a woman (given her partner's education), whereas having a partner who is in education does not lower the rate, in fact, the rate ratio is 1.056 compared to the woman having a partner who has a vocational degree. Since it might have more far-reaching consequences for a woman to have a child while she herself is in education than it has to have child while her partner is in education, this is indeed not surprising.

3.2.3 Assortative mating?

Due to the collinearity of the education variables between the woman and her partner it is of course to be expected that the marginal effects are somewhat larger than the conditional effects as was already described above. On the other hand, even conditional on the partner's education there is still a strong effect of the woman's education - and *vice versa*.

Hence, as expected the idea of *assortative mating* or *educational homogamy* as described by Naz et al. (2006)[6] and Kreyenfeld (2002), respectively, does not seem to be relevant in this case, since both the woman's education as well as the partner's education has its own right as a predictor for the second birth rate.

[6] The model used by Naz et al. (2006) has completed fertility as outcome and is quite different from ours. This might explain why the conclusion regarding assortative mating differ between these studies of two countries, Denmark and Norway, that are often considered to be similar.

Table 9: Effect of education in Model 2a, ie. the model is controlled for an interaction between age at first birth and baseline duration, for calendar year, partnership status and partner's education

Education	RateRatio
high further	1.228
short/medium further	1.210
vocational degree	1
no/low degree	0.992
under edu.	0.676

3.3 The time-squeeze hypothesis

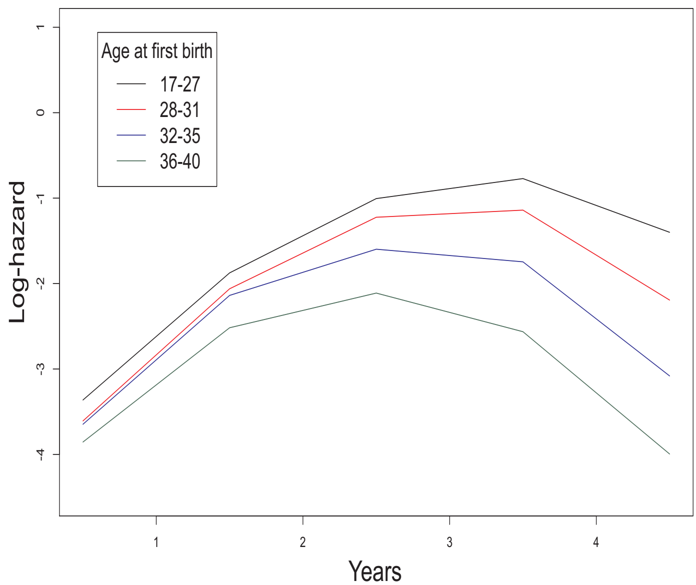
As mentioned in Section 1. the higher second order birth rates for highly educated women might be due to a so-called *time-squeeze effect* meaning that highly educated women should have higher order birth rates, especially shortly after the first birth due to postponed childbearing.

3.3.1 Two-way interaction models

In order to examine the time-squeeze hypothesis we use a duration perspective. We extend Model 1d with an interaction term between age at first birth and the duration since first birth; this model will be referred to as **Model 2a**. The interaction between duration and age at first birth from Model 2a is shown in Figure 1. It concerns a *general* time-squeeze pattern regardless of the level of education (which is included only as a main effect in the model): there seems to be some tendency towards women who are "late starters" squeezing their births closer together than "early starters": women in the youngest age group have the highest birth rates after 3-4 years whereas women in the oldest age group have the highest birth rates one year earlier. These findings are in line with the findings made by Strandberg-Larsen et al. (2007). However, this only seems to be a weak pattern, since the ordering of the birth rates is the same as in Model 1d (ie. the lines do not cross). If we look at the effect of education in Model 2a which is displayed in Table 9 we see that the effect of education is now somewhat smaller than in Model 1d, ie. some of the education effect from Model 1d is taken over by the effect of the interaction between age at first birth and duration since first birth.

Model 2a has a value of Deviance/DF of 1.8, which is better than the Deviance/DF of 2.2 for Model 1d.

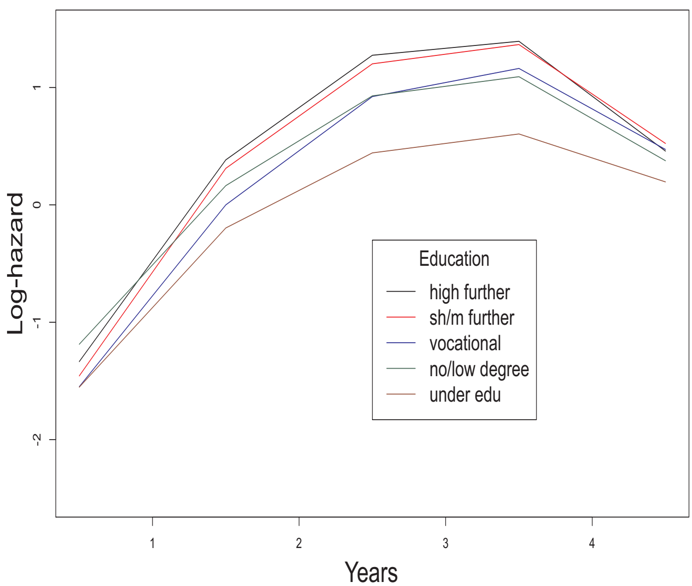
Figure 1: Log-hazards for different groups of age at first birth from Model 2a, which extends Model 1d by including a *two-way interaction between duration and age at first delivery*



However, the fit is still not satisfactory.

Another way of looking at the time-squeeze hypothesis by means of a two-way interaction model is by extending Model 1d with an interaction term between education and duration in order to see whether highly educated women have particularly high second birth rates at shorter durations. This model will be referred to as **Model 2b**. We fit this model in order to see if highly educated women have higher rates than others at earlier durations. The absolute log-rates are shown in Figure 2. There appears to be no pattern of highly educated women having particularly high second birth rates at early durations (net of age at first birth). Model 2b has a value of Deviance/Degrees of freedom of 2.1, which is only slightly better than for Model 1d and worse than for Model 2a.

Figure 2: Log-hazards for different education groups in Model 2b which extends Model 1d by including an interaction between duration and current education



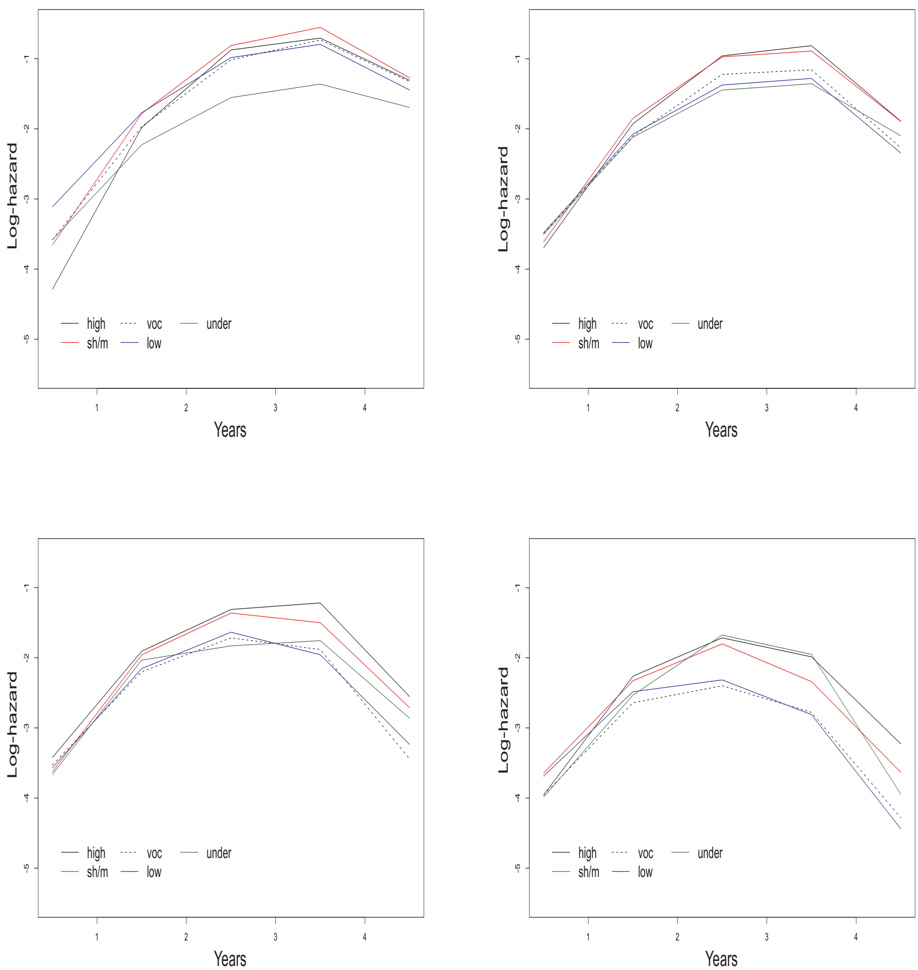
3.3.2 Three-way interaction model

We saw in Figure 1 a weak pattern of women having their first child at a relatively old age also having the highest second birth rate at shorter durations than younger women, but that the rates for the older women were never above those for younger women at any duration.

We now proceed to a three-way interaction model between *age at first birth*, *duration* and *education* in order to answer the question if there is *more to time-squeeze than age*. This interaction model, which we will refer to as **Model 3**, will show if the pattern shown in Figure 1 differs according to the woman's educational level.

The resulting second birth rates as a function of the duration are shown in Figure 3. Each panel corresponds to a separate age group. If a time-squeeze was in fact operating, then we would expect that particularly the women in the two highest education groups had higher second birth rates earlier if they were "late starters". The biological limit of course primarily applies to highly educated women who finish their education late. If we look at Figure 3 there appears to be no such further interaction, ie. there is no indication that particularly the highly educated who are older at the time of first birth have higher second birth rates shortly after the first birth. Hence, we find nothing more to the time-squeeze than age in this case. Model 3 has value of Deviance/DF of 1.7, so the model fit is not improved noticeably compared to Model 2a. We therefore conclude that there is no particular evidence of a *time-squeeze* as a possible explanation for the higher second birth rates for highly educated women for these data.

Figure 3: Log-hazards from Model 3 which includes a 3-way interaction term between education, duration and age at first birth: Each panel corresponds to a different age group defined according to age at first birth. Within each panel the lines correspond to different educational groups



4. Conclusion

In this paper we have modelled the effect of education on second birth rates. We found that women with a higher education had higher second birth rates than women with a vocational degree and women with no education. Furthermore, we found that women who were in education had a lower rate of having a second child.

We first looked into a hypothesis that the positive effect of the mother's high education could be due to the partner's high education. We showed that both the effect of the woman's education *per se* as well as the effect of her partner's education *per se* plays an important role as a determinant for the second birth rate.

We also looked into a *time-squeeze hypothesis* as a possible explanation. It suggested that the positive effect of education on second birth rates might be due to the postponement of first birth of highly educated women. However, we find no convincing pattern, showing that the effect of education should be entirely or mainly explained by this. There might be a weak pattern of women who for some reason get their first child relatively late to squeeze their births together, but this does not apply especially to women with a higher education. Therefore, as a topic for further research it will indeed be relevant to look into the hypothesis suggested by both Kravdal (2001) and Kreyenfeld (2002), that is the *selection hypothesis*. With models such as the ones used in this paper, when comparing highly educated women with women with less education, we are comparing women who have the same age at first birth. But, as discussed by Kravdal (2001), comparing two women with such different levels of education and same age at first birth, we might in fact be comparing women with completely different *preferences* or *family orientation*.

The *selection hypothesis* can be examined by means of a so-called *frailty model* (Vaupel et al., 1979), which incorporates an unobserved heterogeneity term (the *frailty*) for each woman, thereby representing her unobserved characteristics such as eg. her *family orientation*. However, applying frailty models to single spell data such as the data used in the present study might give rise to certain problems. In principle, for the case of a proportional hazards model as we have used here, it is possible to distinguish the time dependence and the frailty distribution under certain assumptions, cf. Elbers and Ridder (1982). Nevertheless, this hinges on the proportionality assumption, which is made in the conditional model *given the frailty* and it therefore also relies on the distributional assumption made on the frailty term. The distributional assumption concerning the frailty is in turn not verifiable because there only is one single spell for each woman. The use of frailty models is therefore far less controversial in the case of repeated events (Keiding, 1998). Hence, it is mainly relevant to use such models when modeling all or several parity transitions jointly.

As was mentioned in Section 1., several recent studies on the effect of education on second birth rates showed a positive effect of the educational attainment of the woman when including age (at first birth), educational level and possibly some other socio-economic variables and partner characteristics. However, only two of these explored the selection hypothesis. Furthermore, the papers by Kreyenfeld (2002) and Kravdal (2001) both showed, that the positive effect of education vanishes when the possibility of selection is taken into account. This, combined with the fact that countries with quite different institutional frameworks as the ones mentioned all have a positive effect of education suggests that a selection hypothesis might indeed be relevant. We will therefore look more into this hypothesis in a later paper.

Hence, the conclusion for now concerning the effect of the mother's education on second birth rates in Denmark 1981-94 must be that there is a positive effect which can neither be explained by *educational homogamy* nor by *time-squeeze*.

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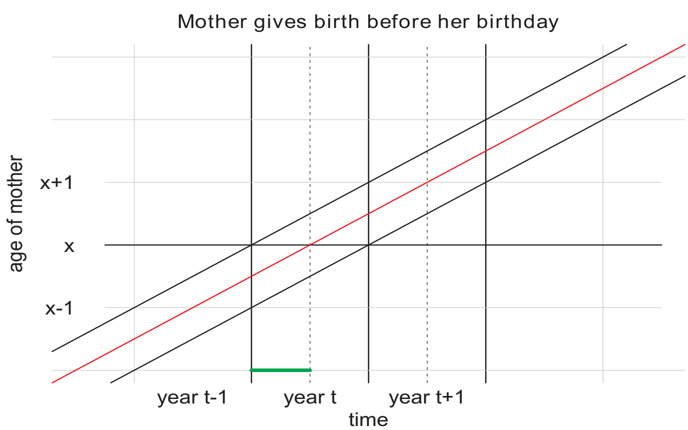
Appendix

In this appendix we describe the calculation of the age of the first child.

The information available for this calculation is the mother's age last birthday on the day she gives birth to her first child and for each calendar year in the subsequent years we know her age last birthday by the end of the year. Also, we know in which year she gives birth to her first child. No information on neither the mother's date of birth nor on the birth date of the first child is available.

Assume that the mother gives birth to her first child in year t in which she reaches the age x. In Figure 5. and Figure 5. the mother's lifeline is the red line shown in the Lexis diagram. Hence, in both cases we have assumed that the woman is born on July 1st. For each year $t + k$, $k = 1, 2, \ldots$ we want to estimate the age of the first child in that year. Now there are two cases:

Figure 1: Illustration of the possible birth dates for the child (green line) when the mother delivers *before* she celebrates her birthday in year t



1. **The woman's age last birthday on the day when she delivers her first child is** $x-1$. Hence, she delivers her child *before* she has celebrated her birthday that year. This situation is illustrated in **Figure 5.**. The possible birth dates for the child are represented by the green line on the time axis. The *earlier* the mother's birthday, the

fewer dates available for her to have her first child, *given* that her age last birthday is $x - 1$ when the child is born. The *later* the mother's birthday, the more dates available for her to give birth. Therefore, in this situation it is more likely that the woman has had her child early in the year than late in the year.
We therefore estimate the age of the first child in year $t + k$ to be

$$x + k - (x - 1) - 0.5 = k + 1 - 0.5,$$

where $x + k$ is the woman's age by the end of year k and $x - 1$ is her age last birthday when she delivers her child. Hence, in year $t + 1$ the age of the first child at July 1st is estimated as 1.5, which we group into the interval $[1, 2]$.

2. **The woman's age last birthday on the day when she delivers her first child is** x. Hence, she delivers her child *after* she has celebrated her birthday that year. This situation is illustrated in **Figure 5.**. The possible birth dates for the child are as before illustrated by the green line on the time axis. In this case, the *earlier* the mother's birthday the more dates available for her to have her first child. On the other hand, the *later* the mother's birthday the fewer dates available for her to have her child. Hence, in this case it is more likely that the woman has had her first child late in the year than early in the year.
We therefore estimate the age of the first child in year $t + k$ to be

$$x + k - x - 0.5 = k - 0.5,$$

where $x + k$ as before is the woman's age by the end of year $t + k$ and x is her age last birthday when she delivers her first child. Hence, in year $t + 1$ the age of the first child at July 1st is estimated as 0.5, which we group into the interval $[0, 1]$.

Figure 2: Illustration of the possible birth dates for the child (green line) when the mother delivers *after* she celebrates her birthday in year t