Age, period and cohort effects on first-child fertility in Danish men

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Abstract

Demographic studies of fertility are most often based solely on information about women, leaving out characteristics of the man. Thereby valuable information may be lost. The present note intends to explore the potential of the classical age-period-cohort model for describing male first-child fertility patterns. The model was fitted to fertility data on Danish men aged 15 to 49 years in the calendar period from 1960 to 1994.

We found the classical age-period-cohort model to be an appropriate model for describing male first-child fertility patterns in Denmark. Fluctuations in age-specific male first-child fertility rates over period were found, with a nadir in the mid 1980s. Furthermore, age-specific first-child fertility rates were found to be lower in men from younger birth cohorts than in men from older birth cohorts.

Introduction

Existing demographic studies of fertility are based predominantly on information about women, obtained through women. This has brought along a 'male invisibility' in the study of reproductive events. Since fertility behavior most often depends on a joint decision between a man and a woman, leaving out characteristics of the man may leave out valuable information when studying fertility. Recent publications, e.g. Knudsen (2003), Bledsoe et al. (1998) who include a chapter on male fertility trends (Coleman 1998) and Greene and Biddlecom (2000), have discussed the limitations following scarce or no information on the role of the male partner in the study of fertility. In the recently completed FFS-Studies (Festy and Prioux 2002) it was decided to give the survey a family rather than solely a fertility focus.

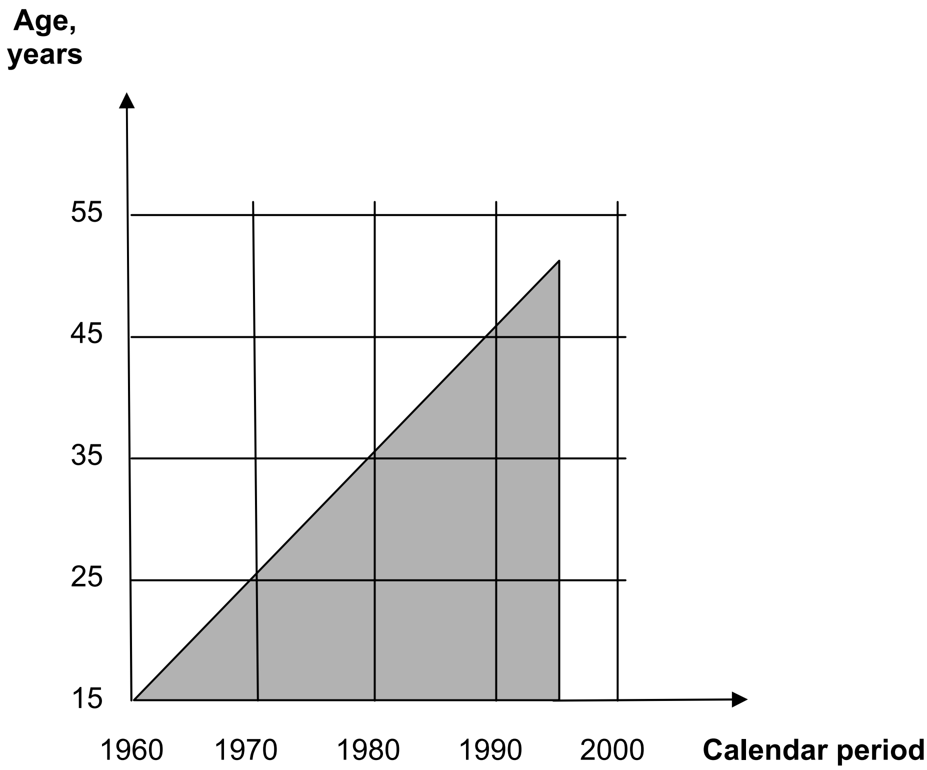
Fertility has undergone considerable fluctuations in Denmark over the last decades, with a nadir in 1983 where the total male period fertility rate constituted 1.3 children per man (Knudsen 1993). The reason for the fluctuations in male fertility in Denmark is not known, but factors such as economic changes, accessibility of contraceptives and abortions could be important in the understanding of the phenomenon. As a step towards elucidating to which degree period and cohort are responsible for the fluctuations in age-specific rates, an age-period-cohort model was applied to fertility data on Danish men. The purpose of the present note is therefore to contribute to the sparsely investigated area of male fertility, particularly the potential of the classical age-period-cohort model, and to estimate the effects of period and cohort, respectively, on first-child fertility in Danish men.

Material

The analysis used aggregated data extracted from the Fertility of Women and Couples Dataset (FWCD), which is primarily based on the Fertility Database (Knudsen 1998). For each woman (and man) the fertility can be described by, for instance, the number of live as well as stillborn children at a given age and point of time and the age at onset of fertility. In the present note, only live born children were included in the material. The FWCD contains information on all women in fertile age (13-49 years) in Denmark each year in the period from 1980 to 1994 and similar information on their co-resident partners. Information on all men in reproductive age was included as of January 1, 1994 (Knudsen and Murphy 1999). The information on when the men had their first child, if any, was initially retrieved from the Register of Population Statistics, which is based on the Central Population Register (Eurostat 1995).

Data were arranged in a table with the sum of first-time fathers and nulliparous men, respectively, stratified by one-year age groups, one-year calendar periods and one-year birth cohorts. Data included men aged 15 to 49 years in the calendar period 1960 to 1994, corresponding to birth cohorts from 1945 to 1979. Due to the nature of data, the number of men who became first-time fathers in this study only included 15-year-old men in 1960, 15- and 16-year-old men in 1961 and so forth, and therefore only constituted about half of the ‘real’ number of men between 15 and 49 years who became first-time fathers in the period from 1960 to 1994 (compare Figure 1). The problem was the same regarding cohorts, since the recent cohorts only included young men. The number of men under ‘risk’ of becoming first-time fathers on the contrary represented all men aged 15 to 49 years who had not previously had children during the period. By means of a Lexis diagram, the calendar period and age groups included in the study are shown in Figure 1. We thus studied male fertility, conditional on their survival until January 1, 1994. Under the natural assumption of independence between fertility and mortality this equals fertility in the usual 'prospective' sense.

Figure 1. Lexis diagram of the calendar period and age groups in the study



Statistical methods

Trends in age-specific fertility rates are related either to calendar time (period), to cohort, i.e. year of birth, or both. To allow for simultaneous effects of period and cohort, an age-period-cohort model was applied to the Danish fertility data. Denote the first-child fertility rate at period p and age a (and hence cohort c = p-a) by λ_{ap}. The age-period-cohort model postulates the additive decomposition

$$\log(\lambda_{ap}) = \alpha_a + \beta_p + \gamma_c$$

Aside from the usual overparametrization because of arbitrary choice of baseline, a more complicated overparametrization problem derives from the exact linear dependency period = age + cohort (Holford 1992). This means that it is not possible to separate the effects of period and age + cohort by simply regressing fertility rates on these variables. This problem has been thoroughly discussed (Clayton and Schifflers 1987a,b, Robertson and Boyle 1998a,b) and one possible solution is constraining for instance the first and the last calendar period to be zero, which was done in the present analyses. The model was fitted using SAS PROC GENMOD with Poisson error distribution and log link (SAS Institute Inc. 1999-2001). The fits of the models were compared by means of deviance analysis (Table 1) and graphical evaluation (Figures 2 to 5).

Second differences

Since constraining the first and the last calendar period is arbitrary and does not give the resulting age-period-cohort parameters any easy interpretation, second differences were calculated. Although the linear effects cannot be ascribed uniquely to period or age + cohort, second differences of all three sets of parameters α_a, β_p ,γ_c are identifiable (Clayton and Schifflers 1987b). In two adjacent periods or cohorts, non-drift effects are expressible as contrasts between the relative risks of these periods or cohorts. Since an additive model was used in this study, the non-drift effects of two adjacent periods and cohorts, respectively, were calculated as

$$(\beta_3 - \beta_2) - (\beta_2 - \beta_1) = \beta_3 - 2\,\beta_2 + \beta_1$$

and simultaneously for other parameter. The above explains the term ‘second differences’ since the effect in a given period or cohort in this equation is a result of the difference between two differences. In a plot of second differences, zero value indicates no change in male first-child fertility, while positive values indicate acceleration, and negative values indicate a deceleration of male first-child fertility. Therefore a plot of second differences is a good means of identifying periods and cohorts where sudden changes in male first-child fertility occur. Since the calculated value of a certain period or cohort is affected only by neighboring data, it is not possible to identify trends in fertility, but only to identify changes compared with the neighboring periods and cohorts. Therefore conclusions regarding effects of periods and cohorts in the present note relied on a combination of trends in fertility calculated by means of the additive Poisson regression model and changes in trend calculated by means of second differences. For easier interpretation, the second differences plots were smoothed.

Results

In this study a total of 648,254 men became first-time fathers during the period from 1960 to 1994. Their mean age when having their first child was 26 years. As seen from the deviance analysis shown in Table 1 as well as in Figures 2 to 5 illustrating the fits of the different models in selected periods and cohorts, the best fitting model was the age-period-cohort model.

Table 1. Deviance analysis

Model	Deviance (D)	DF	Comp. model	ΔD	ΔDF	p-value	D/DF
Empty	720,217	626	-	-	-	-	1150.51
Age	77,211	592	Empty	643,006	34	< 0.0001	130.42
Age-Cohort	20,884	558	Age	56,327	34	< 0.0001	37.43
Age-Period	8,658	558	Age	68,553	34	< 0.0001	15.52
Age-Period-Cohort	1,797	526	Age-Cohort	19,087	32	< 0.0001	3.42
Age-Period-Cohort	1,797	526	Age-Period	6,861	32	< 0.0001	3.42

Fertility rates

Figure 2 illustrates observed and expected age-specific male first-child fertility rates per 1,000. The expected rates are based on the age-period model. In Figure 2, it is not possible to compare the total first-child period fertility in the three selected periods, since all periods do not include men at all fertile ages. The first-child fertility rate can, however, be compared in men aged 15 to 28 years in the selected periods. In Figure 2 the plot for men aged 15 to 28 years in 1973 shows a peak in the observed first-child fertility at a rate of 158 per 1,000 in 27-year-old men. Ten years later in 1983, lower fertility rates were observed at the same ages. In 1983, the observed rate peaks at 103 per 1,000 at age 29. In 1993, the observed first-child fertility rates had increased again and a peak rate of 116 per 1,000 was seen in men aged 29.

Figure 2. Observed and expected age-specific fertility rates for first-time fathers in selected periods. Age-period model.

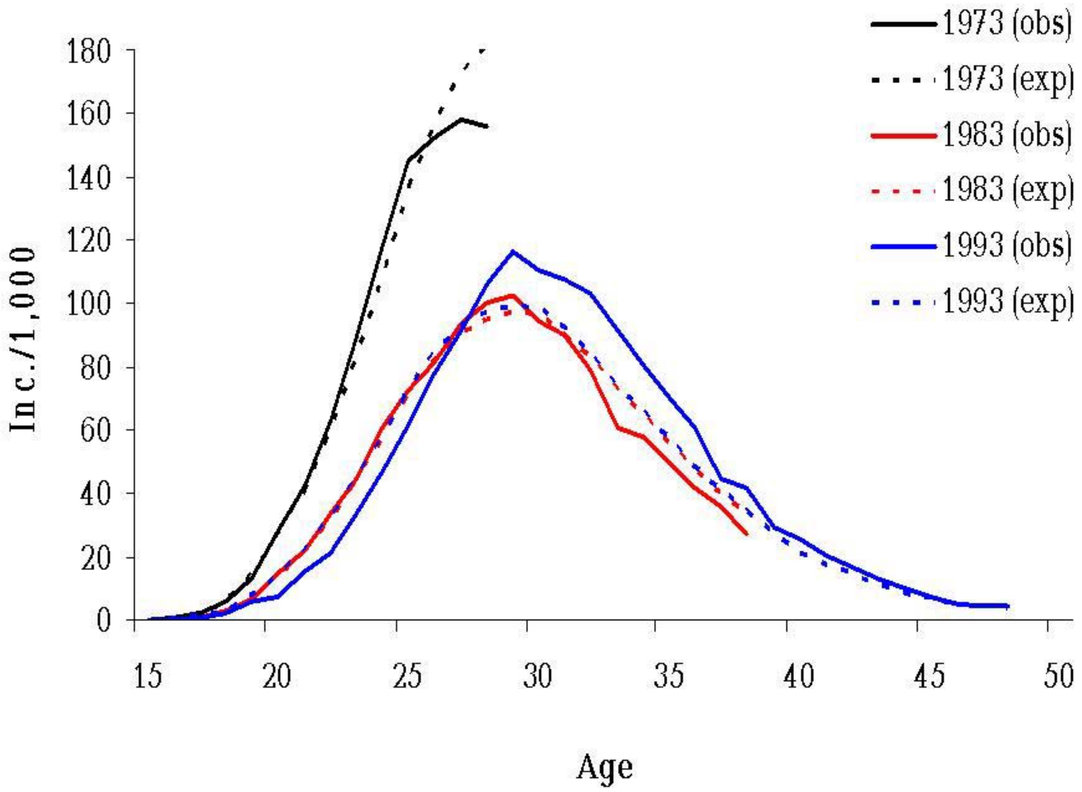


Figure 3 illustrates observed and expected age-specific male first-child fertility rates per 1,000 in selected cohorts. The expected rates are based on the age-cohort model. In Figure 3, comparison of the total male first-child cohort fertility is not possible either, due to the above-mentioned problem. The observed fertility rates of 15- to 48-year-old men from the 1946 birth cohort display a peak rate of 158 per 1,000 at age 26. In men aged 15 to 38 years from the 1956 birth cohort, the first-child fertility rates are considerably lower compared with men from the 1946 birth cohort. However, from age 32 onwards, the first-child fertility rate of the 1956 cohort exceeds that of the cohort born ten years earlier. In men from the 1956 birth cohort, the rate peaks in 29-year-old men, but the peak rate is only 105 per 1,000. Finally, the first-child fertility is observed to peak at approximately the same rate in 28-year-old men from the 1956 birth cohort and the 1966 birth cohort.

Figure 3. Observed and expected age-specific fertility rates for first-time fathers in selected cohorts. Age-cohort model.

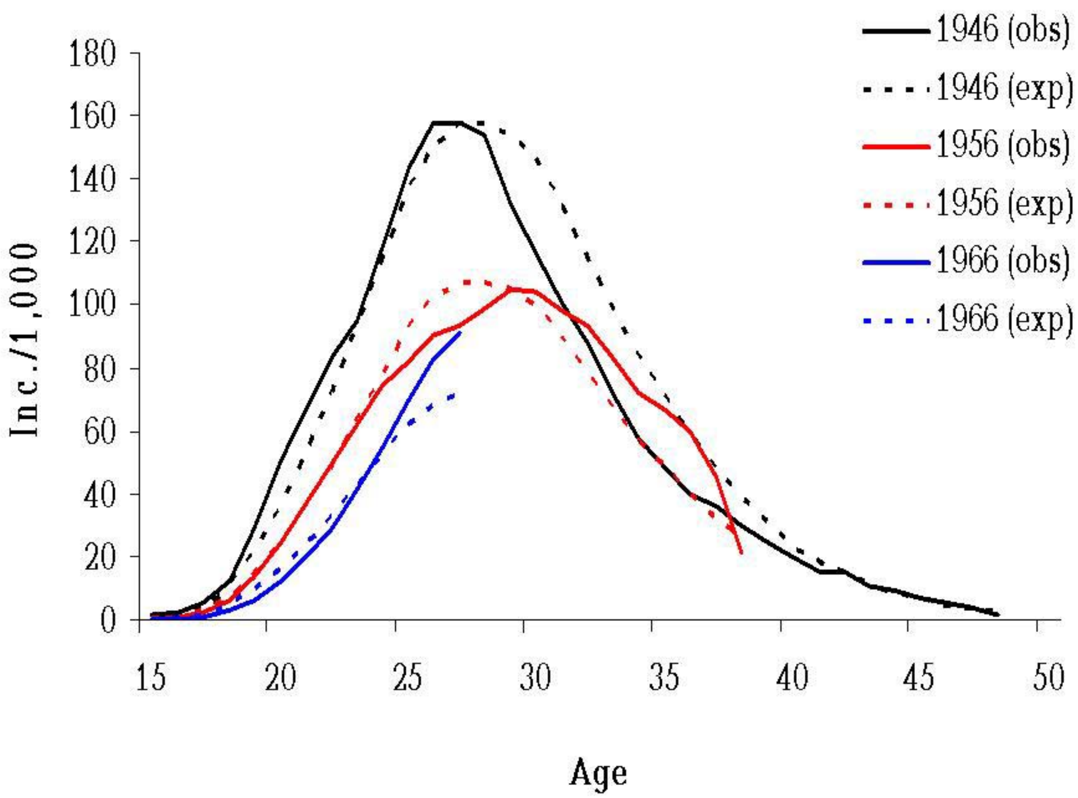
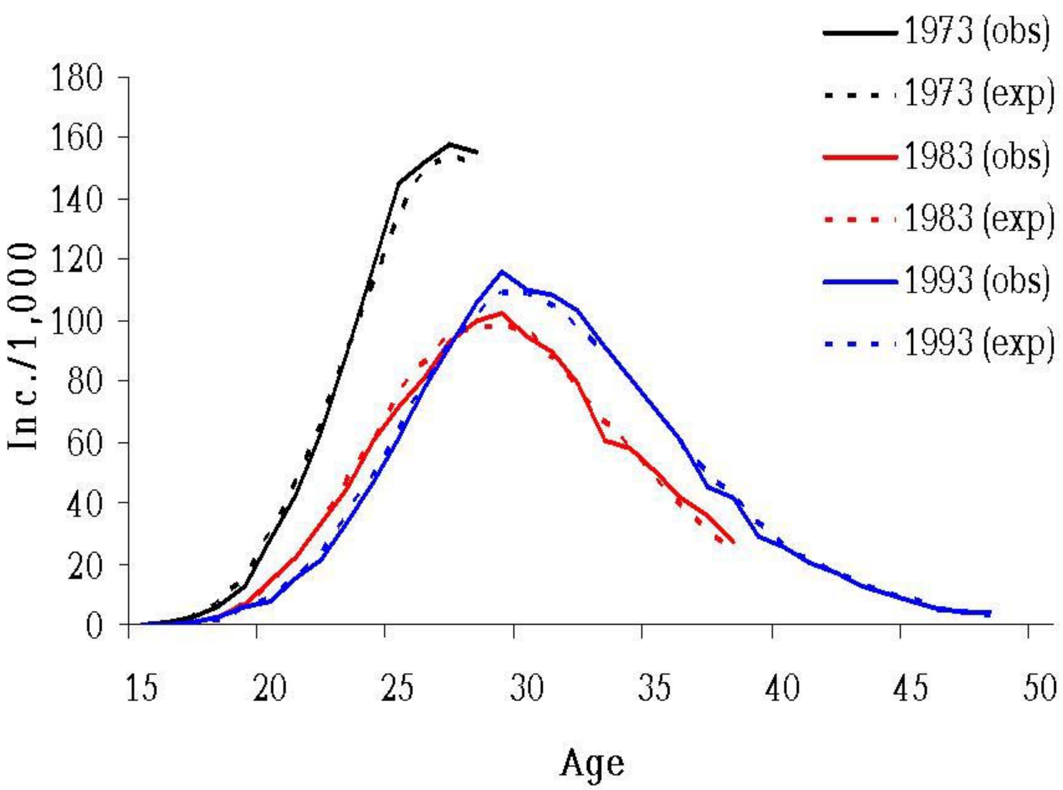


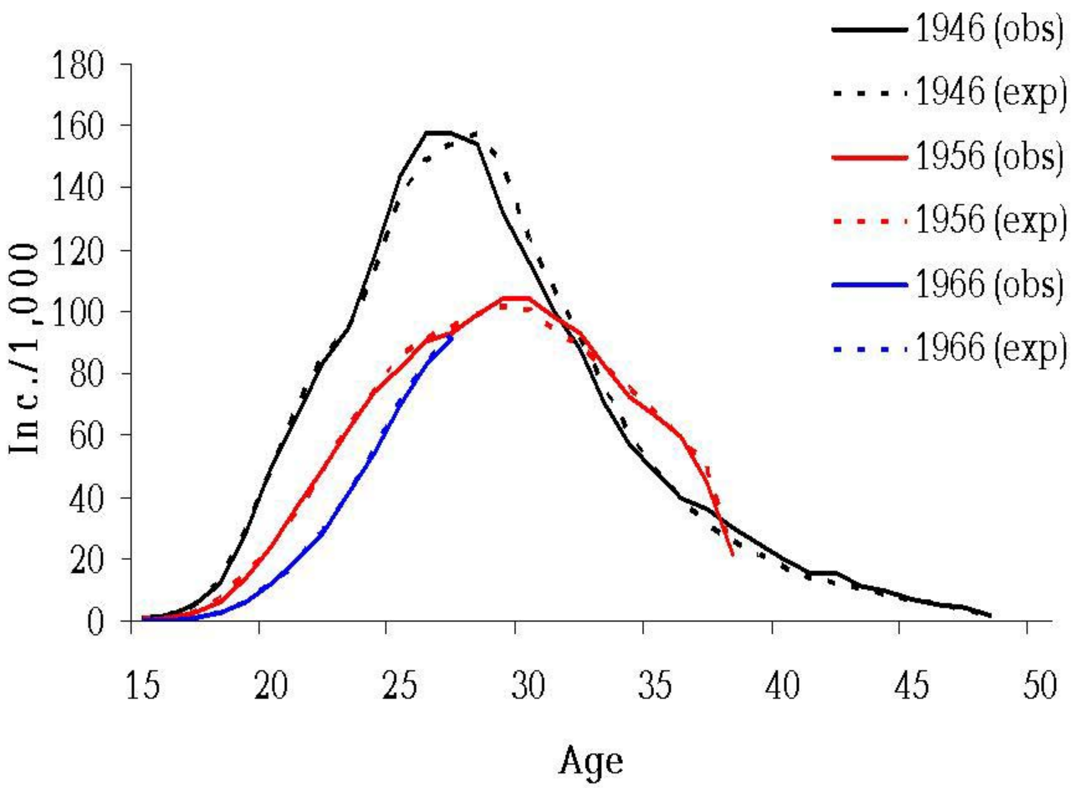
Figure 4 illustrates observed and expected age-specific male first-child fertility rates per 1,000 in selected periods. In Figure 4, the expected rates are based on the age-period-cohort model instead of the age-period model, which was illustrated in Figure 2. In accordance with the results of the deviance analysis, it is seen that the fit of the age-period-cohort model is considerably better than the age-period model.

Figure 4. Observed and expected age-specific fertility rates for first-time fathers in selected periods. Age-period-cohort model.



In Figure 5, observed and expected age-specific male first-child fertility rates per 1,000 are illustrated in selected cohorts. The expected rates are based on the age-period-cohort model. Figure 5 shows a considerably better fit of the age-period-cohort model than the age-cohort model.

Figure 5. Observed and expected age-specific fertility rates for first-time fathers in selected cohorts. Age-period-cohort model.



Second differences

In Figures 6 and 7, the non-drift effect of period and cohort, respectively, on male first-child fertility is shown by means of second differences plots. As previously mentioned, it is not possible to identify the trend in first-child fertility rate in the illustrated periods and cohorts from Figure 6 and 7 alone, but only to identify changes. Figure 6 presents period changes in male first-child fertility rate are shown. Data was restricted to the period from 1965 to 1990. In Figure 6 a deceleration in male first-child fertility is seen in the mid 1960s. The deceleration is followed by accelerations in the late 1960s and in the mid 1970s. In the context of the observed first-child period fertility rates illustrated in Figures 2 and 4, Figure 6 illustrates a linear decreasing first-child fertility rate from the mid-sixties onwards, with stagnation in the late 1960s and the mid 1970s, respectively. In Figure 6, accelerations are also seen in the early and late 1980s, corresponding to the increase in the observed male first-child fertility rate illustrated in Figures 2 and 4.

Figure 6. Second differences plot of the effect of period

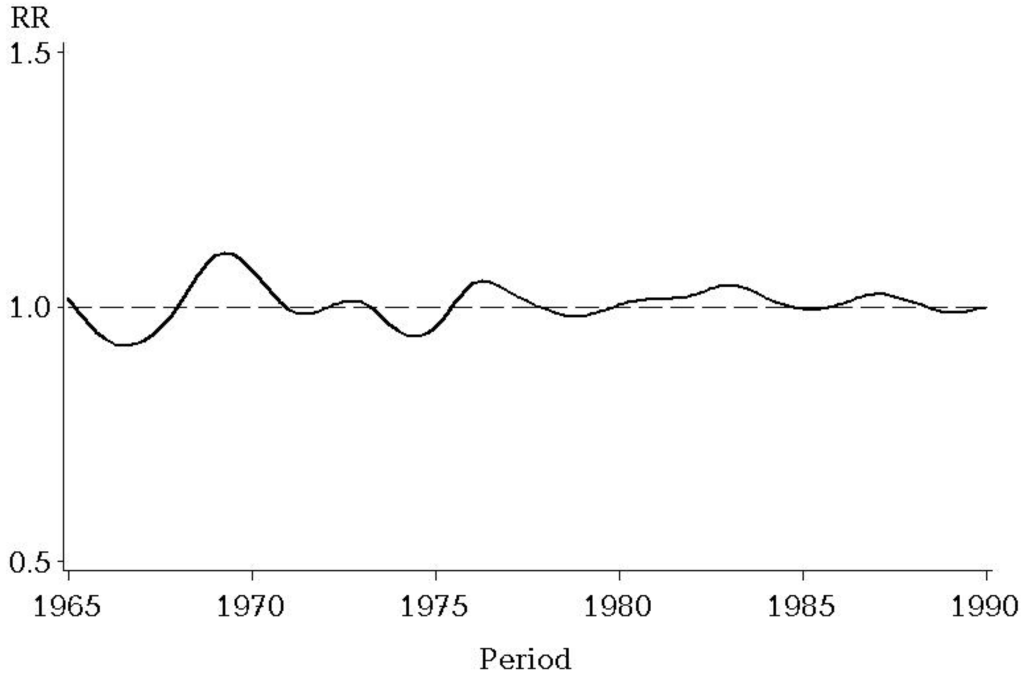
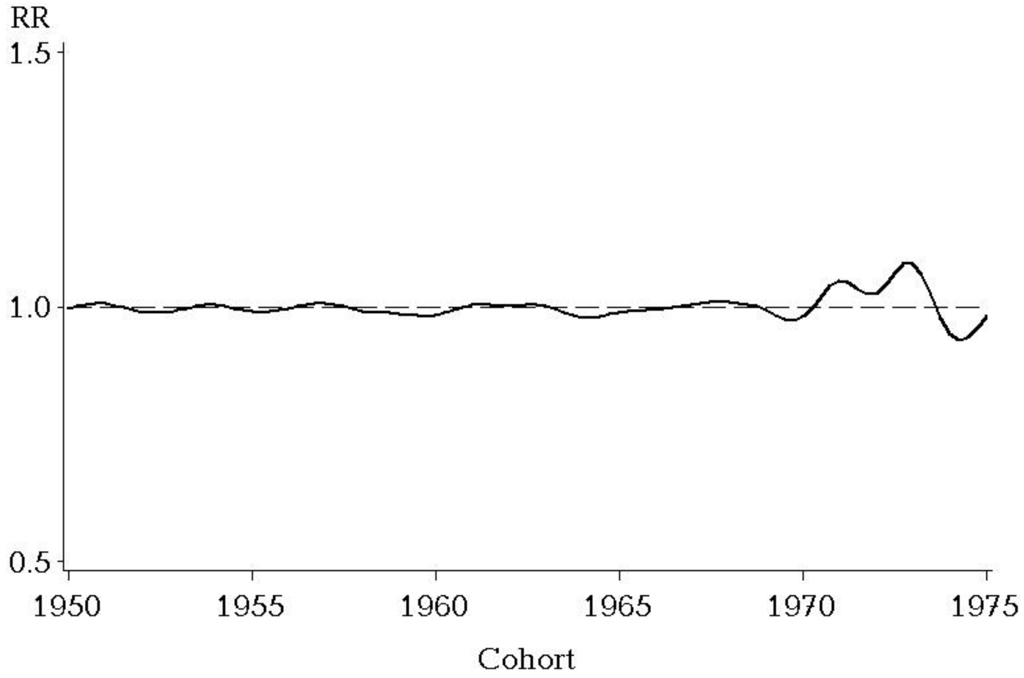


Figure 7 shows the second differences effect of cohort. Data is restricted to cohorts from 1950 to 1975. From Figure 7 it is seen that only little change in first-child fertility occurs in the early cohorts. In the cohorts born after 1970 some fluctuations are seen, but one must keep in mind that these cohorts are very young. The deviation from linearity in Figure 7 may therefore be due to natural variations in fertility of very young men. Bearing in mind the decreasing cohort fertility rates illustrated in Figures 3 and 5, Figure 7 illustrates a general decrease in first-child fertility in Danish men in all cohorts born between 1950 and 1970.

Figure 7. Second differences plot of the effect of cohort



Discussion

In the present note, the effects of period and cohort on male first-child fertility have been studied simultaneously, by applying an age-period-cohort model to Danish fertility data. We found the age-period-cohort model to be an appropriate model for describing male first-child fertility patterns in Denmark. A nadir in male first-child fertility rates was found in the mid 1980s. Finally, age-specific first-child fertility rates were found to be lower in men from younger birth cohorts than in men from older birth cohorts.

Several factors, such as economy, accessibility of contraceptives and abortions affect male first-child fertility rates. Period and cohort are only proxy variables for other factors, and it is thus not possible to determine whether the changes in male first-child fertility found in the present note are due to any of the above factors. The changes in male first-child fertility rate identified in the mid 1960s, in the late 1960s and again in the mid 1970s, respectively, reflect the trend in the female total fertility rate in Denmark in the same period (Knudsen 1993). After almost 20 years of stagnation in female total fertility, a noticeable decrease occurred from 1966 onwards. From 1966 to 1983, the female total fertility rate was halved from 2.6 children per woman to 1.3 children per woman. The decrease was somewhat linear, but stagnation was seen in the late 1960s and again in the mid 1970s.

In estimating effects of demographic variables, calculation of second differences can be very helpful, but the existing literature shows only little practical experience with the interpretation of plots of second differences. Since neighboring ages will always experience different fertility intensities, the plot of second differences will seldom be linear. The deviations from linearity seen in Figure 7 may therefore be due to natural variation in fertility in the beginning of the fertile period. To further investigate the effects of period and cohort in the present note, simulation studies of for example postponement of having first child could have been performed, in which a given postponement per year could be formulated and tested against the observed postponement. Such studies would be helpful in determining whether the observed fluctuations in fertility could be ascribed to e.g. postponement rather than an effect of period or cohort.

Retrospective data on male first-child fertility events was available in the period from 1922 onwards, but in the present note data were restricted to the period from 1945 to 1994 since the linkage between parent and child is considered to be uncertain in cohorts born before 1945 (Knudsen 1993). In Denmark a unique identification number containing a six-digit date of birth and four personal digits allows for children to be linked to their parents. Thus, the first-child fertility events, age, period and cohort in the present note are believed to be accurate.

By applying the classical age-period-cohort model to data from FWCD it was possible to describe effects of period and cohort on rates of first-child fertility in Danish men, despite the fact that data were not available for all ages in the whole period. In conclusion, the present note shows that the classical age-period-cohort model is appropriate for describing male first-child fertility patterns in Denmark, and furthermore that second differences plots is a useful means of identifying changes in e.g. male fertility rates. The note contributes to the knowledge of the effects of period and cohort on male first-child fertility, but further research in this area is needed. To identify factors causing the observed changes in male fertility, the authors suggest that studies including biological, behavioral, economic and social factors be conducted.

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