The History of the Family

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/rhof20>

Unraveling the intergenerational transmission of fertility: genetic and shared-environment effects during the demographic transition in the Netherlands, 1810-1910

Hilde Bras^a, Jan Van Bavel^b & Kees Mandemakers^c

^a Department of History, Radboud University Nijmegen, Nijmegen, The Netherlands

^b Centre for Sociological Research, University of Leuven, Leuven, Belgium

^c International Institute for Social History, Amsterdam, The Netherlands

Published online: 27 Jun 2013.

To cite this article: Hilde Bras, Jan Van Bavel & Kees Mandemakers (2013): Unraveling the intergenerational transmission of fertility: genetic and shared-environment effects during the demographic transition in the Netherlands, 1810-1910, *The History of the Family*, DOI:10.1080/1081602X.2013.803491

To link to this article: <http://dx.doi.org/10.1080/1081602X.2013.803491>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Unraveling the intergenerational transmission of fertility: genetic and shared-environment effects during the demographic transition in the Netherlands, 1810–1910

Hilde Bras^{a*}, Jan Van Bavel^b and Kees Mandemakers^c

^a*Department of History, Radboud University Nijmegen, Nijmegen, The Netherlands;* ^b*Centre for Sociological Research, University of Leuven, Leuven, Belgium;* ^c*International Institute for Social History, Amsterdam, The Netherlands*

(Received 6 May 2013; final version received 6 May 2013)

Differential fertility can be attributed to economic and cultural factors, but the family also plays an important role. Fertility behavior may be transmitted from parents to children through heritable dispositions or via socialization. Previous research has shown, however, that the expression of genetic effects depends on the interplay with the environment. In this article we take a long-term view and examine how the different mechanisms shifted over time and across social and local contexts on the basis of a large-scale database containing 100 thousand sibling pairs born between 1810 and 1870 in the Dutch province of Zeeland, a society undergoing demographic transition and industrialization. Corroborating earlier research, we find a significant increase in the expression of heritabilities and a fading of social influence for women born after the 1840s, who started their reproductive careers during the historical fertility decline in this region. Our study points out that the ‘social control’ of fertility was particularly reduced for women born in towns, women originating from the urban or rural laboring classes, and women from communities with a relatively liberal religious climate. Our findings are in line with research emphasizing the important role played by women in decision-making processes around childbearing, and could indicate the conditions that enhanced women’s position in household bargaining during the historical fertility decline.

Keywords: intergenerational transmission of fertility; genetic influences; the Netherlands; historical fertility decline; sibling models; heritability

1. Introduction

Studies on fertility differentials and reproductive change have mostly focused on economic determinants, such as education and socioeconomic status (Becker, 1981; Easterlin, 1975) or on cultural factors, like religion, language and ethnicity (Coale & Watkins, 1986; Lesthaeghe, 1983). Recently, however, a strong explanatory role has also been attributed to the social relations and interactions that connect individuals to one another (Bongaarts & Watkins, 1996; Watkins, 1990) focusing particularly on individuals’ networks of family and kin. Parents occupy a key position in people’s social networks. It is in the parental home that people are first exposed to processes of procreation and their consequences, while parents may continue to exert a social influence throughout their children’s lives (Axinn, Clarkberg, & Thornton, 1994; Bernardi, 2003; Kohler, 2001). Moreover, parents and children share genetic dispositions that are linked to fertility behavior (Murphy, 1999; Pluzhnikov, Nolan, Tan, McPeck, & Ober, 2007; Rodgers et al.,

*Corresponding author. Email: h.bras@let.ru.nl

2001). Although the intergenerational transmission of fertility has been a subject of interest for more than a century, few studies have been able to separate genetic and social components, let alone their varying articulation over longer time periods (but cf. Kohler, Rodgers, & Christensen, 1999). The aim of this paper is to get a grip on these mechanisms and examine how their influence has changed in a West-European society undergoing industrialization and demographic transition.

An important reason for the lack of studies disentangling genetic and social effects in the intergenerational transmission of fertility is related to the availability of suitable data. Previous research has applied behavioral genetic designs such as twin and adoption analysis (Kohler et al., 1999; Kohler, Rodgers, & Christensen, 2002; Rodgers, Kohler, Kyvik, & Christensen, 2001), while more recent studies employ molecular genetics models (Corbo, Gambina, & Scacchi, 2012; Guo & Tong, 2006). These methods require either life course data on monozygotic and dizygotic twins or adopted children or biological markers; needs not easily met by social scientists. However, as Murphy (1999, p. 15) has suggested

one possible way to address this issue in addition to the classic twin and adoption studies would be to look at the outcomes for sibs of different levels of genetic similarity if there are sufficient numbers who are brought up in different environments.

Thus, apart from the rare data on monozygotic and dizygotic twins, comparisons across full siblings, half-siblings, and step-siblings are useful as well, as long as these pairs represent different socialization contexts and degrees of genetic relatedness (cf. Hatemi et al., 2010; Rodgers, Rowe, & Li, 1994; Van Bodegom, Eriksson, Houwing-Duistermaat, & Westendorp, 2012).

Historical databases with micro data from population registers and vital records are particularly well suited to address these issues (see also: Bittles, Murphy, & Reher, 2008).¹ While (demographic) surveys often contain indicators of fertility behavior of individuals and their parents, data on the fertility behavior of siblings and other kin are hardly ever available, except in twin databases. Historical databases covering complete (regional) populations more often include micro data on life courses and reproductive careers of siblings. Moreover, because of higher levels of adult mortality, numbers of full siblings, half-siblings and step-siblings were much higher. Thus, historical databases may offer unique opportunities for unraveling the interface of genetic and social components of fertility transmission during a period of demographic change and modernization, covering pre-transition, transitional and post-transition societies.

In this article, we use such a large-scale historical database, named GENLIAS, which contains rich data on twin, sibling and half-sibling pairs ($N = 91,002$) from the province of Zeeland, the Netherlands for cohorts born between 1810 and 1870. This data allows us to unravel genetic and shared environment effects on completed fertility and examine the social conditions (birth cohort, social class, religion, and urban–rural differences) under which heritabilities and/or shared environment effects were reduced or more strongly expressed, thus expanding previous research by Kohler and his colleagues (1999). Moreover, we extend existing methods for twin studies (i.e. DF analysis) for including data on siblings and half-siblings. In the next section, we start by elaborating the different mechanisms at play in the intergenerational transmission of fertility, sketch the historical background of our setting and derive a set of testable hypotheses. Next, we describe our database, measures and methods. We then present the estimates of our models. In the last section, we discuss our outcomes and their societal relevance.

2. Background

2.1 Mechanisms behind the intergenerational transmission of fertility behavior

In general, behavioral geneticists distinguish genetic effects from shared and non-shared environmental effects.² Genetic effects, or ‘heritabilities’, refer to the proportions of phenotypic variance attributable to genotypic variance in certain behaviors or traits (Plomin, DeFries, McClearn, & McGuffin, 2008). For a long time, it was envisaged that intergenerational transmission was particularly strong in natural fertility populations and that it would be weaker in contracepting populations. It was believed that primarily physiological mechanisms were heritable; that genetic inheritance worked through the ability to have children, i.e. the fecundity and fecundability of women (Pearson & Lee, 1899). However, subsequent research showed that in natural fertility populations, the correlation between fertility characteristics of parents and their children was very low. More likely, as recent studies indicate, it is the desire for children and childbearing motivations that are heritable (Kohler et al., 1999; Miller, 1986). According to Miller (1992) such (childbearing) motivations are psychological traits or dispositions that are partly derived from the genetic makeup of individuals and that endure in them over time.

Similarity in siblings’ fertility behavior may also result from shared environmental effects. Environmental influences include socio-economic conditions, the normative and/or religious climate, hygienic and health circumstances. Some of these environmental influences are shared by family members, making them similar to each other. Shared environments are however not limited to the family domain. Experiences outside the family can also be shared by siblings, such as peer groups, specific life events, and educational and occupational experiences (Plomin et al., 2008). Many authors have evoked *value socialization* as the prime driver behind shared environmental influences, meaning that preferences and attitudes towards family formation and childbearing are instilled in the younger generation through social interaction, when youngsters grow up in the parental home. Children behave in ways similar to their parents as a result of the adoption of the values, attributes and norms that their parents adhere to. *Role modeling* or *observational learning* entails a less conscious process than value socialization. An alternative explanation for intergenerational correlations in behavior involves the mechanism of *status inheritance*. Parents and children may also act similar because they have been exposed to comparable opportunity structures (Duncan, Freedman, Coble, & Slesinger, 1965; Murphy & Wang, 2001; Steenhof & Liefbroer, 2008).

The extent to which genetic effects are expressed depends on the *interplay with the environment*. Under some conditions, heritabilities may influence phenotypic or behavioral variance more than under other circumstances. *Genotype-environment interactions* may thus alter (the expression of) heritabilities for particular periods or subgroups. Particularly, so it is argued, the higher the level of social constraints in a society, the less the variance in behavior is affected by genetic differences and, conversely, the more choices individuals are permitted, the more the variance in behavior is controlled by individual genotypic differences (Udry, 1996). This argument is corroborated by empirical evidence that shows greater genetic influence on behavior in permissive, low-risk environments (Kendler, 2001). For the case of fertility, a study by Kohler et al. (1999), using Danish twin data for cohorts born between 1870 and 1964, showed that patterns of genetic heritability differed across cohorts and between the sexes. Most strikingly, they showed that at the beginning of the demographic transition, a marked decline in shared-environment effects and an increase in the expression of heritabilities took place for women. For men these shifts could not be observed. In general, they found that heritabilities were high when fertility decisions were

deliberate and social norms and economic conditions allowed a broad range of life-course alternatives. The pattern was reversed when individuals' reproductive experiences were severely affected by wars and economic crises, indicating a 'social control' (Lesthaeghe, 1980) of fertility (Kohler et al., 1999).

Because of data limitations, Kohler and colleagues could not investigate *which environments* most reduced their influence on fertility at the onset of the demographic transition and under what 'new' circumstances heritabilities were expressed to a larger degree. Previous studies have shown that the intergenerational transmission of reproductive behavior varied between genders, regions, social classes and religious denominations (Murphy, 1999; Van Bavel & Kok, 2009; Van Poppel, Monden, & Mandemakers, 2008). These subgroup differences could well be related to specific gene–environment interactions. It is the purpose of this paper to replicate and follow up on the work done by Kohler and colleagues, adding new evidence on the conditions under which the increased expression of heritabilities in women's reproductive behavior took place with the onset of the historical fertility decline. In the next section, we describe the historical background of the population under study, paying special attention to demographic changes, industrialization, and religious and social class differences and subsequently formulate a number of expectations regarding these subgroup differences.

2.2 *The setting: nineteenth-century Zeeland, the Netherlands*

The study population examined in this article consists of individuals who were born (and died) in Zeeland. This province, which consists of peninsulas, islands and a mainland area bordering with Belgium to the south, is situated in the southwestern corner of the Netherlands. During the sixteenth and seventeenth centuries, Zeeland played an important role as a region of industry and trade and could boast influential trading towns such as Middelburg, Zierikzee and Veere. After 1585, when the Spaniards conquered Antwerp, the significance of the Zeeland trade and industry declined and a process of ruralization took place, which made Zeeland increasingly dependent on its agricultural sector (Priester, 1998).

During the nineteenth century, a large part of Zeeland's economy was based on market-oriented, capital-intensive farming that specialized in the production of cash crops, such as wheat, flax, madder and sugar beets (Priester, 1998). Social structure in the countryside was far from egalitarian; a large gap existed between a small segment of wealthy farmers and a mass of agricultural laborers and farm hands. For both men and women, field work was the most important employment opportunity. The occupational structure hardly changed during the nineteenth and first half of the twentieth century (Kok, 1998). The 'potato crisis' of 1845–1848 and particularly the international agricultural depression of the last two decades of the nineteenth century led to processes of mechanization and rationalization of farming practices.

Although the agricultural sector was important, the traditional Zeeland towns continued to fulfill a regional function in terms of trade, industry and administration. The Netherlands had been a relatively urbanized country from the sixteenth century onwards. It was also highly commercialized, particularly in its western parts, including Zeeland. However industrialization and further urbanization did not start until on a large scale after about 1850. Indeed, as of the middle of the nineteenth century there was also a moderate expansion of the industrial sector in Zeeland. Various types of industry, such as shipbuilding, beer brewing, shoemaking, textiles, concrete production and wood sawing could be found, both in the largest cities Middelburg and Vlissingen and in several smaller communities (Franken & Adriaanse, 2004; Zijdemans, 2010).

The population of Zeeland consisted of a mixture of Catholics (specifically in mainland Zeeland-Flanders), Orthodox Protestants and liberal Protestants. The Catholic Church exerted a strong pro-natalist pressure on married couples in the Netherlands, like in other European countries (Engelen & Kok, 2003; Van Bavel & Kok, 2005; Van Heek, 1956; Van Poppel, 1992). The central reason for this was their zealous opposition towards birth control within marriage. In predominantly Catholic communities, paternal authority and the power position of the local clergy were strong, which made it almost impossible for couples not to compel to the ideal of large families. Orthodox Protestants adhered to roughly the same morality and childbearing norms as Catholics (Van Heek, 1956; Van Poppel, 1985). Both Catholics and Orthodox Protestants stayed virulently opposed to birth control within marriage at least until the 1920s.

Given its specific religious character, the Netherlands had a rather late fertility transition in comparison to other European countries, starting only after 1890. Strong regional differences in the fertility transition across Dutch regions existed however, with the southern, mostly Catholic, regions lagging behind and only showing signs of family limitation in the course of the twentieth century. Zeeland followed, from a demographic point of view, a more or less average path to low fertility (see Figure 1). Until about 1880, Zeeland's fertility levels were higher than the Dutch average, while the eventual decline in Zeeland around 1870 was much steeper with fertility levels dropping considerably below the Dutch average after about 1900.

2.3 Hypotheses

Following Kohler et al. (1999) we first of all test the hypothesis that in periods of demographic transition, when norms about fertility behavior are more liberal and allow a wider variety of choices about reproductive behavior, genetic influences are expressed more and comprise a larger share of the intergenerational transmission of fertility behavior. In the case of nineteenth century Zeeland, where both industrialization and fertility decline started off relatively late in comparison to other European societies, we expect an increase in the expression of genetic effects for cohorts born since 1840, who

Figure 1. General marital fertility (number of births per 1000 women of age 15–45) in the Netherlands and in the province of Zeeland, 1830–1960. Source: Based on Hofstee, E.W. (1981). *Korte demografische geschiedenis van Nederland van 1800 tot heden*. Haarlem: Fibula-Van Dishoeck, p. 132.

started their reproductive careers as of 1860/1870. As in the Danish study, we expect this to have been particularly true for females, indicating, as Kohler et al. have suggested, the instrumental role played by women in the adoption of fertility control and in household bargaining about fertility (*H1*).

Similarly, we expect that urban areas, which in the nineteenth century, due to their fast growth, became increasingly composed of a mixture of people from various social classes, religions and geographical backgrounds, had more liberal norms as well as a wider range of economic opportunities than the countryside. It has been argued that urbanization and industrialization weakened parental authority and stimulated the emancipation of children from larger family ties (Alter, 1998; Mitterauer & Sieder, 1983). Although the Zeeland cities were not as cosmopolitan and large-scale as for instance Amsterdam, The Hague or Rotterdam, their traditions (and legal rights) were long-standing and the difference with the rural villages might have been considerable. In the less restrictive urban environment, we expect genetic effects to have been expressed more, particularly for cohorts born after 1840 who experienced the onset of demographic change and industrialization during their reproductive careers (*H2*).

Equivalently, we expect that in social groups that were more liberal, or were faced with less economic restrictions, the proportion of heritabilities in the intergenerational transmission of fertility was larger. As of the second half of the nineteenth century, the working classes profited from the increase of wage labor and the rise of living standards, which facilitated earlier marriage and family formation, whereas the marriage patterns and reproductive behavior of other social groups were still largely governed by the European Marriage Pattern with its strict norms and requirements influencing the timing of marriage and the start of reproductive careers (Hajnal, 1965). In the higher and middle classes and among farmers the norm was still that one had to be able to support a decent household before one could marry. The material prerequisites that were needed to create a household became, because of the rise of living standards, only higher. Therefore, for the propertied classes, household formation remained difficult (Engelen & Kok, 2003). We thus expect that in the lower social classes, and particularly in the rural and urban working classes, heritabilities might have been expressed more than in other social groups (*H3*).

Finally, we expect a larger expression of heritabilities in fertility transmission in places with a more liberal religious climate. In the Netherlands, Catholic priests condemned birth control, and late marriage and celibacy were considered the only means of population control. Among liberal Protestant denominations, on the other hand, the neo-Malthusian alternative was accepted much earlier. Orthodox Protestants, by contrast, had similar strict sexual morals as the Catholics (Engelen & Kok, 2003; Van Bavel & Kok, 2005). Therefore, we expect that genetic effects on fertility were less articulated in communities with many Catholics or Orthodox Protestants (*H4*).

3. Data, measures, and methods

3.1 Data

We base our analyses on a large historical database, named GENLIAS, which contains birth, marriage and death certificates from the province of Zeeland in the Netherlands for the period 1812–1902. Point of departure is a data file that includes coded information from all birth certificates of the province of Zeeland for the period 1812 to 1866 that could be linked with the marriage certificate of the parents of the newborn child ($N = 209,300$). The restriction that the youngest cohort should be born no later than 1866 was based on the fact that we need to reconstruct the reproductive histories of these people, while we do not

have access to documents more recent than 1911 (= 1866 + 45) for legal reasons implied by Dutch privacy laws. The precondition that a match could be made with the marriage of the parents was necessary to enable the identification of pairs of full siblings, half-siblings, and twins. Through the linkage with the marriage certificates of the parents, 777,520 unique pairs of siblings could be identified: 75,887 pairs of half-siblings, 697,230 pairs of full siblings, and 4403 twin pairs. Since we need information about the full reproductive life cycle, and since we only collected such information within the province of Zeeland, we dropped all individuals for which we could not find a death certificate, because absence of a death certificate (in the province of Zeeland) is a strong indication of out-migration. Also, since we analyze fertility histories, we dropped a large number of cases where one or both siblings died before reaching age 15. Applying this selection yielded a sample of 99,372 sibling pairs: 91,022 pairs of full siblings, 8102 pairs of half-siblings, and 248 twin pairs. These sibling pairs were derived from more than 16,000 families (see Table 1).

3.2 Measures

We analyze completed fertility as the fertility trait under study, representing the quantum rather than the timing of reproduction. Figure 2 depicts completed fertility by birth cohort on the basis of the Zeeland GENLIAS database. As of birth cohort 1830 completed fertility declined from on average 4.9 to on average 4.2 children for the cohort 1860, with a fast decrease particularly as of cohort 1850 (which started childbearing as of the 1870s). The birth cohort of 1820, which had its childbearing years

Table 1. Summary statistics of the data and variables used in the extended DF regression models.

Number of sibling pairs	99,372
Number (and %) of male sibling pairs	48,782 (49.1%)
Number (and %) of female sibling pairs	50,590 (50.9%)
Number (and %) of non-twin full sibling pairs	91,022 (91.6%)
Number (and %) of half-sibling pairs	8102 (8.2%)
Number (and %) of twin pairs	248 (0.2%)
Number of families (parental marriages)	16,390
Completed fertility	4.6 (4.6)
Birth cohort	
1810	5338 (5.4%)
1820	15,143 (15.2%)
1830	22,676 (22.8%)
1840	23,305 (23.5%)
1850	21,054 (21.2%)
1860	11,856 (11.9%)
Degree of urbanization birthplace	
Rural	74,893 (75.4%)
Urban	24,479 (24.6%)
Social class	
Higher and middle class	9274 (9.3%)
Skilled workers	15,614 (15.7%)
Farmers	13,467 (13.6%)
Unskilled workers	11,616 (11.7%)
Farm workers	47,090 (47.4%)
Religious climate birthplace	
< 10% Orthodox Protestants and Catholics	17,615 (17.7%)
10 < 60% Orthodox Protestants and Catholics	69,994 (70.4%)
60 < 100% Orthodox Protestants and Catholics	11,763 (11.8%)

Source: GENLIAS_2010_01_Siblings

Figure 2. Completed fertility by birth cohort, province of Zeeland. Source: as in Table 1.

during the potato crisis of the 1840s, had very depressed numbers of children. The relatively low number of children of the 1860s cohort might have been due to the onset of family limitation in this population, but may have also been partly due to the effect of the international economic depression.

We constructed a number of independent variables. First of all, dummies for ten-yearly birth cohorts were made, with cohort 1820 referring to individuals born between 1820 and 1829, the latter year included. Clearly, we have the fewest cases for the oldest birth cohort (see Table 1). Furthermore, birth places were classified as urban or rural on the basis of the historical designation of the municipality as a town. Among the urban places were fairly large cities such as Middelburg and Vlissingen (Flushing) and somewhat smaller towns that primarily fulfilled a regional function in terms of trade, industry and administration, like Goes, or that had been given legal rights as a town, like Veere.

Social class was indicated by the occupation of the father taken from his marriage certificate. All occupations were grouped according to the historical social class categorization HISCO (Historical International Standard Classification of Occupations) (Van Leeuwen, Maas, & Miles, 2002). HISCO is synchronized with the International Standard Classification of Occupations (ISCO68). The occupational categories were then grouped into HISCLASS, a historical social class scheme proposed by Van Leeuwen and Maas (2010, 2011). We employ the following categories in our analyses: (1) higher and middle class, (2) skilled workers, (3) farmers and fishermen, (4) unskilled workers, and (5) farm workers. In Zeeland, almost half of all individuals belonged to the farm workers class; the other half was split more or less equally among the other four social groups.

Unfortunately we do not have the religious denomination of the individual siblings. Instead we used a proxy for the religious composition of the siblings' birthplaces. This variable is based on two indicators: (1) the proportion of Catholics in the community in 1849, and (2) the proportion of eligible voters for the main orthodox Calvinist party for the municipal and provincial elections in 1935 (1935 being the first year when it was possible to chart voters for this party) (Knippenberg, 2003). Although the year in which electoral support was measured lies outside our period of study, these election results largely reflect the religious landscape of Zeeland back in the nineteenth century. As outlined in the theoretical section, studies have documented clear spatial segregation of Catholics and Protestants throughout the nineteenth century.

3.3 Methods

We test our hypotheses by way of behavior-genetic models that allow the partitioning of variance in behavior in additive genetic, shared-environment, and non-shared environment effects and their interactions with the environment (Plomin et al., 2008). More specifically, we employ a multiple regression model, called a DF model after DeFries and Fulker who pioneered this type of analysis (DeFries & Fulker, 1985). DF models were originally developed for the analysis of twin data in selected samples (i.e. extremes analysis), but their use has been extended to unselected samples and sibling data as well (Rodgers et al., 1994; Zieleniewski, Fulker, DeFries, & LaBuda, 1987).

The basic setup of the DF regression model, as applied in this paper, is as follows:

$$F_1 = \beta_0 + \beta_1 F_2 + \beta_2 R + \beta_3 R F_2 + e \quad (1)$$

where F_1 represents the fertility trait of sibling 1, F_2 the same trait for sibling 2. R indicates the expected degree of genetic relatedness between sibling 1 and 2. R is equal to 0.5 for full siblings and to 0.25 for half-siblings. For monozygotic twins, R should be about 1.0 while for dizygotic twins the expected degree of genetic overlap is the same as for full siblings, i.e. 0.5. Since we cannot tell the difference between mono- and dizygotic twins, we take the average value of 0.75 as a rough approximation for twins, except for different-sex twins, who are always dizygotic (so $R = 0.5$ for them). The β 's are the conventional regression parameters. DeFries and Fulker (1985) showed that OLS-estimates of β_1 can be used to measure the degree of common environment effects on the investigated trait F_1 , while β_3 indexes the degree of heritability.

Three assumptions underlie the interpretation of the regression parameters of the DF model: (1) a linear polygenic model; (2) negligible assortive mating; and (3) equal environmental influences on the investigated phenotypic trait for twins and siblings (DeFries & Fulker, 1985). The last assumption is particularly challenging for our research, since most of the statistical leverage that we use comes from comparing full siblings with half-siblings. Indeed, it is not plausible that half-siblings share the same environment to the same extent as full siblings do. Note, however, that the crucial point in this assumption is not that siblings should grow up in exactly the same environmental circumstances, but rather that their environments should be the same as far as they are related to the trait of interest (Hatemi et al., 2010). If this is not the case (so to the extent that the third assumption is violated), the degree of heritability estimated from model (1) will be biased upwards. In contrast, violations of the first two assumptions of the DF model will create a downward bias in the estimates of heritability.

It is likely that there are differences between the environments of full and half-siblings that do affect their reproductive behavior. Therefore, we added an index for the degree of environmental relatedness to the basic DF model, in addition to the degree of genetic relatedness R . More particularly, we used the degree of age similarity for this purpose, called A . If two siblings have the same age (which will happen only with twins), the age similarity is set to 1.0. The higher the age difference, the lower the index of age similarity A . We argue that the relationship between age difference and environmental similarity will probably not be linear: small age differences (up to say four years) should give rise to only small decreases in A ; somewhat higher age differences should lead to a rapidly declining index of shared environment, quickly approaching $A = 0$ and then staying just above that limit. We parameterized this relationship between age difference and A with a logistic functional form, as depicted in Figure 3.

Figure 3. Relation between age difference between siblings and the index of age similarity A .

The extended DF model, with the index of age similarity A included, looks like this:

$$F_1 = \beta_0 + \beta_1 A + \beta_2 R + \beta_3 A F_2 + \beta_4 R F_2 + e \quad (2)$$

In this approach, β_3 represents the effect of shared environment on the fertility trait (c^2) while β_4 indexes heritability. Finally, in all models we took account of the fact that siblings might appear more than once in the dataset. We thus controlled for clustering of children in parental marriages by using cluster robust standard errors (Woolridge, 2003).

4. Results

To what extent can we observe heritabilities and shared environmental effects in the intergenerational transmission of fertility behavior and how did this change over time? In Table 2, parameter estimates for the effects of shared environment and heritability on completed fertility are presented for the different cohorts. All models were estimated separately by (decennial) cohort and by gender combination (female sibs and male sibs). So, 'cohort 1820' refers to people born between 1820 and 1829 (included). The results pertain to completed fertility, i.e. the total number of births observed for each of the members of the sibling pairs. According to the 'naïve' DF model estimates, there are no statistically significant shared-environment effects on completed fertility for women; the estimates tend to be lower than their standard errors. The estimates exhibit no clear pattern. In contrast, heritability estimates are higher and, starting from the cohort of the 1840s, they are statistically significant, reaching a maximum of 0.46 in the two most recent cohorts. Yet, the latter estimates are probably generally too high, since differences in environment between siblings are not taken into account in the naïve model. Moreover, standard errors are underestimated because of the fact that children from the same parents (siblings) can appear more than once in the data set. Therefore, the right hand side of Table 1 reports the results of an extended DF model in which account is taken of both differential environments of siblings and clustering on the level of (parental) marriages. Now a clear pattern emerges for the female sibling pairs: in the earliest cohorts, shared-environment effects are statistically significant, while their trend is decreasing (with the exception of the

Table 2. Effects of shared environment and heritability on completed fertility by birth cohort, estimated from the simple DF model (left panel) and from the extended DF model (right panel).

	DF						Extended DF					
	c^2 -Shared environment			h^2 -heritability			c^2 -Shared environment			h^2 -heritability		
	B	se	p	b	se	p	B	se	p	b	se	p
Female sibs												
1810	-0.05	0.12	0.69	0.39	0.25	0.12	0.15	0.07	0.04	0.10	0.28	0.72
1820	0.01	0.08	0.94	0.21	0.16	0.19	0.11	0.04	0.01	0.03	0.18	0.85
1830	0.02	0.06	0.80	0.23	0.13	0.07	0.08	0.03	0.02	0.13	0.15	0.37
1840	-0.03	0.06	0.57	0.30	0.13	0.02	0.01	0.04	0.87	0.29	0.15	0.06
1850	-0.10	0.06	0.11	0.46	0.13	0.00	0.09	0.04	0.01	0.34	0.14	0.01
1860	-0.07	0.08	0.36	0.46	0.16	0.01	-0.02	0.05	0.74	0.48	0.19	0.01
Male sibs												
1810	-0.07	0.14	0.60	0.37	0.29	0.20	-0.10	0.08	0.23	0.56	0.33	0.09
1820	-0.12	0.08	0.12	0.47	0.16	0.00	0.00	0.04	0.93	0.47	0.19	0.01
1830	0.00	0.07	0.97	0.25	0.14	0.06	-0.00	0.03	0.95	0.26	0.17	0.12
1840	-0.02	0.06	0.78	0.22	0.13	0.09	0.02	0.04	0.65	0.20	0.19	0.30
1850	0.03	0.07	0.72	0.21	0.15	0.15	0.01	0.04	0.87	0.20	0.20	0.33
1860	0.07	0.08	0.39	0.07	0.17	0.67	0.06	0.05	0.19	-0.04	0.20	0.83

Source: As in Table 1

1850s cohort). In contrast, heritability is low and not statistically significant in the earliest cohorts but then rises steadily and becomes statistically significant from the 1850s cohort onwards.

The point estimates of the extended DF model, along with their confidence intervals (calculated using two times the reported standard error) are summarized in Figure 4. The two left figures summarize the results for female sibling pairs. For men, the results point in the opposite direction in the sense that heritability tends to decline with cohort (see middle panel of Figure 2). This holds both for the simple and for the extended DF model; although the point estimates generally do not differ significantly from zero. Shared environment effects are low and statistically not significant. Overall, these results suggest that the role of heritability rose in more recent cohorts for women, while the opposite holds for men. The role of shared environment effects is limited, as far as these estimates go.

Table 3 shows the effects of shared environment and heritability on completed fertility by type of birthplace (rural or urban) of sibling 1. For both female and male sibling pairs, the influence of heritability is much larger as well as statistically significant than the effect

Figure 4. Effects of shared environment and heritability on completed fertility, estimated from the extended DF model, by gender and cohort.

Table 3. Effects of shared environment and heritability on completed fertility by degree of urbanization of birthplace (all cohorts), estimated from the extended DF model.

	c^2 -Shared environment			h^2 -heritability		
	b	se	p	b	se	p
Female sibs						
Rural	0.07	0.02	0.00	0.16	0.08	0.05
Urban	0.02	0.05	0.77	0.51	0.18	0.00
Male sibs						
Rural	0.01	0.02	0.64	0.21	0.09	0.03
Urban	0.00	0.06	0.95	0.58	0.22	0.01

Source: as in Table 1.

of the shared-environment. However, the level of heritabilities is more than twice as high for the urban-born in comparison to the rural-born, corroborating our hypothesis. The shared environment effects are higher for the rural-born than for urban-born for all types of sibling pairs, which also confirms our hypothesis.

In Table 4 rural–urban differences are examined by cohort. We distinguish two cohorts, i.e. those born before 1840 and those born after that year, in line with our earlier results in Table 2 and in order to avoid too small numbers. The estimates point out that in the cohorts born before 1840 heritability effects were particularly strong and significant for male sibling pairs, while in the later-born cohorts they were strong and significant for women. In both cases heritability is stronger for urban-born than for rural-born; the effects being at least two times larger in magnitude.

In Table 5 we test our third hypothesis. We expected that in the rural and urban laboring classes, heritabilities would be expressed more than in other social classes. In these social groups, household formation became more loosely connected to the European Marriage Pattern, particularly after 1860 with industrialization and the growth of wage labor. Contrary to our expectations, we observe significant and high shared-environment effects for females from unskilled and farm workers' backgrounds born before 1840. It is women in farming families that show high significant genetic influences

Table 4. Effects of shared environment and heritability on completed fertility by degree of urbanization of birthplace and cohort, estimated from the extended DF model.

		c^2 -Shared environment			h^2 -heritability		
		b	Se	p	B	se	p
Cohorts < 1840	Female sibs						
	Rural	0.10	0.03	0.00	0.05	0.12	0.68
	Urban	0.06	0.07	0.41	0.35	0.26	0.19
	Male sibs						
	Rural	−0.00	0.03	0.98	0.29	0.12	0.02
Cohorts ≥ 1840	Urban	−0.08	0.07	0.24	0.79	0.34	0.02
	Female sibs						
	Rural	0.05	0.03	0.10	0.26	0.10	0.01
	Urban	−0.02	0.07	0.75	0.62	0.23	0.01
	Male sibs						
	Rural	0.02	0.03	0.44	0.13	0.13	0.34
	Urban	0.07	0.08	0.39	0.37	0.26	0.14

Source: as in Table 1.

Table 5. Effects of shared environment and heritability on completed fertility by social class and birth cohort, estimated from the extended DF model.

		c^2 -Shared environment			h^2 -heritability		
		b	se	p	b	se	p
Cohorts < 1840	Female sibs						
	Higher and middle class	0.07	0.10	0.53	-0.15	0.35	0.67
	Skilled workers	0.03	0.08	0.62	0.27	0.31	0.37
	Farmers	0.01	0.07	0.90	0.47	0.24	0.05
	Unskilled workers	0.24	0.09	0.01	-0.15	0.32	0.63
	Farm workers	0.10	0.04	0.02	0.06	0.18	0.73
	Male sibs						
	Higher and middle class	- 0.21	0.11	0.05	0.85	0.38	0.03
	Skilled workers	-0.11	0.07	0.09	0.04	0.24	0.86
	Farmers	-0.04	0.08	0.65	0.19	0.27	0.49
Cohorts $\geq$ 1840	Unskilled workers	- 0.16	0.08	0.04	-0.09	0.48	0.86
	Farm workers	0.10	0.05	0.02	0.45	0.18	0.01
	Female sibs						
	Higher and middle class	0.12	0.08	0.14	0.62	0.32	0.05
	Skilled workers	0.02	0.06	0.79	0.42	0.24	0.08
	Farmers	0.04	0.07	0.52	0.16	0.22	0.48
	Unskilled workers	0.07	0.08	0.38	0.71	0.31	0.02
	Farm workers	0.01	0.04	0.83	0.37	0.14	0.01
	Male sibs						
	Higher and middle class	0.20	0.11	0.07	0.52	0.40	0.18
	Skilled workers	0.04	0.07	0.62	0.26	0.41	0.53
	Farmers	0.09	0.06	0.18	0.22	0.24	0.35
	Unskilled workers	0.00	0.07	0.97	- 0.83	0.37	0.03
	Farm workers	0.01	0.04	0.88	0.02	0.16	0.89

Source: as in Table 1.

on fertility. For males, the estimates are even more blurry. Comparatively high significant shared environment effects are found for male farm workers and comparatively low and significant shared environmental effects for unskilled workers and the higher and middle classes. However, males of the farm workers class and the higher and middle classes also expressed relatively high and significant heritabilities.

For cohorts born after 1840, we find no significant shared-environment effects. For males we see only a comparatively, very low significant genetic effect for unskilled workers. For females results are in line with our hypotheses. Heritabilities were, as expected, high and significant for women of the unskilled working ($h^2 = 0.71$) and the farm working class ($h^2 = 0.37$), but also, which was not surmised, for the higher and middle class ($h^2 = 0.62$). It might be that well-to-do women were also less subject to (previously) strict social norms influencing their reproductive behavior as these groups were forerunners in the diffusion of family limitation during the fertility decline (Coale & Watkins, 1986). Thus, the main finding in Table 2 of an increase in the expression of genetic effects for women with the onset of the demographic transition and the high level of heritabilities for females in the towns (Table 4) can now be more specifically accounted for by the social groups of rural farm workers and particularly by urban unskilled workers, as well as by women from the higher social strata.

Finally, in Table 6 we observe differences in the effects of heritability and shared environment on completed fertility according to the religious climate of the birth place (of sibling 1). We expected that in places with a more liberal religious climate (i.e. less

Table 6. Effects of shared environment and heritability on completed fertility by degree of religiousness and birth cohort, estimated from the extended DF model.

		<i>c</i> ² -Shared environment			<i>h</i> ² -heritability		
		b	se	p	b	se	p
Cohorts < 1840	Female sibs						
	< 10%	0.11	0.07	0.14	−0.32	0.22	0.15
	10 < 60%	0.10	0.04	0.00	0.16	0.14	0.25
	60 < 100%	0.05	0.09	0.57	0.47	0.34	0.17
	Male sibs						
	< 10%	0.30	0.29	0.30	0.29	0.12	0.02
	10 < 60%	−0.02	0.04	0.55	0.43	0.14	0.00
	60 < 100%	−0.11	0.08	0.17	0.50	0.33	0.13
Cohorts ≥ 1840	Female sibs						
	< 10%	0.10	0.06	0.10	0.57	0.24	0.02
	10 < 60%	0.02	0.03	0.60	0.30	0.11	0.01
	60 < 100%	0.46	0.34	0.17	0.13	0.32	0.69
	Male sibs						
	< 10%	−0.00	0.06	0.98	0.40	0.23	0.08
	10 < 60%	0.05	0.03	0.14	0.14	0.15	0.33
	60 < 100%	0.00	0.08	0.95	−0.00	0.32	0.99

Source: as in Table 1.

orthodox Protestants and/or Catholics) the effects of heritability would be larger than in places with a religiously more normative character. We again subdivide the data in cohorts born before and after 1840. Those born after 1840 had their reproductive careers between 1860 and 1910 at the height of the process of pillarization (religious segregation) in the Netherlands, which was accompanied by a tightening of religious norms. The estimates show that for the younger cohorts (born after 1840) heritability effects are indeed higher, the more liberal the religious climate of the birthplace is. In the case of female sibling pairs, the heritability effects of the two categories with most liberal places differ significantly from zero. For the older cohorts we do not find such a consistent pattern (and even a reverse pattern in the case of male sibling pairs).

5. Conclusion and discussion

Differential fertility can be attributed to economic and cultural factors, but the family also plays an important role. Fertility behavior may be transmitted from parents to children through heritable dispositions or via socialization. Previous research has shown, however, that the expression of genetic influences depends on the interplay with the environment. In this study, we aimed to unravel the intergenerational transmission of fertility behavior, separating its genetic and social components. We took a long-term view and examined how the different mechanisms shifted over time and varied across social and local contexts on the basis of a sample of almost 100 000 sibling pairs born between 1810 and 1870 in the Dutch province of Zeeland, a society undergoing industrialization and demographic transition.

Corroborating the main findings of the study by Kohler et al. (1999), we found a significant increase in the expression of heritabilities and a fading of environmental influences for women born since the 1840s, who started their reproductive careers in the 1870s or later, after the onset of the fertility decline in this region. By including covariates measuring the degree of urbanization, religion, and social class we were able to identify

what circumstances reduced the social control of fertility and led to a heightened expression of genetic influences on female fertility behavior. Our findings show that the social influence on fertility decreased for women born in towns as compared to those born in the countryside, and that it were particularly women from the urban unskilled working class and the highest social strata whose fertility behavior was less determined by social conditions. In the countryside, daughters of farm workers too experienced a fall in the social control of fertility behavior. Finally, heritabilities were more strongly expressed in the fertility behavior of women who grew up in places that were characterized by a relatively liberal religious climate as opposed to women who grew up in places with high proportions of Catholics or Orthodox Protestants. The varying expression of heritabilities, but also the historical shifts in the social control of fertility behavior with changing social, economic and religious circumstances has important consequences not only for our understanding of the historical fertility decline, but also for grasping current and future trends in fertility behavior in Western and non-Western societies.

First of all, previous research on the historical fertility decline has emphasized that more equal, less patriarchal, gender relations may have been an important prerequisite for the large-scale adoption of birth control. This study, as well as Kohler et al.'s earlier work, is in line with research showing the instrumental role that women played in household bargaining and decision-making processes around childbearing. Our results could indicate that enhancement of women's position took place under certain conditions, i.e. in more open, tolerant urban areas, under improved economic circumstances for lower class groups (increased wage labor opportunities), and in less normative religious climates. Increased gender equity most likely was directly or indirectly associated with the diffusion of modern attitudes and practices of family limitation. Such favorable circumstances for enhancing women's status may be an important precondition for population change in present-day non-Western societies as well.

Secondly, the strength of the intergenerational transmission of fertility is not stable, but varies over time. Previous research has shown that the correlation between parents' and children's fertility has increased in Western societies, particularly since the second demographic transition. Nowadays, the intergenerational effect is considerable. The influence of parents' fertility on their children's fertility behavior is of a magnitude similar to that of educational level on fertility (Murphy & Wang, 2001). This long-term development has several repercussions. From a societal point of view, the strengthening of intergenerational continuities leads increasingly to a gap between child-poor and child-rich families. Whereas in the West-European Marriage Pattern the differences between men and women who bore children and those that remained celibate could be mainly found *within families*, we are now moving towards a situation with increasing inequality *across families*. This has consequences for the care provision for the elderly in our rapidly ageing societies with declining welfare state arrangements. For policy makers devising population and family policies aimed at countering low and lowest-low fertility as well as social inequalities in the well-being of the elderly, it is important to know to what extent fertility behavior is innate or learned. This study showed how social and heritable aspects of human fertility interact and under what 'malleable' circumstances.

Acknowledgements

This study was supported by a VIDI Innovational Research Grant from the Netherlands Organization for Scientific Research, for the project entitled 'The Power of the Family: Family Influences on Long-Term Fertility Decline in Europe, 1850–2010' (contract grant number 452-10-013). Earlier

versions of this article were presented during the international seminar on 'The intergenerational transmission of reproductive behavior: comparative perspectives' (Leuven, Belgium, 9–10 June 2011), organized by the Historical Demography Network, funded by FWO-Vlaanderen and during the international seminar on 'Combining Biology and Social Science in Life Course Studies' (Helsinki, 8–9 September 2011, organized by the Network on Quantitative Methods in the Social Sciences, funded by the European Science Foundation. The authors wish to thank the participants of both seminars for their valuable comments and insights.

Notes

1. Other examples of the use of historical databases for the study of intergenerational processes of demographic behavior can be found in the papers belonging to the special issue of *Human Nature* (2008) that resulted from a workshop on 'Inherited dimensions of human populations in the past', which was held in Menorca in 2005.
2. Non-shared environmental influences refer to effects not explained by heredity or by shared environment, including measurement error.

References

- Alter, G. (1998). *Family and the female life course. The women of Verviers, Belgium, 1849–1880*. Madison: The University of Wisconsin Press.
- Axinn, W. G., Clarkberg, M. E., & Thornton, A. (1994). Family influences on family size preferences. *Demography*, 31(1), 65–79.
- Becker, G. (1981). *A treatise on the family*. Cambridge, MA: Harvard University Press.
- Bernardi, L. (2003). Channels of social influence on reproduction. *Population Research and Policy Review*, 22(5/6), 427–555.
- Bittles, A., Murphy, M., & Reher, D. (2008). Inherited dimensions of human populations in the past. *Human Nature*, 19(1), 1–6.
- Bongaarts, J., & Watkins, S. C. (1996). Social interactions and contemporary fertility transitions. *Population and Development Review*, 22(4), 639–682.
- Coale, A. J. & Watkins, S. C. (Eds.). (1986). *The decline of fertility in Europe*. Princeton: Princeton University Press.
- Corbo, R. M., Gambina, G., & Scacchi, R. (2012). How contemporary human reproductive behaviors influence the role of fertility-related genes: The example of the P53 gene. *PLoS ONE*, 7(4), e35431.
- DeFries, J. C., & Fulker, D. W. (1985). Multiple regression analysis of twin data. *Behavior Genetics*, 15(5), 467–473.
- Duncan, O. D., Freedman, R., Coble, J. M., & Slesinger, D. P. (1965). Marital fertility and size of family of orientation. *Demography*, 2, 508–515.
- Easterlin, R. A. (1975). An economic framework for fertility analysis. *Studies in Family Planning*, 6(3), 54–63.
- Engelen, T., & Kok, J. (2003). Permanent celibacy and late marriage in the Netherlands, 1890–1960. *Population*, 58, 67–96.
- Franken, T., & Adriaanse, L. (2004). *Op stoom! Industrieel erfgoed in Zeeland (1850–1970)*. Middelburg: Provincie Zeeland.
- Guo, G., & Tong, Y. (2006). Age at first sexual intercourse, genes, and social context: Evidence from twins and the dopamine D4 receptor gene. *Demography*, 43(4), 747–769.
- Hajnal, J. (1965). European marriage patterns in perspective. In D. V. Glass & D. E. C. Eversley (Eds.), *Population in history. Essays in historical demography*. London: Arnold.
- Hatemi, P. K., Hibbing, J. R., Medland, S. E., Keller, M. C., Alford, J. R., Smith, K. B., & Eaves, L. J. (2010). Not by twins alone: Using the extended family design to investigate genetic influence on political beliefs. *American Journal of Political Science*, 54(3), 798–814.
- Kendler, K. S. (2001). Twin studies of psychiatric illness: An update. *Archives of General Psychiatry*, 58(11), 1005–1014.
- Knippenberg, H. (2003). Van verzuilde naar zwevende kiezers. De politieke kaart in de negentiende en twintigste eeuw. In E. Beeking, O. Boonstra, T. Engelen & H. Knippenberg (Eds.), *Nederland in verandering. Maatschappelijke veranderingen in kaart gebracht 1800–2000* (pp. 123–152). Amsterdam: Aksant.
- Kohler, H. -P. (2001). *Fertility and social interaction*. New York: Oxford University Press.

- Kohler, H. -P., Rodgers, J. L., & Christensen, K. (1999). Is fertility behavior in our genes? Findings from a Danish twin study. *Population and Development Review*, 25(2), 253–288.
- Kohler, H. -P., Rodgers, J. L., & Christensen, K. (2002). Between nurture and nature: The shifting determinants of female fertility in Danish twin cohorts. *Biodemography and Social Biology*, 49(3–4), 218–248.
- Kok, J. (1998). “Vrijt daar je zijt”: huwelijk en partnerkeuze in Zeeland tussen 1830 en 1950. *Zeeland. Over Zeeuwse mensen. Demografische en sociale ontwikkelingen in Zeeland in de negentiende en twintigste eeuw*, 7, 131–143.
- Lesthaeghe, R. (1980). On the social control of human reproduction. *Population and Development Review*, 6(4), 527–548.
- Lesthaeghe, R. (1983). A century of demographic and cultural change in Western Europe: An exploration of underlying dimensions'. *Population and Development Review*, 9(3), 411–435.
- Miller, W. B. (1986). Proception: An important fertility behavior. *Demography*, 23(4), 579–594.
- Miller, W. B. (1992). Personality traits and developmental experiences as antecedents of childbearing motivation. *Demography*, 29(2), 265–285.
- Mitterauer, M., & Sieder, R. (1983). *The European family: Patriarchy to partnership from the middle ages to the present*. Chicago: University of Chicago Press.
- Murphy, M. (1999). Is the relationship between fertility of parents and children really weak? *Social Biology*, 46, 122–145.
- Murphy, M., & Wang, D. (2001). Family-level continuities in child-bearing in low-fertility societies. *European Journal of Population/Revue européenne de Démographie*, 17(1), 75–96.
- Pearson, K., & Lee, A. (1899). On the inheritance of fertility in mankind. *Philosophical Transactions of the Royal Society of London, Series A*, 192, 282–330.
- Plomin, R., DeFries, J. C., McClearn, G. E., & McGuffin, P. (2008). *Behavioral genetics*. New York: Worth Publishers.
- Pluzhnikov, A., Nolan, D. K., Tan, Z., McPeck, M. S., & Ober, C. (2007). Correlation of intergenerational family sizes suggests a genetic component of reproductive fitness. *The American Journal of Human Genetics*, 81(1), 165–169.
- Priester, P. (1998). *Geschiedenis van de Zeeuwse landbouw circa 1600–1910*. 't Goy-Houten: HES Uitgevers.
- Rodgers, J. L., Hughes, K., Kohler, H. -P., Christensen, K., Doughty, D., Rowe, D. C., & Miller, W. B. (2001). Genetic influence helps explain variation in human fertility: Evidence from recent behavioral and molecular genetic studies. *Current Directions in Psychological Science*, 10(5), 184–188.
- Rodgers, J. L., Kohler, H. -P., Kyvik, K. O., & Christensen, K. (2001). Behavior genetic modeling of human fertility: Findings from a contemporary Danish twin study. *Demography*, 38(1), 29–42.
- Rodgers, J. L., Rowe, D. C., & Li, C. (1994). Beyond nature versus nurture: DF analysis of nonshared influences on problem behaviors. *Developmental Psychology*, 30(3), 374–384.
- Steenhof, L., & Liefbroer, A. C. (2008). Intergenerational transmission of age at first birth in the Netherlands for birth cohorts born between 1935 and 1984: Evidence from municipal registers. *Population Studies*, 62(1), 69–84.
- Udry, J. R. (1996). Biosocial models of low-fertility societies. *Population and Development Review*, 22, 325–336.
- Van Bavel, J. V., & Kok, J. (2005). The role of religion in the Dutch fertility transition: Starting, spacing, and stopping in the heart of the Netherlands, 1845–1945. *Continuity and Change*, 20(2), 247–263.
- Van Bavel, J., & Kok, J. (2009). Social control and the intergenerational transmission of age at marriage in rural Holland, 1850–1940. *Population (english edition)*, 64(2), 341–360.
- Van Bodegom, D., Eriksson, U. K., Houwing-Duistermaat, J. J., & Westendorp, R. G. J. (2012). Clustering of child mortality in a contemporary polygamous population in Africa. *Biodemography and Social Biology*, 58(2), 162–172.
- Van Heek, F. (1956). Roman-Catholicism and fertility in the Netherlands. *Population Studies*, 10, 125–138.
- Van Leeuwen, M. H. D., & Maas, I. (2010). SPSS recode job HISCO into HISCLASS. Retrieved from <http://historyofwork.iisg.nl/>
- Van Leeuwen, M. H. D., & Maas, I. (2011). *HISCLASS. A historical international social class scheme*. Leuven: Leuven University Press.

- Van Leeuwen, M. H. D., Maas, I., & Miles, A. (2002). *HISCO: Historical international standard classification of occupations*. Leuven: Leuven University Press.
- Van Poppel, F. W. A. (1985). Le retard du déclin de la fécondité néerlandaise : rôles de la religion, de la catégorie socio-économique et de la région. *European Journal of Population*, 1(4), 347–373.
- Van Poppel, F. (1992). *Trouwen in Nederland. Een historisch-demografische studie van de 19^e en vroeg 20^{ste} eeuw*. Wageningen: Dissertation Landbouw Universiteit Wageningen.
- Van Poppel, F., Monden, C., & Mandemakers, K. (2008). Marriage timing over the generations. *Human Nature*, 19(1), 7–22.
- Watkins, S. C. (1990). From local to national communities: The transformation of demographic regimes in Western Europe, 1870–1960. *Population and Development Review*, 16(2), 241–272.
- Woolridge, J.M. (2003). *Introductory econometrics. A modern approach*. Mason, OH: Thomson/South-Western.
- Zieleniewski, A. M., Fulker, D. W., DeFries, J. C., & LaBuda, M. C. (1987). Multiple regression analysis of twin and sibling data. *Personality and Individual Differences*, 8(6), 787–791.
- Zijdeman, R. L. (2010). *Status attainment in the Netherlands, 1811–1941. Spatial and temporal variation before and during industrialization*. (unpublished PhD dissertation, ICS dissertation series, nr. 164).