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Detecting Deliberate Fertility Control in Pre-transitional Populations: Evidence from six German villages, 1766–1863

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Abstract

This article deals with the possible existence of deliberate fertility control before the fertility transition. The timing of the fertility response to economic stress, as measured by fluctuations in grain prices, is used as a measure of deliberate, but non-parity specific, control. Birth histories from six German villages (1766-1863), including information on occupation of the husband, are used together with community-wide grain price series in a micro level event-history analysis. The results show a negative fertility response to grain prices both in the year immediately following the price change, and with a one-year lag. The response was also highly different between socioeconomic groups, with the most pronounced effects among the unskilled laborers. Moreover, the response in this group was very rapid, already present 3-6 months after the price change. Because all involuntary fertility responses to economic hardship (e.g. malnutrition, spousal separation, and spontaneous abortion) come with a considerable time lag, the existence of such a rapid response among the lower social groups suggests that individual agency (deliberate control) was an important aspect of reproductive behavior also before the fertility transition.

Keywords: Deliberate fertility control, natural fertility, historical demography, Cox proportional hazards model, economic stress

Mise en évidence d’un contrôle volontaire des naissances dans des populations pré-transitionnelles: Le cas de 6 villages allemands, 1766-1863

Abstract

This article deals with the possible existence of deliberate fertility control before the fertility transition. The timing of the fertility response to economic stress, as measured by fluctuations in grain prices, is used as a measure of deliberate, but non-parity specific, control. Birth histories from six German villages (1766-1863), including information on occupation of the husband, are used together with community-wide grain price series in a micro level event-history analysis. The results show a negative fertility response to grain prices both in the year immediately following the price change, and with a one-year lag. The response was also highly different between socioeconomic groups, with the most pronounced effects among unskilled laborers. Moreover, the response in this group was very rapid, already present 3-6 months after the price change. Because all involuntary fertility responses to economic hardship (e.g. malnutrition, spousal separation, and spontaneous abortion) come with a considerable time lag, the existence of such a rapid response among the lower social groups suggests that individual agency (deliberate control) was an important aspect of reproductive behavior even before the fertility transition.

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Résumé

Cet article s’intéresse à l’existence possible d’un contrôle volontaire des naissances avant la transition de la fécondité. Le calendrier de l’évolution de la fécondité en fonction de la tension économique, mesurée par les fluctuations du prix des céréales, est utilisé comme mesure de contrôle volontaire des naissances, mais non lié à la parité. Des histoires génésiques comprenant la catégorie professionnelle du père, provenant de six villages allemands (1766-1863), sont utilisées en association avec des séries temporelles des prix des céréales au niveau communautaire pour effectuer une analyse biographique au niveau individuel. Les résultats indiquent une évolution négative de la fécondité en fonction du prix des céréales, à la fois dans l’année qui suit le changement de prix et l’année d’après. Cette évolution était très variable en fonction du groupe social, avec un effet maximal parmi les travailleurs non qualifiés. De plus, la réaction dans ce dernier groupe était très rapide, car déjà visible 3 à 6 mois après le changement de prix. Sachant que toutes les modifications involontaires de fécondité face aux difficultés économiques (par exemple à la malnutrition, aux ruptures conjugales, et aux avortements spontanés) ne se produisent qu’après un délai très long, l’existence d’une réaction si rapide parmi les groupes sociaux les plus défavorisés laisse penser que l’initiative individuelle (contrôle volontaire) était déjà, avant la transition de la fécondité, un aspect important du comportement reproducteur.
Mots-clés: Contrôle délibéré des naissances, fécondité naturelle, démographie historique, Modèle de Cox, pression économique

1 Introduction

It has been a widely held view in historical demography – stressed for instance in the conclusions of the European Fertility Project – that the great fertility decline during the first demographic transition was caused by, or at least intimately connected to, the advent and diffusion of parity-dependent fertility control (see, e.g., Cleland and Wilson 1987; Coale and Watkins 1986; Knodel 1977, 1987, 1988). This led to a limitation of family size and to declining marital fertility; before the decline however, family size was not limited in a deliberate way (Knodel 1978, 1987, 1988; Wilson 1984). Even though it was sometimes acknowledged that non-parity specific control might have been practiced, it was usually judged not to have been of great importance before, or early, in the fertility decline (Knodel 1987). French demographer Louis Henry coined the term natural fertility to describe this absence of parity-specific fertility control, which characterized most pre-transitional societies (Henry 1961). In the literature however, this predominance of natural fertility in pre-transitional contexts often seems to have been extended to mean not only the absence of parity-specific control, but also the absence of deliberate fertility control more generally. Thus, prolonged breastfeeding, low coital frequency, and other factors having a fertility depressing effect, are usually not assumed to have been used deliberately to limit family size, or to adjust birth intervals (see, e.g., Knodel 1987, 1988).

According to this interpretation, families in pre-transitional societies took no deliberate actions regarding childbearing within marriage. The fertility transition therefore, resulted from the innovation of families beginning to control their fertility in a parity-dependent way, with socioeconomic change playing a secondary role at best (see Coale and Watkins 1986 for a summary account). Pre-transitional differences in marital fertility levels would then mainly have been related to collective norms rather than to individual agency.

However, according to some anthropologists these collective norms could be critically reinterpreted according to individual needs. For example, abstinence, abortion and abandonment were methods used in the past by families to control reproduction to face changing situations and without necessarily having a target family size (Skinner 1997).

In addition, a number of studies over recent decades have argued both for the importance of socioeconomic factors in the fertility decline (e.g. Brown and Guinnane 2002, 2007; Dribe 2009; Galloway et al. 1994; Schultz 1985) and for the role of non-parity specific control (spacing) in the early phases of the fertility transition in the United States and Britain (Anderton and Bean 1985; Bean et al. 1990; Crafts 1989; David and Sanderson 1986; Haines 1989; Morgan 1991; Szreter 1996).

According to this revisionist view, families might also have deliberately controlled fertility in societies where parity-specific stopping was largely absent. The problem is that it is very difficult to measure the practice of deliberate, but non-parity specific, control in a preindustrial context using only demographic and other information from various historical registers, which could also explain the preoccupation with parity-specific control in much of the literature (Knodel 1987). Some studies have looked at the timing of births in relation to the number of surviving children or previous experience of child deaths as an indication of deliberate, non-parity-specific, control (David and Mroz 1989a, 1989b; Mroz and Weir 1990; Reher and Sanz-Gimeno 2007; Van Bavel 2004, Van Bavel and Kok 2004), or used the absence of a parity effect on the duration of closed birth intervals as an indicator of spacing (Van Bavel 2004; Van Bavel and Kok 2004).

In a recent study of a sample of parishes in southern Sweden, Bengtsson and Dribe (2006) present a different approach, where they use the timing of the fertility response to economic stress as an indicator of deliberate, but largely non-parity specific, control in a rural pre-transitional society with no evidence of parity-specific control. The simple idea is that a fertility response very soon after an economic change (price change in this case) is unlikely to be caused by anything other than deliberate postponement of childbirth. Non-deliberate fertility responses through malnutrition, spousal separation, or spontaneous abortions all imply a prolonged time lag between economic shocks and the fertility outcome, as will be explained in more detail in the following section. Hence, the clear response in fertility in the months immediately after the price change in the Swedish study supports the hypothesis that families took active action to avoid having children in difficult times, and deliberately postponed childbirth in years when they foresaw bad economic times.

The aim of this article is to adopt the same approach in a different geographic context to see if the results from southern Sweden have more general application. We study the timing of the fertility response to grain price fluctuations in different communities in Germany between 1766 and 1863, controlling for socioeconomic status and some demographic variables. The sample of parishes covers three different areas of Germany, in the north, the middle, and the south. We use demographic and occupation data from village genealogies (see Knodel 1988) and local level price data taken from towns in the three areas (Jacks 2005).

In the following section, we discuss the analytical framework followed by a description of the area under study and the data and methods used. We then present the empirical results, followed by a concluding discussion.

2 Analytical framework

Clear responses of fertility, mortality, and nuptiality to short-term changes in food prices or real wages have been found in aggregate studies of several preindustrial countries, including Germany, indicating the high degree of vulnerability in those societies (see, e.g., Bengtsson and Ohlsson 1985; Galloway 1988; Hammel and Galloway 2000; Lee 1981; Weir 1984). The fertility response was usually much stronger and more consistent than that of mortality (Galloway 1988) and was not dependent upon fluctuations in marriage (Bengtsson 1993; Lee 1975). Micro-level studies of different contexts have also shown the same marital fertility response to economic stress, and also that the response differed considerably across socioeconomic groups (Bengtsson and Dribe 2006, 2010). In this section, we present an analytical framework for detecting deliberate fertility control in times of economic stress, based on the one outlined by Bengtsson and Dribe (2006). Marital fertility can be affected by economic stress caused by changes in food prices in several ways. Our framework is based on the timing of the response in relation to the price change, which we assume took place in the fall after the harvest. Fig. 1 summarizes the hypothetical time lags for the different mechanisms producing the fertility response.

Figure 1 here

Firstly, economic stress may influence exposure to sexual intercourse by inducing people to migrate temporarily in search of work, provided that alternative labor markets were within reach, leading to the separation of spouses if women stayed behind while men went looking for work. The groups that potentially might have migrated temporarily are different types of workers who were not hired on annual contracts. However, in a grain producing economy, such as the areas under study, we expect most farm laborers to have remained until after the harvest, because work was usually available until all crops had been harvested, even in bad economic years. The time to leave to find work would be shortly after the harvest, which would depress fertility at least nine months later and for as long as the absence lasted plus nine months gestation time. Another three months later, which we assume is the average waiting time to conception, a normal level of fertility would be attained. Seasonal migration appears to have been quite common in preindustrial Germany (Hochstadt 1981, 1983), although we lack more precise information for the communities under study. For example, in the eighteenth century, thousands of poor peasants migrated every summer from the northwest of Germany to Holland to help with the hay harvest (Hochstadt 1981, 1983). The so-called *Hollandsgehen* was a mass seasonal flux which certainly involved at least one of the north-western villages included in our analysis (Knodel 1988, p. 519), but we do not know the extent to which this kind of migration was connected to short-term economic stress. Evidence from southern Sweden in the nineteenth century indicates that migration did not respond to fluctuations in grain prices (Dribe 2003).

Secondly, families may deliberately postpone childbirth in times of economic hardship by using contraception (mainly abstinence or withdrawal), or through induced abortion. Induced abortion will indeed give a faster fertility response than contraception, perhaps as short as six months, because abortion usually takes place in the first trimester (see, e.g., Hammel and Galloway 2000). Some scholars have argued that, although illegal, inducing abortions very early in gestation by taking different drugs or herbs to regain menstruation was quite common in Europe before 1900 (McLaren 1990; Shorter 1982, chap. 8) and was even considered to be similar to contraception (McLaren 1990, pp.160–161). In their study of the eighteenth- and nineteenth-century Balkans, Hammel and Galloway (2000) argued that the deliberate fertility response to price fluctuations observed resulted mainly from induced abortion. Van de Walle (1997), on the other hand, argued that women used various herbs and plants mainly to stimulate the natural menstruation cycle rather than to induce abortion. Nevertheless, it is difficult to rule out the possibility that induced abortion early in gestation was used as one method of controlling fertility among married women in the areas under study. According to a survey of rural Protestant clergy in Germany during the mid-1890s, abortion was not widespread and was mainly practiced by unmarried women (Knodel 1988, p. 315). German legislation also explicitly punished abortion from at least 1851, when the Penal Code for Prussia was codified (David et al. 1988, p. 82). For earlier periods there is some evidence of abortions from transcriptions of trials and other court archives. Even though it is difficult to establish the frequency of this phenomenon, the sources give an idea about the population concerned; abortion trials involved maidens, servants, prostitutes, and nuns but rarely married women (Van de Walle 1999, pp. 124–125).

Some kinds of post-birth control, like infanticide or child abandonment, could also possibly be connected to economic stress. However, according to the evidence from the period under study, it mostly involved young, unmarried domestic servants (Ulbricht 1985, p. 217). Those convicted of infanticide or child abandonment were unmarried women in dependent positions in agriculture and domestic service (Richter 1998, p. 513). As we focus on continued childbearing (second and higher order births) this form of post-birth control is most likely of very limited significance in our context.

Because the main concern of this study is the distinction between deliberate and involuntary fertility responses to short-term economic stress, and not the actual methods that were practiced in the deliberate timing of childbirth, it is not significant for our purposes whether families controlled fertility through withdrawal, abstinence, or induced abortion early in gestation. These contraceptive actions should all be viewed as methods to deliberately affect the timing of childbirth, and it is quite clear that people in the past were aware of different traditional contraceptive methods (e.g. McLaren 1990; Santow 1995).[1] It is also reasonable to assume that rural people were able to form a general idea about local harvest outcomes and food price developments at least during the spring, i.e. long before fall when the harvest was stored in the barns and the new price of grain became known. Evidence for this can be seen in early twentieth-century text books on farming practices (e.g. Rydberg et al. 1919) and in efforts by official agencies in eighteenth- and nineteenth-century Sweden to collect harvest forecasts at the county level in order to estimate likely harvest outcomes

[1] However, based on literary evidence, Van de Walle (2000) and Van de Walle and Muhsam (1995) argued that these methods were practiced mainly outside marriage in the preindustrial period.

(Utterström 1957, p. 194; see also the discussion in Bengtsson and Dribe 2006). Thus, a deliberate fertility response could become evident very quickly after the price change and continue until conditions improved, plus some nine months or slightly longer due to the waiting time to conception and gestation. Even in cases when it was impossible to foresee economic problems, the effect of contraception would still be experienced well within a year after price change in the fall following the harvest.

Thirdly, fertility may have been affected involuntarily by lower fecundity and temporary sterility, and possibly by a higher degree of spontaneous abortions, following malnutrition or increased exposure to disease. There seems to be general agreement that fertility can be affected by periods of severe but temporary malnutrition (i.e. subfecundity due to starvation, stress, and/or heavy work load), although there is disagreement concerning the effects on fertility of chronic but less severe malnutrition (Bongaarts 1980; Frisch 1978; Menken et al. 1981; Scott and Duncan 2000; Yong and Wang 2005). Because we are dealing solely with short-term effects in this study, we can safely conclude that temporary and severe malnutrition may have led to the cessation of ovulation, loss of libido, and reduced sperm production, all of which would have lowered fecundity and thereby fertility. Such an effect of malnutrition would have influenced fertility with at least a nine-month lag. Malnutrition may also have affected fertility through spontaneous abortions. Because the risk of fetal loss is highest during the first trimester of pregnancy (Wood 1994, Table 6.7), such malnutrition effects on fertility through spontaneous abortions should come with at least a six-month lag. As malnutrition in a rural preindustrial society was usually most severe during the spring, when food became scarce, we would expect the fertility effects to have appeared 12-15 months after food prices increased, depending on whether the reduced fertility was due to spontaneous abortions or infecundity. Thus, regardless of the mechanisms, malnutrition should have affected fertility with a considerable delay compared with a deliberate response.

Finally, short-term economic stress might have influenced fertility indirectly through lactational infecundability, following changes in breastfeeding. Assuming that people were aware of this effect of breast-feeding, it might have been a deliberate way to avoid pregnancy. However, although there is evidence that the fertility-depressing effect of breast-feeding was known to people in the past, the most common view seems to be that regional differences in breast-feeding practices were more related to customs and culture than to reproductive agency on the part of the families (see, e.g., Knodel 1987, 1988). Women may also have been forced to breast-feed longer in difficult times as a result of lack of food. On the other hand, one could also argue that they had to breast-feed for shorter periods because of the need to work harder during harsh years. Thus, there are several possible links between short-term economic stress and breast-feeding. Bad economic years may have prolonged or shortened breast-feeding, and breast-feeding could also have been used deliberately to control fertility, which makes it difficult to have any *a priori* expectations of how economic stress influenced fertility through breast-feeding. Regardless, we expect any effects to have appeared at least a year after prices increased.

One problem with using aggregated data to analyze the impact of economic fluctuations on fertility, which has been the main approach used in the literature, is the difficulty in distinguishing between the different potential mechanisms previously identified. Another, related problem is that it is impossible to disaggregate the results by socioeconomic status. This is very important because farmers can be expected to have responded quite differently than farm laborers to changes in market prices of grain; farmers were producers and benefited from high prices, while laborers suffered due to their dependence on the market for buying food (see Abel 1980, pp. 9–11; Dribe 2000, chap. 7). Farmers and the higher occupations should have been far less vulnerable to price changes than laborers because they had better opportunities to store wealth (grain, livestock, and valuable items) and because they had more chances to borrow money as well as the opportunity to adjust production costs.

In this study, we use micro-level individual data, enabling us to study the fertility response to short-term economic stress in much more detail than is possible using aggregated data. We are able to distinguish the fertility response between different socioeconomic groups (based on occupation of the father), controlling for demographic factors, and to study the timing of the response in great detail. Clearly, the timing of the response is crucial to understand the mechanisms in operation, as shown previously in Fig. 1. Lowered fertility very soon after the economic downturn—say, within six to nine months—is strongly indicative of deliberate control as a result of families foreseeing bad times. If, on the other hand, the response was lagged for more than nine months, several factors, both intentional and unintentional, could have been at work.

3 Study area

The villages under study represent a considerable range of demographic conditions and are quite different from a geographical point of view, covering the north (Middels), the center (Braunsen and Massenhausen) and the south (Kappel, Rust and Öschelbronn) of Germany (see map). Kappel and Rust are situated in the southern region of Baden, close to the Rhine. In both these villages, the economy was based on fishing and agriculture, with the latter dominating. Because the greater part of the land was concentrated in the hands of a small group of wealthy farmers, the sharp social differences became more and more evident. It is important to underline that, before embankment works, especially in Kappel, harvests were frequently ruined by flooding, provoking hunger and subsistence crisis. Öschelbronn, Middels and the two villages of Braunsen and Massenhausen in Waldeck, were also dominated by agriculture, and here migration fluxes resulted from the growing pressure on the scarce sources and the limited economic opportunities (Knodel 1988).

Map here

The demography of these villages has been analyzed in great detail by John Knodel in a long-term research project summarized in his 1988 book *Demographic Behavior in the Past*. He also studied the emergence of family limitation (parity-specific control) using traditional demographic techniques in a series of studies (e.g. Knodel 1977, 1978, 1987). According to these analyses, even though total marital fertility over age 20 was above 8.5 (see Table 1 below) during the whole period in question, there was nonetheless considerable variation in marital fertility between different villages. During the eighteenth and the nineteenth centuries, the marital fertility indexes of two Bavarian villages (not included in the present analysis) showed the highest levels (the Coale I_g index was 0.9 in the period 1800–1924), whereas Middels in East Friesland had the lowest (about 0.6 still in 1800–1924). The other villages had marital fertility between these levels. These differences are probably connected to differences in infant feeding practices, as breastfeeding was almost absent in the two Bavarian villages while it was practiced in Middels (Knodel 1988).

Table 1 here

In addition, focusing on fertility levels in the pre-transitional period, Knodel found evidence that parity-specific control was largely absent in these populations until the second half of the nineteenth century, as demonstrated for example by Coale-Trussel *m* values around 0.2 or less as shown in Table 1 (see Coale and Trussel 1974, 1978 for the underlying methodology). Even if the steady rise of the *M* index reveals an increasing marital fertility at younger ages, the age at which women bore their last child was late, and was apparently not influenced by previous experience with infant and child deaths. It was generally around 40 years, without significant differences between villages, which is similar to the levels in other European populations before the fertility decline (Knodel 1988).

In general, deliberate stopping appears to have been the major behavioral mode through which marital fertility came under volitional control and it is the major feature of reproductive change during the initial phase of the fertility transition. Thus, the initial stage of the fertility transition was primarily the result of the introduction of family limitation through stopping behavior in this area (Knodel 1987).

Finally, it is interesting to note that Knodel did not find any pronounced differences by occupation in pre-transitional marital fertility (Knodel 1978). In fact, socioeconomic differences within villages appear to have been less evident than differences found in the average fertility levels between villages. Only after the beginning of the fertility transition did occupational differences become more visible (Knodel 1988, pp. 293–297).

4 Data

The data used is based on a collection of village genealogies or *Ortssippenbuch*, literally the "book of local kinsmen".[2] This study is based on a sample of 6 of the 14 villages used by Knodel. It is only for these six villages (Brausen, Kappel, Massenhausen, Middels, Öschelbronn and Rust) that the data include all individuals in the villages. Only pre-selected couples were coded for the other eight villages. Even if most of the selected couples in the sample were locally married, unlike the typical genealogies in other countries, which were not generally representative of the entire population, this source includes all the vital events of all families that were registered in the village parish registers. The organization of the data is based on family histories for each nuclear family unit and accords with the same logical

[2] Information about the collection and the characteristics of the *Ortssippenbucher* is provided in chapter 2 of Knodel (1988). These data were digitized and archived by the Population Studies Center of the University of Michigan. On the website of the Population Studies Center it is possible to download further documentation: http://www.psc.isr.umich.edu/dis/data/.

scheme as the traditional family reconstitution. However, there are some characteristics in the original dataset which are important to underline. Firstly, the original data includes all couples for which the date of marriage was known, and individual codes allow the linkage of couples to all children ever born. Dates of birth and death are given for the husband and the wife, although in many cases this information is missing for one or both spouses. As in other family reconstitution studies, missing death dates makes it impossible to determine the time at risk of giving birth. Knodel defined a set of restrictions in order to select a reduced sample of individuals with complete information (Knodel 1988, p. 464).

There may be some concern regarding potential under-registration of stillbirths in this kind of genealogical data, because these would have no genealogical relevance. The proportion of stillbirths as recorded in the village genealogies varied considerably from village to village (Knodel 1988, pp. 281, 494). According to our calculations, the stillbirth rate in the six considered villages was 33 per 1000 births during the period 1766–1863. This value is within the range of 25–65 per 1000 births, which has been estimated for historical European populations (Woods 2005: 153), as well as the 26–48 per 1000 births at the district level in Germany, reported in the official statistics for the period 1875–77 (Knodel 1988, pp. 481–482).

The information in the original dataset has been reshaped in a longitudinal form suited for event-history analysis. As will be explained in the methods section below, we include only closed birth intervals instead of analyzing only women whose full reproductive history is known (i.e. where the death is observed), because this would have reduced the sample size considerably, and would also have entailed potential selection bias from only looking at the stayer population (see, e.g., the discussion in Kasakoff and Adams 1995; Ruggles 1992, 1999; Wrigley 1994). Twins are treated as one childbirth (delivery). In total, the reproductive life histories of 3,401 married women have been reconstituted, taking into account more than 13,000 births in the period 1766–1863. The distributions of women and births in the six villages during this period are shown in Table 2.

Table 2 here

The occupation of the husband at marriage is reported in the original data. We coded all occupations into HISCO (Historical International Standard Classification of Occupation), and classified them into HISCLASS (Van Leeuwen et al. 2002; Van Leeuven and Maas 2005).[3] HISCO has become the standard coding scheme for historical occupations and is used as a basis of different class schemes (see, e.g., Van de Putte 2006; Van Leeuwen and Maas 2005). In the analysis we use a seven-category classification based on HISCLASS: 1. Higher manager and professionals, 2. Lower managers, lower professionals, clerical and sales, 3. Skilled workers, 4. Farmers, 5. Lower skilled workers, 6. Unskilled workers, and 7. No occupation. The two highest status groups (1 and 2) can be expected to have had access to resources implying that they were not severely affected by fluctuations in grain prices. The lowest group of unskilled workers we expect to have been most affected by grain prices as they were neither primary producers of grain, nor had assets or other resources enough to live from savings in times of scarcity and high prices. The situation for skilled workers, and lower skilled workers, is more uncertain. Among the skilled workers there were probably a substantial number of people with considerable assets, who might have had fair opportunities to hedge against risks of high grain prices. On the other hand, they might have been affected by declining demand for their products, as consumers had to spend a higher proportion of their income on food, which makes it difficult to judge their vulnerability to food price variations *a priori*. At least in times of more normal variations in prices, farmers might

[3] The website of the History of Work Information System contains documentation, bibliography and information about both the historical international classification of occupations (HISCO) and the social class scheme HISCLASS: http://historyofwork.iisg.nl/index.php. The classification into HISCLASS was made using the recode job: hisco_hisclass12a_@.inc, May 2004, see http://historyofwork.iisg.nl/list_pub.php?categories=hisclass

actually have benefited from high prices, provided that the local harvest was not worse than average (see the discussion in Dribe 2000, chap. 7). Finally, it should be noted that the “no occupation” category includes not only the non-professional status in HISCO but also the cases in which the professions were unknown in the original data.

Table 3 shows the distribution of women in the sample by their husband´s socioeconomic status. While farmers, skilled and unskilled workers are numerous in all villages, specific differences between villages for other categories reflect the peculiarities caused by variation in the local production structure.

Table 3 here

We use fluctuations in grain prices to measure short-term economic stress. We chose the price of rye – an important basic bread grain in the period under study – rather than a composite index.[4] In the pre-industrial era, rye made up a considerable proportion of the wages of laborers (Hagen 1986) and rye cultivation was very important in German agricultural production (Friedmann 1978). During this period, in countries like England, France and Germany, rye was the usual bread grain of the laboring population, while wheat was primarily a luxury food (Ashley 1921). Indeed, in early nineteenth-century Prussia, four times as much rye as wheat was used for bread (Ashley 1921). It is quite clear however, that short-term price fluctuations were rather similar between the grains, and thus to take a different approach would not have changed the picture in any noticeable way. We used prices from three different places to represent the different areas of Germany included in the study (see the map above). For the northern village we used prices from the town of Emden. There are some gaps in this series, so data from nearby Lüneburg and Stade were used to supplement it (in a total of 10 years). For the villages in the middle of Germany we used prices from Göttingen, which were available for the whole period, and for the southern

[4] Prices were collected by David Jacks and all data is available online at: http://www.sfu.ca/~djacks/data/prices/prices.html (see also Jacks 2004, 2005).

villages we used prices from Heilbron. However, the latter are only available until 1832, and after this date we used Göttingen prices for the southern villages also. Prices used refer to harvest years, here defined as the period October 1 – September 30. We have used prices noted in October to December, depending on the locality and availability of data. Thus, the prices reflect conditions after the harvest, and we want to assess the timing of the fertility response in relation to the price change in the fall. From these prices we calculated three different indexes, each representing an area of Germany where the villages are located (see Fig. 2).

Figure 2 here

In order to measure short-term fluctuations, we calculated the deviation from a medium term trend, using the Hodrick-Prescott filter with a smoothing parameter of 6.25 (Hodrick and Prescott 1997). Thus, in contrast to using first differences to remove the trend we are not primarily measuring change from one year to the next, but deviations from what could be considered as normal years. With first differences a change from very low to normal would yield the same value as from normal to very high, while in our case a high positive value always indicates high prices, while negative values indicate prices lower than normal. The price residuals shown in Fig. 3 are the ones used in the estimations.

Figure 3 here.

5 Methods

Following the approach of Bengtsson and Dribe (2006), we model the duration to next birth as a function of price deviations using a hazard model controlling for demographic and socioeconomic variables. We estimate the overall fertility response to price fluctuations, the interaction between socioeconomic status and prices, and the distributed fertility response to a price change by three-month periods. In this way, we get a good picture both of the overall response, which can be compared to previous aggregated studies, and of the more detailed response both in terms of socioeconomic status and the timing of the response in relation to the price change. As noted previously, knowledge about the timing of the response is crucial to an understanding of the underlying mechanisms.

All women are followed from first marriage, which implies that no observations are left truncated. We limit the analysis to second and higher order births, because first births are connected as much with the marriage decision itself as with decisions on fertility, and thus require different models and a separate analysis. The quite high proportions of prenuptial pregnancies (see Knodel 1988, p. 228) testify to this intimate connection between marriage and first birth. As was previously mentioned, we also limit the analysis to closed birth intervals, which implies that we condition upon a future birth taking place when selecting women into the sample. However, estimations on all birth intervals using the "reconstitutable minority", i.e. only the women whom we know lived their entire reproductive period in the village, yielded practically identical results, indicating that our results are robust to the choice of empirical strategy (results not shown).

Because we are analyzing all birth intervals except the first, women included in the sample often experienced several births, and there might have been differences in the risk of childbirth between different women due to different woman-specific factors (biological or behavioral) that are not controlled for in the model. To control for this unobserved heterogeneity, we estimate a Cox proportional hazards model with shared frailty (random effects) at the individual level (see Therneau and Grambsch 2000, pp. 232–233):

$$ln\ h_{ij}(a, t) = ln\ h_0(a) + \beta X_{ij} + \gamma Z(t) + \omega_j$$

where: $h_{ij}(a, t)$ is the hazard of giving birth to a child for a woman (j) of observed parity i at duration (time since last birth) a and harvest year t; $h_0(a)$ is the baseline hazard, i.e. the hazard function for an individual having the value 0 on all covariates, β is the vector of parameters for the individual covariates (X_{ij}) in the model, γ is the parameter for the prices ($Z(t)$, where t is harvest year, October 1-September 30), and ω_j are the random effects at the individual level (all births to the same woman), assumed to be normally distributed (Gaussian).[5]

The crucial variables in the analysis are rye prices and socioeconomic status. As already discussed we use prices by harvest year (October to September) and include both current prices and prices lagged by one year. Thus the price in the fall of, say, 1830 is used for the period October 1, 1830 to September 30, 1831. In this way there is a built-in lag of up to one year also for current prices. The lagged price in this example covers the period October 1, 1829 to September 30, 1830. Socioeconomic status is time-invariant and refers to the occupation of the husband at marriage. This is clearly a disadvantage of the data, and also makes it different from the study by Bengtsson and Dribe (2006), where socioeconomic status was time-varying and also included information on land holding in addition to occupation.

In addition to these main variables, we also include a set of control variables, which are not the main focus of analysis but capture important aspects of the reproductive process: age of woman, village of residence, place of marriage (in the village or outside), birth place of the spouses, and age difference between spouses. Finally, we control for the life status of the previous child and also distinguish when child deaths took place (before or after age two). Because breast-feeding was normally practiced in the first two years, any difference in the effect of child death within two years and after two years would indicate the importance

[5] The estimations were made using the 'eha' package in R, developed by Göran Broström at the Department of Statistics, Umeå University, specifically designed to estimate this kind of combined time-series and individual survival model. Previous analyses have shown that estimations assuming Gamma distributed frailty produce the same results (see Bengtsson and Dribe 2006).

of the termination of breastfeeding for the chance of having another birth (Knodel 1988, p. 396; see also Tsuya et al. 2010, chap. 3).

6 Results

Table 4 displays estimates for three different models: a basic model including only age of woman, village and grain price; a full model with all covariates; and the full model with interactions between socioeconomic status and price. Before turning to the price effects, something should be said about the control variables. Because only closed intervals are analyzed, women will be censored after their last observed birth, which explains the low proportion of women over 40 in the sample. This also explains why the risk of child birth increases at higher ages, because older women who give birth are a selected group with higher than average fecundity or with different behavior in terms of breast feeding, etc.

Table 4 here

There are also quite marked differences between the villages in the average durations of birth intervals, and even though the coefficients differ somewhat between the basic and the full model the inter-village differences cannot be explained by other covariates in the model, such as socioeconomic status, age homogamy, migration or breast-feeding (effect of child death within 2 years). The same differences were also noted by Knodel in his analysis using the fertility index I_g (Knodel 1988, pp. 250–251). The northern village (Middels) had lowest fertility, the villages in the south-west (Kappel, Öschelbronn and Rust) had the highest, and the villages in middle Germany (Braunsen and Massenhausen) had a level in between.

In-migrating couples had higher birth risks than couples where at least one spouse was born in the village. Husband-older marriages were related to lower birth risks than marriages where the woman was older. The effects of child death are as expected and point to an important effect of breast-feeding on fertility, because the chance of having another birth is greatly elevated if a child died within two years (i.e. when breast-feeding can be expected to have been practiced, and thus was terminated because of the death of the child) compared to when more than two years passed since the death of the child. Finally, there were notable differences in fertility risks between socioeconomic groups. The higher status occupations had higher birth risks (shorter birth intervals) than farmers and skilled workers, while lower skilled or unskilled workers had lower fertility. Thus, at least among fully established families (i.e. who experienced at least one birth), lower socioeconomic status was associated with lower fertility. The variance of the random effects is statistically significant in all models, indicating that there were some unobserved differences between women, which could be related to coital frequency, breast-feeding, or underlying levels of fecundability not captured by the control variables.

Turning to the fertility response to grain prices, the basic model shows statistically significant negative effects of both current prices and prices lagged one year. It should be remembered that prices refer to harvest years, and not calendar years, which means that current prices run from October 1 to September 30. The statistically significant fertility response to current prices means that prices had a very rapid effect on fertility, bearing in mind that we study births and not conceptions. A comparison of the price effects of the basic model and the full model shows only minor differences, indicating that the price response was independent of level effects of the other covariates.

What is perhaps even more interesting is to look at the interaction model which estimates the differences in price effects on fertility according to socioeconomic status. Only one of the interaction effects is statistically significant, namely the one for unskilled workers. This group experienced a more negative price effect than the other groups. However, the signs and magnitudes of the other effects indicate that the overall pattern is as expected, at least for current prices, with stronger negative effects for the lowest status groups and weaker effects for higher status groups. Thus, in the short term (current prices) it was mainly unskilled workers and those with no occupation who suffered from high prices, as shown by their lower fertility, while in the longer term (lagged prices) all groups seem to have been affected in a more similar way. Interaction effects between parity and price show no significant difference in the price response according to number of previous children born (no statistically significant effects, and small magnitude of the coefficients), which indicates that the price response was largely parity-independent (results not shown).

In order to provide a more detailed picture of the timing of the fertility response to prices, we estimated an interaction model where quarter of a year was interacted with prices. The interaction effects show the extent to which there were differences in the price response between different quarters of the year. Because prices refer to harvest years we can calculate the quarter-specific response to the price changes in the fall, and thereby see how the timing of the response evolves over the two years following the price change. Table 5 shows the estimates and Fig. 4 displays the net effects ($e^{(\text{base effect of price+interaction effect price*quarter})}$). The base effect of current prices is only statistically significant for unskilled workers and no occupation, while lagged prices are statistically significant in all groups (p=0.06 among the skilled and lower skilled is close of being statistically significant). Once again this shows that the price response was more similar between the socioeconomic groups in the longer term than in the short term.

Table 5 and Figure 4 here

Only two of the interaction effects are statistically significant, and neither of these in the groups with the most significant price response: the unskilled and no occupation. This could be interpreted as an indication that the fertility response to prices indeed was very rapid in this group, because otherwise there would have been clear interaction effects pointing to a response only in the final quarters of the harvest year. Indeed, the net effects in Fig. 4 reveals that already in January to March – about 3-6 months after the price change – fertility was significantly depressed, and it took about a year before it started to increase again. This is clear evidence of reproductive agency in lower status families in these areas of pre-transitional Germany. Fig. 4 also shows the delayed response among farmers, skilled workers and lower skilled workers, leaving quite similar patterns after about a year after the price change.

To examine the degree of linearity in the fertility response, we looked at the fertility response to categorized prices (Table 6). Prices were categorized into five groups "very low", "low", "normal", "high" and "very high". Each category has been created in order to get an approximately even distribution between the categories. The model was estimated only for the unskilled/no occupation groups. The response to prices higher than normal was more or less linear, with a greater effect for very high prices than for high prices. This is fully consistent with the interpretation that the response is deliberate, while an involuntary response related to malnutrition could be expected to be clearly non-linear because, as previously discussed, only severe malnutrition can be expected to depress fecundity.

Table 6 here

It is interesting to note that there is also a negative non-linear fertility effect of very low prices. Times of very low grain prices should clearly be favorable times for groups dependent on the market for their food consumption, which makes a negative fertility response quite unexpected. At the same time however, very low prices would have adverse effects for farmers, artisans and other employers of unskilled labor, and it could be that the negative effect observed is related to a lower demand for labor, and generally unfavorable times in the local community when prices were very low.

7 Conclusion

In this article we have looked at the fertility response to economic stress as a way to detect deliberate control in a pre-transitional fertility regime. The six German villages under study showed no signs of family limitation (parity-specific control) in the period under consideration (1766–1863). By adopting a longitudinal, micro-level approach, our analysis has indicated that deliberate, non-parity specific, control was practiced in times of economic stress even before the fertility decline.

Firstly, a significant fertility response to grain price changes was found both in the year immediately following the price change and with a one year lag. Secondly, the results support expectations of a differential socioeconomic fertility response to economic fluctuations. As shown by the interaction model, only unskilled workers experienced a significant price response in the first year after the price change, whereas the fertility of other socioeconomic groups was also reduced in the second year.

As expected, the fertility of lower status families was depressed already three to six months after the price change. Because non-deliberate effects on fertility through malnutrition, spousal separation, shorter breastfeeding or spontaneous abortions would come with a considerably longer delay, the very rapid response must be interpreted as a clear indication that families foresaw bad economic conditions and deliberately postponed childbirth. In contrast, the upper social groups like farmers and skilled workers had a much slower response, which points to the conclusion that they were less severely affected, and could use assets or stored grain to cope with economic stress. However, the clear response in the second year after the price change in these groups clearly shows that they could not fully isolate themselves from the adverse impact of economic fluctuations.

As expected, the analysis of potential threshold effects demonstrated that the response to high grain prices was rather linear. However, there was also a non-linear negative fertility effect of very low grain prices among the unskilled/no occupation groups, indicating a possible adverse effect on fertility of low demand for labor and/or unemployment.

The results obtained for these German villages are very similar to those previously found for southern Sweden by Bengtsson and Dribe (2006). There, the fertility response to short-term economic stress was also very rapid, pointing to the deliberate postponement of childbirth as the main mechanism. As in the case of the German villages studied here, the Swedish sample showed no indications of parity-specific control being practiced. While they were both areas which have previously been considered as not showing any conscious action, or agency, in fertility there nonetheless appears to have been a clear practice of deliberately adjusting the timing of childbearing in times of economic stress, even if this was generally done quite independently of parity.

Taken together, this gives strong support to the hypothesis that individual agency in the reproductive process was a salient feature of preindustrial Europe, even though it was not aimed at family limitation, but at adjusting the timing of childbirth in line with economic conditions.

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Table 1 Fertility indicators in a combined sample of German villages, 1750–1899

Year of marriage	Age-specific marital fertility (per 1000 population)						TMFR20	M	m
	20-24	25-29	30-34	35-39	40-44	45-49			
1750-74	439	425	374	303	173	26	8.70	0.95	-0.03
1775-99	455	426	376	301	155	25	8.69	0.99	0.05
1800-24	463	412	362	285	151	18	8.46	0.99	0.08
1825-49	503	430	379	286	141	15	8.77	1.07	0.18
1850-74	533	450	362	288	128	15	8.88	1.14	0.27
1875-99	547	462	353	247	104	6	8.60	1.20	0.46

Source: Knodel, 1988, Table 10.2.

Table 2 Distribution of married women and births in the six German villages, 1766–1863

	Braunsen	Kappel	Middels	Massenhausen	Öschelbronn	Rust	Total
Women	209	669	576	325	512	1 110	3 401
%	6	20	17	10	15	33	100
Births	755	2 837	1 970	1 183	2 283	4 298	13 326
%	6	21	15	9	17	32	100

Note: Only women included in the analytical sample and births of the second and higher order.
Source: *Ortssippenbucher*, archived at the Population Studies Center, University of Michigan.

Table 3 Percentage of married women by husband's occupation in the six German villages, 1766–1863

	Braunsen	Kappel	Middels	Massenhausen	Öschelbronn	Rust
Higher managers-professionals	5	1	2	5	4	1
Lower managers-professionals, clerical and sales	3	3	2	2	2	8
Skilled workers	25	22	6	12	36	28
Farmers	22	29	49	23	34	19
Lower skilled workers	10	9	5	7	11	8
Unskilled workers	24	29	29	14	4	23
No occupation	11	6	6	38	11	13
Total	100	100	100	100	100	100

Source and *Note*: See Table 2. The number of observations is displayed in Table 2.

Table 4 Relative risks (RR) of second and higher-order births in the six German villages, 1766–1863. All married women.

	Mean	Basic Model		Full Model		Model with interactions	
		RR	p	RR	p	RR	p
Age of woman							
15-24	0.11	1.20	0.00	1.23	0.00	1.23	0.00
25-29	0.25	1.00	r.c	1.00	r.c.	1.00	r.c.
30-34	0.27	0.85	0.00	0.82	0.00	0.82	0.00
35-39	0.21	0.67	0.00	0.63	0.00	0.63	0.00
40-44	0.08	0.59	0.00	0.54	0.00	0.54	0.00
45-49	0.01	0.76	0.01	0.66	0.00	0.66	0.00
Unknown	0.07	0.72	0.00	1.19	0.04	1.20	0.04
Village							
Braunsen	0.06	1.00	r.c	1.00	r.c.	1.00	r.c.
Kappel	0.21	1.09	0.22	1.17	0.03	1.17	0.03
Middels	0.18	0.70	0.00	0.75	0.00	0.75	0.00
Massenhausen	0.09	0.95	0.51	1.03	0.73	1.03	0.72
Öschelbronn	0.15	1.54	0.00	1.35	0.00	1.35	0.00
Rust	0.31	1.16	0.03	1.21	0.01	1.21	0.01
Place of marriage							
Parish of residence	0.94			1.00	r.c.	1.00	r.c.
Other parish	0.06			0.99	0.84	0.99	0.85
Birth place of spouses							
Both in village	0.73			1.00	r.c.	1.00	r.c.
One in village	0.23			0.99	0.87	0.99	0.88
None in village	0.04			1.31	0.00	1.31	0.00
Spousal age difference							
Wife older	0.19			1.00	r.c.	1.00	r.c.
Husband older < 6 years	0.40			0.91	0.02	0.91	0.02
Husband older > 6 years	0.28			0.90	0.02	0.91	0.02
Unknown	0.13			0.52	0.00	0.52	0.00
Life Status of previous child							
Alive	0.86			1.00	r.c.	1.00	r.c.
Dead and < 2 years since previous birth	0.10			4.46	0.00	4.46	0.00
Dead and > 2 years since previous birth	0.04			1.18	0.00	1.18	0.00
Socioeconomic Status (SES)							
Farmers	0.31			1.00	r.c.	1.00	r.c.
Higher managers, professionals and sales	0.02			1.37	0.00	1.38	0.00
Lower managers, professionals and sales	0.04			1.13	0.13	1.13	0.13
Skilled workers	0.23			1.05	0.21	1.06	0.20
Lower skilled workers	0.09			0.91	0.01	0.91	0.10
Unskilled workers	0.22			0.91	0.03	0.91	0.03
No occupation	0.10			0.72	0.00	0.72	0.00
Rye price							

Price (t)	0.85	0.00	0.86	0.00	0.93	0.34
Price (t-1)	0.83	0.00	0.80	0.00	0.78	0.00
*Interactions SES*Price (t)*						
Higher managers, professionals and sales					1.61	0.12
Lower managers, professionals and sales					1.02	0.94
Skilled workers					0.95	0.64
Lower skilled workers					0.94	0.72
Unskilled workers					0.75	0.02
No occupation					0.88	0.45
*Interactions SES*Price (t-1)*						
Higher managers, professionals and sales					1.08	0.80
Lower managers, professionals and sales					0.81	0.37
Skilled workers					1.10	0.38
Lower skilled workers					1.07	0.66
Unskilled workers					0.95	0.66
No occupation					1.01	0.98
Frailty variance	0.40	0.00	0.37	0.00	0.37	0.00
Likelihood ratio test	6 252	0.00	8 268	0.00	8 286	0.00
Number of births	13 326		13 326		13 326	

Note: Relative risks from Cox proportional hazard estimates, p refers to Wald p-value, r.c. denotes the reference category.

Source: See Table 2 and Figure 2.

Table 5 Relative risks (RR) of second and higher-order births with quarter*price interactions

	Unskilled and No occupation		Farmers		Skilled and Lower Skilled Workers	
	RR	p	RR	p	RR	p
Quarter						
January-March	1.00	r.c.	1.00	r.c.	1.00	r.c.
April-June	0.86	0.00	0.82	0.00	0.94	0.18
July-September	0.96	0.40	0.89	0.01	1.09	0.04
October-December	1.04	0.43	0.98	0.73	1.08	0.06
Rye Price						
Price (t)	0.69	0.02	0.97	0.84	1.17	0.26
Price (t-1)	0.67	0.01	0.70	0.02	0.76	0.06
*Interactions Quarter*Price (t)*						
April-June	1.03	0.89	0.85	0.42	0.80	0.26
July-September	0.92	0.71	1.08	0.70	0.58	0.01
October-December	1.30	0.21	0.92	0.68	0.71	0.08
*Interactions Quarter*Price (t-1)*						
April-June	1.18	0.44	1.34	0.17	1.42	0.08
July-September	1.27	0.26	1.13	0.54	1.29	0.20
October-December	1.04	0.87	1.03	0.88	0.90	0.61
Frailty Variance	0.36	0.00	0.35	0.00	0.32	0.00
Likelihood ratio test	2 517	0.00	2 737	0.00	2 402	0.00
Number of births	3 961		4161		4 390	

Note: See Table 4. The model controls for age of mother, village, place of marriage, spousal place of birth, age difference between spouses, and life status of previous child.

Source: See Table 2 and Figure 2.

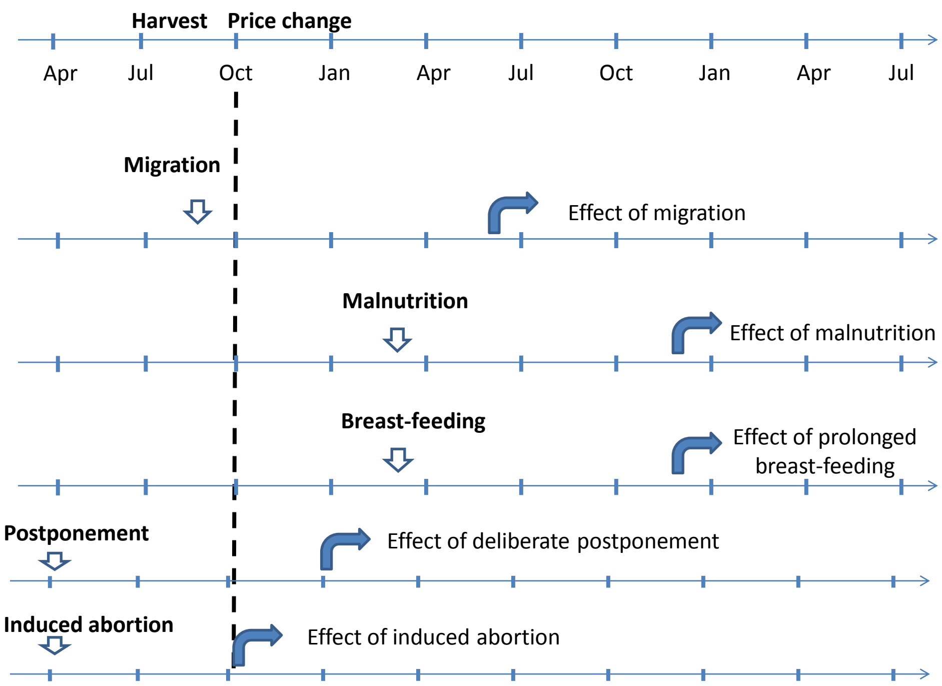
Table 6 Relative risks of second and higher-order births with categorized rye prices."Unskilled and No occupation" groups

	Mean	RR	p
Rye Price			
Very low	0.22	0.85	0.00
Low	0.20	0.92	0.14
Normal	0.18	1.00	r.c.
High	0.18	0.84	0.00
Very high	0.22	0.73	0.00
Frailty Variance		0.36	0.00
Likelihood ratio test		2497	0.00
Number of births		3961	

Note: See Table 4. The model controls for age of mother, village, place of marriage, spousal place of birth, age difference between spouses, and life status of previous child.

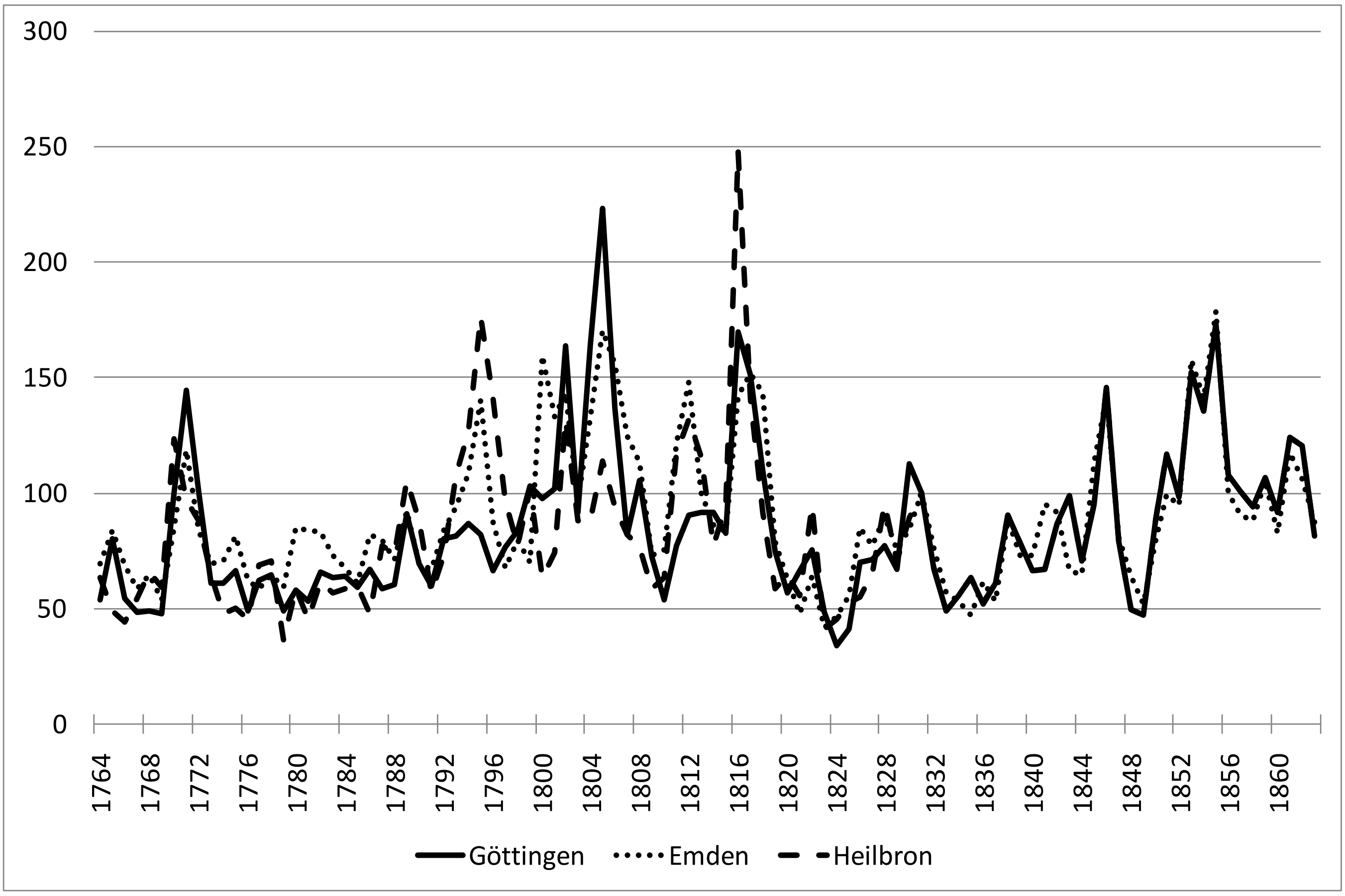
Source: See Table 2 and Figure 2.

Fig. 1 Illustration of the timing of fertility response to change in rye prices



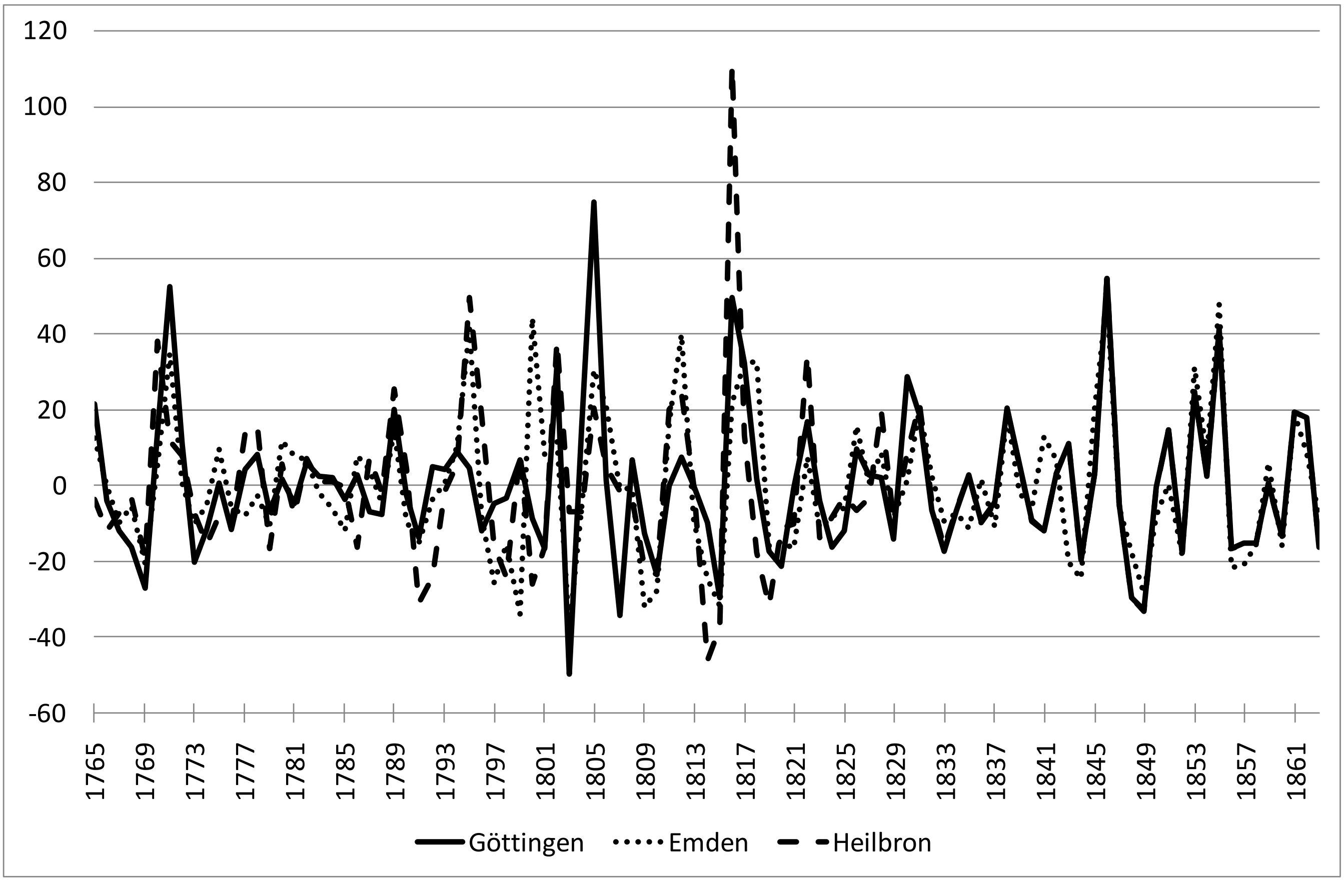
Note: Arrows indicate the earliest likely response. For explanations see text.

Fig. 2 Rye price index 1764–1863 in Emden, Göttingen and Heilbron (1831=100)



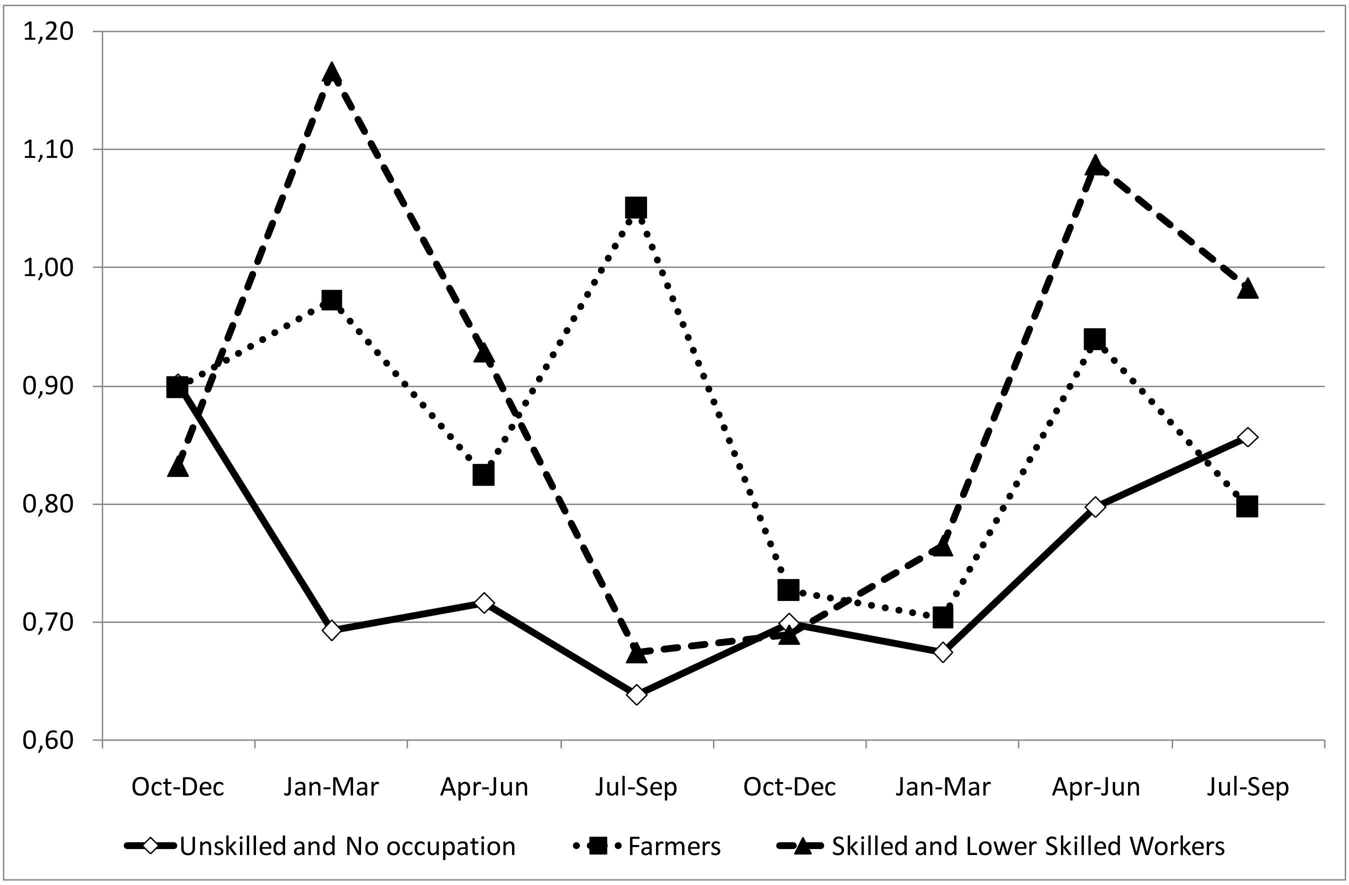
Source: Jacks 2004, 2005.
Note: For construction of the series, see text.

Fig. 3 Rye price deviations from Hodrick-Prescott trend, 1765–1863 in Emden, Göttingen and Heilbron



Source and *Note*: see Figure 2. Hodrick-Prescott trend was calculated using a smoothing parameter of 6.25.

Fig. 4 Distributed fertility response over two years. Effect of a 100 unit deviation in rye price index compared to the normal level (trend)



Note: Based on the estimations of the model in Table 5.

Map Geographical references of the demographic data and the price series