Short term fertility response to economic fluctuations in a manorial society: Rural Estonia in 1834-1884

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In the pre-industrial era, changing economic conditions had a strong influence on demographic processes. Using pre-industrial rural Estonia as an example, the article studies fertility response to short-term economic stress in a manorial society in eastern Europe. It considers whether the fertility response to rye price fluctuations was deliberate and whether it was socially differentiated. It appears that an increase in the price of rye resulted in the drop of conceptions within the next year and the magnitude of the impact on fertility was roughly similar to that in several other European settings in the 19th century. As long as the manorial system was maintained, farmers were more sensitive to price hikes than the landless, but with the decline of the mutual economic dependence between manors and farms, the landless laborers became more vulnerable to price increases. Our analysis of the timing of the fertility response reveals no deliberate postponement of conceptions immediately before or after the low harvests or price increases. Instead, conceptions dropped only in the spring and summer season of the next year, indicating a non-deliberate and spontaneous response.

Keywords: natural fertility; socio-economic status; economic stress; manorial economy; Eastern Europe

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1. Introduction

In the pre-industrial era, changing economic conditions had a strong influence on demographic processes. Clear responses of fertility, mortality, and nuptiality to short-term fluctuations in food prices or real wages have been previously documented in the aggregate (Schultz 1985; Lee 1981; Galloway 1988; Hammel and Galloway 2000), as well as micro-level studies pertaining to several contexts (Bengtsson et al. 2004; Bengtsson and Dribe 2006; Dribe and Scalone 2010; Tsuya et al. 2010; Bengtsson et al. 2014; Breschi et al. 2014; Jennings et al. 2017). Both types of studies suggest that fertility was more sensitive than mortality or nuptiality to deteriorating economic conditions indicated by food price hikes (Galloway 1988; Bengtsson 2004, p. 38; Bengtsson and Dribe 2006, 2010a). While the aggregate studies suggest that the magnitude and pattern of the impact on fertility were similar across "all countries and all periods" throughout historical Europe (Galloway 1988), micro-level research shows that the size of the price effect varied over time and across settings (Allen et al. 2005). More substantial knowledge on the emergence of negative association between fertility and food prices is lacking, as studies of rural Germany and Scania suggest that in the 18th century, the relationship between prices and conceptions was still insignificant (Amialchuk and Dimitrova 2012; Willführ and Störmer 2015; Heinecke and Willführ 2024-current issue; Bengtsson and Quaranta 2024-current issue).

Micro-level research on fertility response to food price variations, however, has been limited to a fairly small number of regions. In much of preindustrial Europe, the manorial estate was an important institution in the rural economy that could, because of its mere size, offer its subjects protection against short-term economic stress, such as harvest failures (Dribe et al. 2012). This said, surprisingly few attempts have been made to measure the effect of price fluctuations on various demographic outcomes in these societies and the results call for a more thorough study. In his study of the parish of Borshevka in Russia, Steven Hoch (1988) found no association between the changes in mortality and fluctuations in prices. However, he explained the lack of impact not by the protection afforded by the manors but by the peasant communes and multiple-family households. The price-mortality relationship has been found to be weak also for the tsarist Russian province of Livonia, except for the years of severe subsistence crises (Klesment and Lust 2021). Using parish-level data, Hammel and Galloway (2000) showed that in Croatia-Slavonia-Srem, the negative effect of price changes on fertility was relatively small until the late 1830s, but increased substantially thereafter. The effect was stronger among civil than military serfs and this difference persisted into the post-emancipation era. Both the qualitative sources as well as the timing of the decline in conceptions suggest that the fertility was deliberately checked there.

At the nexus of historical demography and economic history, one of the central questions is whether fertility response to food price dynamics was largely non-deliberate—in other words, that fertility decline during economic hardships was due to malnutrition, spousal separation, or miscarriages. High food prices may have reduced fertility levels by forcing husbands to migrate in search of work opportunities, leading to a lower probability of conceptions (Dribe and Scalone 2010; Kolk 2011; Amialchuk and Dimitrova 2012). Moreover, malnutrition during crises may have indirectly impaired fecundity and increased exposure to diseases. Alternatively, temporary reduction of fertility was deliberate, and that would imply some degree of birth control (Bengtsson and Dribe 2006; Lee et al. 2010, p. 17; Jennings et al. 2017, pp. 325ff; Marco-Gracia 2019). Awareness of traditional methods of contraception, such as *coitus interruptus*, abstinence, or induced abortion (Bengtsson and Dribe 2006; Dribe and Scalone 2010; for Estonia, see Metsvahi 2016), made it possible to postpone childbearing until economic situations improved.

In this paper, we analyze the association between fertility and grain price variation in the tsarist Russian province of Livonia (today southern Estonia and northern Latvia). We pose the following three questions: a) When short-term grain prices increased and food shortages loomed, did it temporarily reduce the likelihood of childbearing among the various socioeconomic groups in rural Estonia? b) As the farm economy became more commercialized, did the price-fertility relationship change over the period observed? c) If grain price hikes and fertility are found to be negatively associated, can this be attributed to the deliberate postponement of births among different strata of the rural population—in other words, is there evidence of deliberate fertility control? To answer these questions, we use a dataset constructed from linked vital records of eight rural municipalities or manors (seven noble estates in Helme Parish and one state estate in Paistu Parish) covering the period of 1834–1884. We apply event history techniques to model the duration between births and its relationship to grain price dynamics.

A way to identify a causal link in the fertility response to short-term economic stress is to study the timing of the response (Bengtsson and Dribe 2006, 2010b). Contrary to the general assumption that before the demographic transition, couples' reproductive response to short-term economic stress was largely passive or biological, studies from Scania (Sweden) and Germany show that postponement of births was likely caused by families taking deliberate action to avoid having children in hard times (Bengtsson and Dribe 2006, 2010b; Dribe and Scalone 2010). As married couples became aware in the spring and summer that the upcoming harvest would be poor, they avoided conceptions, and this extended the duration between births. We apply a similar analytical approach to identify whether temporary fertility decline at the time of rising prices was due to the deliberate postponement of having the next child. In our regression models, this is achieved by dividing the harvest year into four quarters, which are then interacted with the grain price of the same harvest year and of the previous (lagged) harvest year.

According to our results, the percentage change in fertility attributable to rising grain prices is roughly similar to that in rural Aragón, Scania, Casalguidi, and Hungary (Bengtsson and Dribe 2010a; Marco-Gracia 2019, Pakot and Őri 2024-current issue). We find that a 10% increase in grain price associates with a roughly 3–6% decline in the likelihood of a subsequent conception, depending on whether the price dynamics is operationalized as a continuous variable or as an indicator for exceeding the predetermined threshold over the detrended average. In line with findings from Germany and Scania, our main models detect a response of fertility to rising prices during the same harvest year, with no lagged effect from the previous year. This supports our hypothesis that short-term grain prices and childbearing were negatively associated. During the years of substantially above-average prices, conception hazards were 6.6% lower. Using harvest failure as an indicator variable for bad economic conditions, we see a similar decline in conceptions.

With regard to whether the control of fertility was deliberate, our findings suggest that rural couples did not deliberately postpone conceptions when anticipating times of economic stress. Instead, a reduction in conceptions was more likely in the summer that followed the autumn in which grain prices rose. Our findings show that the fertility response was little differentiated socially until the mid-1860s and farmers were more sensitive to price fluctuations. These results differ from those in rural northern and western Europe (Dribe and Scalone 2010; Alter et al. 2010; Bengtsson and Dribe 2010a; Jennings et al. 2017), where landless groups timed the births in response to short-term economic stress, and are more in line with what has been found for rural Aragón, where not only the landless but also landowners also timed the births in response to short-term economic stress (Marco-Gracia 2019). Previous research has suggested that market-producing peasants, who were net producers even in the years of bad harvests, felt no need to reduce their fertility (Bengtsson and Dribe 2006, 2010a), whereas small peasants (such as those in Aragón) became net consumers and responded to rising prices by decreasing their fertility. In Estonia, the price-fertility relationship for the farmers and the landless changed over time: the landless became increasingly sensitive to price fluctuations, whereas the landed peasants, instead of decreasing their fertility, increased it when the prices increased.

To summarize, our work complements a growing body of literature on the relationship between economic fluctuations and demographic outcomes by extending micro-studies on fertility response to economic stress into a manorial society in Eastern Europe. The variation in empirical findings indicated above calls for an expansion of the geographical scope of research in order to obtain a more nuanced account of short-term fertility response to economic fluctuations among the past populations of Europe. It contributes to the discussions about whether this response was deliberate and whether it was socially differentiated. Our results suggest that the response was non-deliberate and little differentiated socially.

The remaining part of the paper is structured as follows. First, we introduce the historical setting that generated the data we use in this study and then briefly describe previous findings about the fertility and mortality of Estonia at the time. Thereafter, we introduce the data and explain how they were prepared for the analysis. The same section describes our methods and variables. In the last two sections, modeling results are introduced and discussed in the light of earlier research.

2. Historical setting

In the 19th century, Estonian villages, which were highly self-sufficient, underwent a transition to a more market-oriented economy. However, the first important institutional reform, the liberation of the serfs in the provinces of Estland and Livland (in 1816 and 1819, respectively), did not significantly change the basic economic relationships, as the *corvée*-based manorial system survived for another half-century, and almost all agricultural land belonged either to nobles or to the state. Estonian historiography has traditionally highlighted the shift from labor rent to money rents, the introduction of peasant land ownership, land consolidation, and the enclosure of common pastures as the essential preconditions for the capitalist transformation of the peasant economy from the 1860s onwards (Lust 2023). The "unlimited" demand for food on the European market provided a major incentive to modernize farming and increase output in Eastern Europe as well (Berend 2003).

As previous research on fertility response has suggested, the influence of grain price fluctuations varied according to a given household's socioeconomic status, access to resources, and ability to accumulate wealth (e.g., the size of the landholding, type of tenancy, form of remuneration, type and length of the work contract) and the degree of commercialization in agriculture (Bengtsson and Dribe 2010a). The producers were more likely to benefit from high prices in commercial agriculture, where prices were determined by distant markets, and the consumers were more vulnerable in settings where they were dependent on the market for their consumption.

Figure 1. Map of Estonia. The two parishes included in the study are highlighted in grey, Paistu (1), in which Holstre is located, and Helme (2).
Source: Mapped by Ago Tominga.

In rural Estonia, access to resources was largely determined by access to land, which was distributed very unequally among households. In the area under study, manorial lords controlled (directly managed) almost half of the land, whereas nearly two-thirds of the peasant population had no real access to land except for tiny plots. Farmers with large and medium-sized farms comprised a majority of the population under study. There were almost no small farms in the area under study (Lust et al. 2023, Table 1).

During the period under study, the tenure rights of landed peasants changed profoundly (Klesment and Lust 2021; Lust et al. 2023). On noble estates, the tenant farmers had weak rights of tenure, and labor rent was unlimited. Tenancies were short-term and unstable. As long as the rent was paid in labor and farm products, tenants could neither increase their revenues by selling at higher prices nor stabilize consumption by firing servants (*corvée* workers for manors) to lower their costs. Even in years of bad harvests, farm rents were only temporarily rescinded, and the tenants had to pay them afterward. The transition from labor to money rents occurred in the 1850s and 1860s. The peasant laws set neither time limits nor land price levels, and the state government did not provide any credit to the purchasers of farms on noble land. Therefore, the practice of purchasing farms gained momentum only in the mid-1860s. In the parish of Helme, peasants bought their holdings through long-term mortgages between 1850 and 1878; most of the contracts, however, were concluded between 1866 and 1871.[3]

On state estates like Holstre, in contrast to noble manors, labor dues, contract duration, rental levels, and land prices were fixed. In 1869, hereditary tenure of farms was established. In Holstre, all tenants switched to money rent in 1849, and most of them bought their holdings outright between 1875 and 1884.[4] On average, redemption payments on state estates were one-half to one-third of the purchase prices on noble estates (Lust 2021).

With the transition to money rent and the transformation of tenancies into freeholds, peasant farmers had to combine self-sufficiency with growing commodity production. In the area under study, livestock and flax were shown to be major cash-earning products (Lust 2021). Most of the arable land was sown with grain, but in the 1880s, commercial food grain production lost much of its importance, as grain from Russia and overseas flooded the market. At least three-fourths of the rye and barley that was harvested was consumed in the farmer's household or used to pay servants. On manors, the distilling industry flourished, but it increasingly used potatoes instead of grain as a raw material.

In Estonia, grain prices were dictated by export prices (i.e., those on distant markets), as well as by local harvests. Until the mid-19th century, a strong correlation can be seen between movements in grain prices and harvests (Lust 2013). Afterwards, this relationship was greatly attenuated due to improved railway connections and integration with the empire-wide market.

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[3] National Archives of Estonia (RA, EAA), fonds no 3760, inventory no 1, files no-s 7313–7341.
[4] Latvian State Historical Archives (LVVA), fonds no 183, inventory no 94, file no 173.

As long as a subsistence economy prevailed, especially before the 1860s, periods of high prices indicated a low supply of grain and low levels of consumption, including for grain-producing tenants. We may speculate that with the introduction of peasant land ownership and increasing market integration, the farmer peasants went from being vulnerable to periods of high grain prices (i.e., bad harvests) to benefiting from rising grain prices.

Landless peasants circulated among the farmsteads and manors as hired labor. As long as the labor rent prevailed, until the 1850s and 1860s, unmarried as well as married servants were members of the farmstead, and multiple-family farmsteads were typical of the area (Lust et al. 2023). Aside from the families of farm heads, members of the farmstead could also include servants, cottagers, widows and widowers, incapacitated veterans, wives of conscripts, paupers, and/or orphans. Some of them were also related by blood or marriage. Cottagers had a small parcel of land or no land at all and normally worked for wages as day laborers. Parish registers and poll-tax lists do not distinguish between those who dwelled in separate cottages and those who lived with a farm head, but customarily, cottagers and married servants lived separately, while unmarried servants shared the house and the same bowl and table at meals with the farm head's family. Married servants were given a small patch of land, foodstuffs, clothes, lodging, heating, and the right to keep livestock such as cattle or a pig, while unmarried servants received fixed payments in kind and cash (Klesment and Lust 2021). In general, non-monetary remuneration and home production made up most of their income. Insofar as local harvests influenced grain price dynamics, their subsistence was clearly affected by the prices. The proportion of cash in their remuneration increased with the commercialization of the farm economy and an increase in the percentage of unmarried servants.

As Dribe (2003) argues, in pre-industrial rural areas like the communities under study, migration was hardly an effective way of dealing with economic hardship if there was no nearby area or economic sector unaffected by the same conditions that were producing economic stress in the community. In grain-producing areas, year-round servants and manorial workers were also expected to stay home until all the crops had been harvested, even in years of bad harvests. In the area under study, it was not only the low level of urbanization and industrialization that slowed down out-migration; various restrictions on peasants' mobility, lifted gradually from the 1820s to 1863, also discouraged moving. In accordance with work contracts, those leaving early were fined. Nearby towns—Valga and Viljandi—were very small and located 10 to 35 kilometers away (Fig. 1). The landless group and cottagers could expect little help from municipal poor relief institutions, which were designed to assist only those in the population incapable of working and those without relatives to assist them (Lust 2022).

3. Mortality and fertility change

Analysis of the aggregate historical demographic data in Estonia is very scant, and the study of individual-level data has started only recently. In the following, crude death and birth rates derive from general overviews. All other indicators are calculated on the basis of the dataset used for the current study.

On the territory of Estonia, crude death rates (CDR) fell below 30 per thousand in the 1810s but then stagnated for the next half-century with occasional mortality surges related to crop failures and outbreaks of infectious diseases (Katus 1990). Subsequently, improvements were made, and the CDR fell by a third by the end of the 19th century. For the area and period under study, death hazard ratios for different age groups have been analyzed before (Lust et al. 2023, Fig. 2, Table 3). Starting in the mid-1850s, a decline in death rates can be seen; by the end of the period under study, death rates for adults had declined by almost half. For infants, the fall was about one-third; for children more than one year old, the drop was the smallest.

A previous study on the mortality response to grain price variations in the two parishes under consideration identified a sizable mortality increase for individuals above the age of one in the years of price increases (Klesment and Lust 2021). However, socioeconomic status differentials in mortality, detected for the entire period under study, either became less apparent in the years of sharp increases in grain prices or followed an unexpected pattern. Surprisingly, it emerged that the young children of farmers were more vulnerable to price fluctuations than those of the landless. Factors that may have suppressed the mortality differentials between the landed and landless peasants include similarities in living arrangements, sanitary conditions, habits, and so on. Moreover, the sources do not allow us to capture the possible heterogeneity among the landless and semi-landless groups. Earlier research on other European settings has indicated that socioeconomic mortality differentials are evident during the period of agricultural transformation but weak or invisible in the pre-transformation phase (Bengtsson et al. 2004; Bengtsson and Dribe 2005, p. 361). As shown above, the period before the 1860s might well be categorized as a pre-transformation era in Estonia.

The period under study also saw the start of a fertility transition in Estonia. The crude birth rate, which was still around 35 in the 1860s, dropped to 31.7 in 1881, but regional differences were considerable. Viljandi County, where the area under study was located, was among the first to experience this fertility decline (Katus 1994).

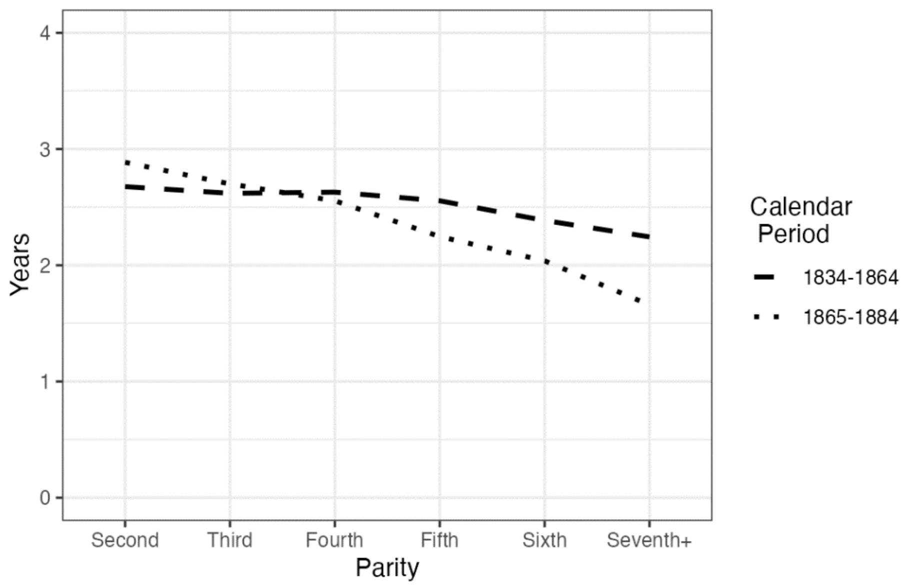

Figure 2. Mean duration between conceptions by parity of the child and calendar period, 1834–1884

Source: Birth and death registers and migration records and poll tax lists from the parishes of Helme and Paistu, preserved at the National Archives of Estonia, own estimation.

Birth intervals were relatively stable across parities. As shown in Figure 2, the average interval ranged between 2.5 to 3 years for the lower parities and somewhat shorter for higher parities. Interestingly, for the later period, we see that the duration between higher-order children (five or more children) declines below two years, while the duration between the first birth and the second increases compared to the earlier period. The latter can be explained by some parity-specific control in the later period, which presumably postponed the second child. The reduced intervals between higher-order births are probably associated with the higher socioeconomic status of the mothers. Among the landless, depending on the cohort, birth intervals were, on average, three to eight months longer than among the farmers (cohorts born between 1811 and 1860). Births control methods have not been studied yet.[5]

As we know from previous research, childbearing patterns often varied among social groups. In the rural context, these differences have largely been associated with differences in

[5] In literature, there are only references to the practices of *coitus interruptus* and extending breastfeeding (Palli 1997; Metsvahi 2016).

access to productive resources and in household size (Dribe and Scalone 2010; Bengtsson and Dribe 2010b; Breschi and Manfredini 2008; Brechi et al. 2014). It has been shown for Estonia that lower social groups had a markedly lower fertility than the higher-status groups (Palli 1997, pp. 101–103). Also in our study population, we find that not only landless but also skilled workers groups have a lower birth risk.

4. **Data and methods**

Our study focuses on the period of 1834–1884. In these years, the local Lutheran parishes used to include individuals' surnames and socioeconomic status in their register entries, which allows us to link different registers and analyze socioeconomic fertility differentials. We use the 1834 poll-tax list (or "soul revision") to obtain the stock of population in that year (4,737 people on the seven manors in Helme and 2,537 on Holstre manor). The poll-tax list includes information about the sex, age, marital status, and SES of individuals. To this dataset all subsequent births, marriages, and deaths in the area until 1884 are added using data from Lutheran and Russian Orthodox parish registers. The initial dataset for the period 1834–1884, combined with price and harvest data, includes 13,848 births. From this we exclude births to mothers under age 15 or over age 50 (n=255), as well as those to mothers born before 1790 (n=7). We also exclude multiple births (n=274), first births (n=3,540), and births after the 10th child (n=115). Some observations turn out to have a negative birth interval due to an incorrect birth date (n=297) or a missing value for the mother's age (n=16); those we exclude as well. The final study sample contains 9,344 observations for 2,708 married women. Parish registers, poll-tax lists, registers of parishioners, and listings of migrants enable us to account for the out-migration of mothers. The size of the sample is similar to (Bengtsson and Dribe 2006) or even larger than in other similar studies (Jennings et al. 2017; Marco-Gracia 2019; Pakot and Őri

2024). The quality of the source material is also good. The proportion of infant deaths taking place in the first month was 37% for the landless as well as for the landed.

Socioeconomic status (SES) is derived from birth and death registers and poll tax lists. The population under study is categorized into three major SES groups: farmers, skilled workers, and landless farm workers/cottagers. Farmers were generally tenants and, after they had bought their holdings outright, landowners. The smallest group—skilled laborers—includes families of individuals who made their living from non-agricultural production (e.g., forest wardens, peasant-school teachers, storekeepers, bailiffs, foremen, gardeners, innkeepers, millers). These were often not lifelong jobs but only occupied a period in one's life. Parish registers normally do not differentiate between different segments of unskilled laborers and artisans or do so inconsistently. Regarding fertility response, we expect that there are dissimilarities between socioeconomic groups. As access to resources varied across social groups, some were more vulnerable to price fluctuations. Several studies indicate a clear difference in response by socioeconomic status (Dribe and Scalone 2010; Bengtsson and Dribe 2010a; Jennings et al. 2017), while some do not find such differentials (Kolk 2011).

Our main explanatory variable captures short-term grain price dynamics, which we expect to be positively associated with economic hardship. We use the local price of rye, the major grain in Estonia in terms of both production and consumption. Prices were reported monthly at the county level. These are October or November prices reported from Tartu County, which bordered on Viljandi County. Although Tartu County is farther away from the area under study, we have used its surviving price data because it is more consistently reliable than that of Viljandi County (Lust 2013, pp. 220–223, 226–230). To focus on annual price fluctuations, we transformed the time-series of the price of rye into logarithm form and detrended this series using the Hodrick-Prescott filter with a smoothing parameter of 6.25 (Fig. 3). For regression analysis, the variable is scaled so that the estimated coefficients correspond to a 10% change in prices. As an alternative to continuous price fluctuation data, we experiment with a binary variable that indicates years with a price hike of at least 10% over the detrended average. To corroborate the findings we obtained using grain price dynamics, we will use harvest failure as an explanatory variable. Following the contemporary estimates, harvest failure is defined as rye yielding less than four grains per seed, and a dummy variable is entered in the model to indicate years of harvest failure. The number of observations for the harvest failure model is more limited (978 fewer births), since grain yield data is available only for the period since 1841.

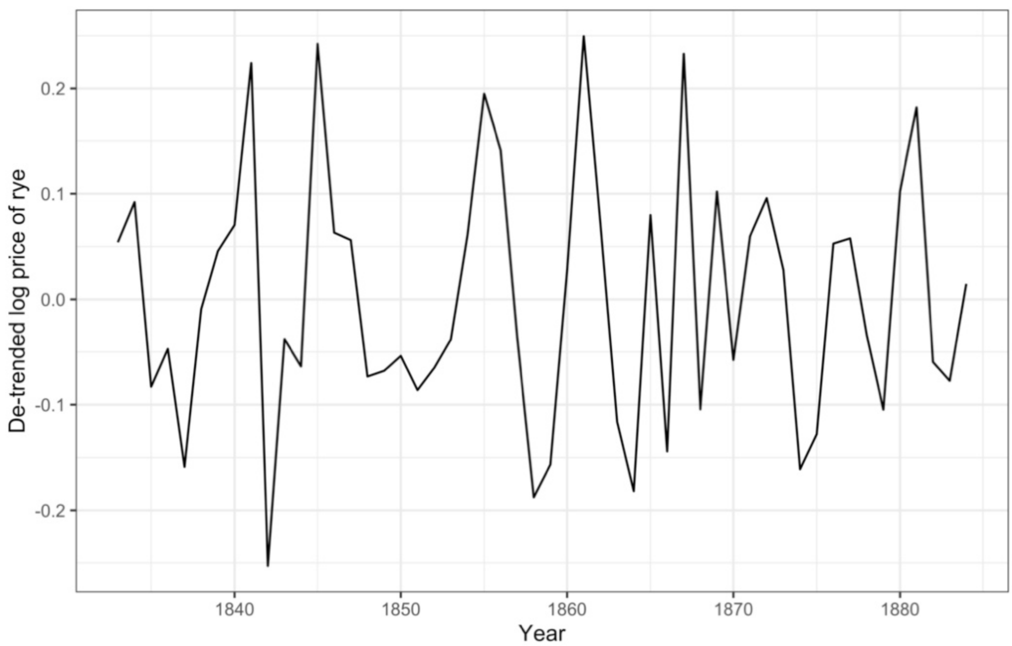

Figure 3. Detrended logarithm of the price of rye, 1834–1884

Source: Klesment and Lust 2021.

We analyze the duration between conceptions using survival regression methods. Since first births generally correlate with the beginning of marriage, we focus on second and higher-order births. We also exclude births after the 10th child, as the number of such events is very small. As a result, all women are followed from the first to last birth—or the 10th child as the last if the woman had more than 10 children—unless they are censored due to out-migration or reaching age 50. This means that all birth intervals, with a few exceptions, are closed and there is no left-truncation or right-censoring. The time of conception is estimated at nine months before the child's date of birth.

To account for mothers' migration, we allow right-censoring for those cases when there is out-migration between births. Censoring also occurs when the woman reaches age 50 between births. As a result, out of the total 9,344 observations in our study sample, 9,147 represent closed intervals between births, and the rest are right-censored. In case of multiple migrations, we exclude births after the first out-migration, as it is not possible to determine how many births happened before the woman moved back to her home parish. Undetected births would then lead to underestimating the childbearing intensity of those who were more prone to migrate.

The association between grain price dynamics and birth intervals is modeled using Cox proportional hazards regression. This is a semi-parametric event history model that does not assume any specific shape in the hazard function. Since most mothers in our data experienced multiple births, the observations in the dataset are not independent. It is possible that some mothers are more likely to have children in shorter intervals due to factors that are not captured by variables in the data. To account for this unobserved heterogeneity between mothers, we fit a Cox model with an added shared frailty term. This is similar to a random effects regression model, which uses a grouping variable to nest observations within groups. The hazard rate in this case is defined as:

$$h_{ij}(t) = h_0(t)\alpha_i \exp\,(\mathrm{X}_{ij}\beta)$$

where $h_0(t)$ is the baseline hazard function at duration *t*, X_{ij} is the vector of covariates for the observation *j* belonging to group *i* and β is the coefficients to be estimated. The difference from the standard Cox model is the shared frailty term α_i, which is an unobservable quantity estimated from the data, with the assumption of being gamma-distributed. In our case, the grouping variable i is the mother's ID. In our regression tables, we report the variance of the shared frailty term.

Grain price dynamics is the most important explanatory variable in our models. The price variable applies not to the calendar year but to the harvest year, which runs from October 1 to September 30. Thus, the price in October or November will be in effect from October until September of the next year. We also include a 1-year lagged price variable, which aims to capture whether a price change from the previous year has a lasting effect on birth intervals. To gain insights into possible changes in the relationship between price dynamics, SES, and manor type, we fit interaction models separately for earlier and later periods. The period under study is divided into two subperiods (1834–1864 and 1865–1884) to take into account changes in tenure rights and the increasing commercialization of the farm economy. Considering two geographic localities, we also capture a difference between manor types: while Helme Parish was composed of noble manors, Holstre represents the state manors.

Following the example of Dribe and Scalone (2010), we want to disentangle how the fertility response to price changes was timed during the harvest year. If we make a similar assumption that peasants were able to anticipate harvest failures and bad seasons, then those peasants could have been postponing births starting in the summer months before the harvest. To capture the seasonality in fertility response, we introduce a variable that divides the harvest year into four quarters, starting from the October–December period. If a bad harvest was anticipated and fertility reduced deliberately, we expect to find that the intensity of conceptions was lower in the summer prior to an increase in grain prices. To test this, the quarter variable is interacted with grain price and lagged grain price. We fit these interaction models separately for each SES group, as in previous research.

Multiple individual-specific control variables are included in our regression models. The age of the mother at the time of the birth is specified as a categorical variable distinguishing age groups 15–24, 25–29, 30–34, 35–39, 40–44, and 45–49. Next, the age at first birth indicates whether the woman entered motherhood before age 20, between 20 and 24, or at age 25 or later. The life status of the previous child distinguishes those whose previous child was still alive at the time of the next birth from those whose previous child did not survive. The latter group is further divided into two, depending on whether the previous child died within two years or later. To take into account different propensities of migration, we add a control variable that counts the mother's migration events.

	1834–1864	1865–1884
SES		
Farmers	2,379 (41%)	1,195 (33%)
Skilled workers	261 (4.5%)	262 (7.3%)
Landless	3,129 (54%)	2,118 (59%)
Estate type		
Noble estate (Helme)	4,170 (72%)	2,647 (74%)
State estate (Holstre)	1,599 (28%)	928 (26%)
Age of woman at birth		
15–24	1,081 (19%)	274 (7.7%)
25–29	1,724 (30%)	837 (23%)
30–34	1,581 (27%)	1,019 (29%)
35–39	1,003 (17%)	834 (23%)
40–44	331 (5.7%)	470 (13%)
45–49	49 (0.8%)	141 (3.9%)
Age at 1st birth		
<20	1,405 (24%)	418 (12%)
20–24	2,691 (47%)	1,631 (46%)
25+	1,673 (29%)	1,526 (43%)
Quarter of harvest year		
1 (Oct–Dec)	1,252 (22%)	800 (22%)
2 (Jan–Mar)	1,458 (25%)	931 (26%)
3 (Apr–Jun)	1,731 (30%)	1,064 (30%)
4 (Jul–Sep)	1,328 (23%)	780 (22%)
Previous child		
Alive	4,873 (84%)	3,238 (91%)
Died in <2 years	752 (13%)	292 (8.2%)
Dead in >2 years	144 (2.5%)	45 (1.3%)
Harvest failure	1,523 (32%) †	336 (9.4%)
Number of migrations	0.399 (0.727)	0.493 (0.895)
Detrended log of rye price	-0.06 (1.31)	0.07 (1.08)
N	5,769	3,575

Table 1. Study sample. Distribution of observations by period

Source: Birth and death registers and migration records and poll tax lists from the parishes of Helme and Paistu, preserved at the National Archives of Estonia, own estimates.
Notes: Counts and percentage distribution shown for categorical variables, means and standard deviation for continuous variables.
† Harvest data begin later and are not available for 978 out of 5,769 observations in the 1834–1864 period.

5. Results

We first fit regression models using different specifications of price and harvest variables (Table 2). Model 1 estimates how the price of rye and the one-year lagged price of rye associate with the conception hazard. The reported hazard ratio indicates that a 10% increase in the price of rye is associated with an approximately 2.8% reduction in the risk of next birth. Lagged price, however, does not associate with conception risk in this model. Model 2 fits a similar model but applies an indicator variable that equals 1 for years when the price of rye was at least 10% above the mean of detrended price and 0 otherwise. The result suggests that during the years of substantially above-average prices, conception hazards were 6.6% lower. In Model 3, we use an indicator variable that assigns a value of 1 to years when there was a harvest failure (a grain yield of less than four grains per sown seed) and 0 otherwise. Such years show a 6.6% lower conception risk than non-failure years. To summarize, all three models suggest a negative fertility response to increasing grain prices, or to a harvest failure, during the same harvest year.

To assess whether the response to grain price dynamics is similar across different SES groups, Model 4 in Table 2 takes Model 1 and adds an interaction between price and SES. The result suggests that the negative effect of the price of rye on fertility remains at about 3%, although only at a 10% significance level, while interaction terms with SES are not statistically significant. According to this, the farmers, skilled workers, and landless families reduced their fertility similarly in response to the increase in grain prices. In all models shown in Table 2, there are consistent differences in conception risk by SES and estate type. Skilled workers and the landless have a lower conception risk than farmers. Moreover, the conception risk is higher on the noble estate than on the state estate. There is no statistically significant difference between the two calendar periods. However, in the next step we will investigate whether there was any change over time in how different groups responded to a price change.

	Model 1		Model 2		Model 3		Model 4	
	HR	p	HR	p	HR	p	HR	p
Age of woman								
15–24	1.762**	0.00	1.759**	0.00	1.734**	0.00	1.762**	0.00
25–29	1		1		1		1	
30–34	0.676**	0.00	0.677**	0.00	0.687**	0.00	0.676**	0.00
35–39	0.495**	0.00	0.495**	0.00	0.505**	0.00	0.495**	0.00
40–44	0.321**	0.00	0.321**	0.00	0.331**	0.00	0.320**	0.00
45–49	0.275**	0.00	0.275**	0.00	0.283**	0.00	0.275**	0.00
Age at 1st birth								
<20	0.757**	0.00	0.757**	0.00	0.769**	0.00	0.758**	0.00
20–24	1		1		1		1	
25+	1.413**	0.00	1.412**	0.00	1.374**	0.00	1.413**	0.00
Previous child								
Alive	1		1		1		1	
Died in <2 years	4.430**	0.00	4.441**	0.00	4.131**	0.00	4.433**	0.00
Dead in >2 years	0.629**	0.00	0.628**	0.00	0.611**	0.00	0.630**	0.00
Estate type								
State estate	1		1		1		1	
Noble estate	1.202**	0.00	1.204**	0.00	1.223**	0.00	1.202**	0.00
SES								
Farmer	1		1		1		1	
Skilled worker	0.739**	0.00	0.739**	0.00	0.705**	0.00	0.740**	0.00
Landless	0.684**	0.00	0.684**	0.00	0.683**	0.00	0.684**	0.00
N of migrations	0.990	0.64	0.99	0.64	0.991	0.70	0.99	0.64
Period								
1834–1864	1		1		1		1	
1865–1884	1.032	0.32	1.029	0.37	1.034	0.31	1.032	0.32
Rye price	0.972**	0.00					0.971+	0.05
Rye price, 1-year lagged	0.996	0.69					0.996	0.69
Price threshold 10%			0.934*	0.02				
Harvest failure					0.934*	0.03		
SES and rye-price								
Skilled worker*price							0.964	0.43
Landless*price							1.004	0.83
Theta	0.347	0.02	0.347	0.02	0.355	0.02	0.347	0.02
LR test	634.9		635.0		553.1		634.9	
N of births	9,344		9,344		8,366		9,344	

Table 2. Relative risks of second- and higher-order child conceptions, 1834–1884

Source: see Table 1.
Notes: + p<0.1, * p<0.05, ** p<0.01, *** p<0.001.

In order to assess how the relationship between grain price dynamics and conception hazard varies across combinations of SES and manor type, and whether this relationship changes during the period under study, we fit interaction models separately for the earlier and the later calendar period. A three-way interaction in these models combines SES, manor type, and rye-price variables. As we are mostly interested in the response of the agricultural population, those belonging to the smallest SES category, skilled workers, are omitted from these models. Non-linearities in the relationship with the price of rye are allowed by adding a quadratic term to the price variable. Since complex interaction results are more difficult to assess, we use the obtained models (tables not shown) to predict hazard ratios of conception by interacted variables and show the predictions graphically.

In Figure 4, the left side shows results for the earlier period and the right side for the later period, while the panels A and B pertain to noble estates and the panels C and D to the state estate. In both periods, farmers have a higher conception hazard than landless families. However, the difference between the two groups is not constant over time. During the earlier period, on both estate types the landless have a relatively low conception hazard. Confidence intervals of prediction for the landless overlap with those of the farmers only on noble estates and only for more extreme price changes, which means that the difference in conception hazards for the two groups becomes smaller when there are large price changes. In the later period, as expected, the picture changes. On the state estate, the gap between the two SES groups decreases, illustrated by smaller gaps in point estimates and overlapping confidence intervals. On noble estates, the difference between landowning peasants and the landless widens if the price of rye increased more than 10%. This is because the noble estates' farmers' response to price, when graphed, has a convex shape in the later period, while the landless exhibit a slightly negative association with price increase.

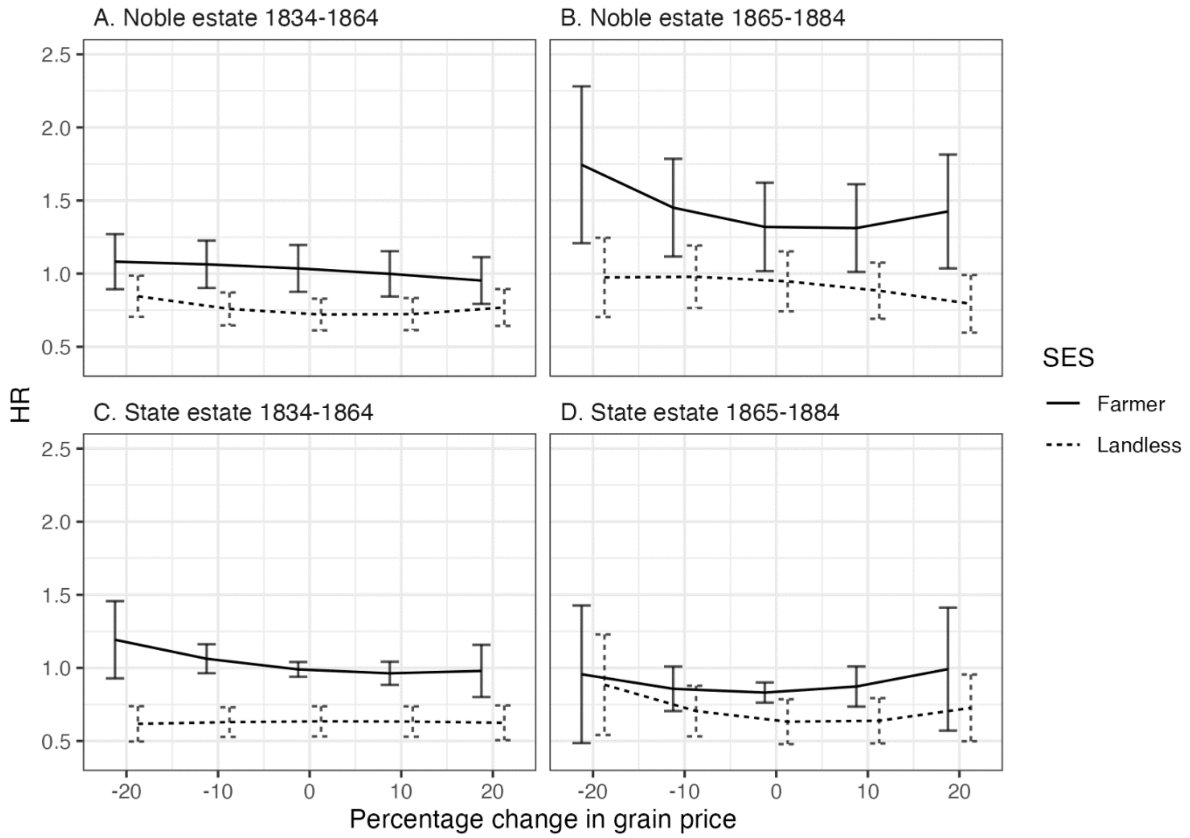

Figure 4. Predicted hazard ratios of conception by SES, manor type, and calendar period, 1834–1884

Note: separate models by calendar period. Shared frailty models controlled for mother's age group, age at first childbirth, status of previous child, mother's number of migrations, and the lagged price of rye. Control variables set at their means for prediction. Vertical lines indicate 90% confidence intervals of prediction.
Source: see Fig. 2.

Based on Figure 4, the change in conception hazard gap between the two SES groups is mostly due to farmers' response to grain price dynamics. In the earlier period, the association is negative in both estate types, but in the later period it exhibits a flat U-shape. It is possible that farmers were able to take advantage of the price increases in the later period and were not hurt by price drops. The response of the landless group is relatively flat in the earlier period and slightly negative on the noble estates in the later period, which suggests that the increasing commercialization of the farm economy made them more sensitive to the price fluctuations.

Next, we turn to models that include the seasonality of the price effect, which helps determine the timing of the fertility response. The results are presented in Table 3, and we have three models, one for each SES group. All models include one interaction term between the price of rye and the quarter, and another between the 1-year lagged price of rye and the quarter. The reference group for the quarter variable is the first quarter of the harvest year (October–December). Out of the three models, we find statistically significant interaction terms only for farmers, and we will only comment on this model. The coefficient associated with the main effect of the price of rye is not statistically significant, which means that there was no price effect immediately at the beginning of the harvest year. Also, the coefficients for the main effect of different quarters are not statistically significant, although the third quarter associates with a slightly higher conception hazard (similar to the distributions in Table 1). Among the interaction terms using the price of rye, only the one associated with the fourth quarter is statistically significant; it indicates that there is a roughly 10% decline in conception hazard. For the third quarter, there is a roughly 4.5% lower risk of conception, but this is not statistically significant. These results suggest that as the grain price increased by the start of the harvest year (first quarter), there was no immediate effect on conception risks in the second quarter. A 10% rise in prices is associated with a somewhat depressed conception hazard in spring (third quarter) but results in a significant decline in the summer period (fourth quarter), before the next harvest year. These results do not indicate an immediate response to worsening economic conditions or deliberate postponement of pregnancies due to expectations of poor harvest. It is likely that conception risks were lowered due to grain reserves being depleted by summer and malnutrition affecting the likelihood of pregnancies. However, the intensity of food shortages was most acute during the spring and early summer, normally from March until July. The start of growing season brought some relief in summer, even if fruits and vegetables had a poor reputation among the Estonian country folk. The third and especially the fourth quarter are associated with the highest-intensity field work on farms: hay-making and reaping.

In the model we also have interaction of quarters with the 1-year lagged price of rye, i. e. the fifth to eighth quarters, since the change in price. The coefficient associated with the lagged price variable suggests a slightly lower conception hazard (HR 0.967) at the beginning of the next harvest year (fifth quarter), but this difference is not statistically significant. For the following quarters, lagged price and quarter interaction terms suggest some recuperation of conception risks over the following three quarters, and there is a statistically significant interaction term, with 11% higher risk in the eighth quarter. For easier interpretation of the quarter and price interaction in the farmers' model, we compute hazard ratios for all eight quarters using different values for price and lagged price variable. The results, shown in Figure 5, demonstrate that a 10% increase in the price of rye leads to a roughly 10% decline in conception hazard by the July–September period of the same harvest year, after which there is some recovery and recuperation the following summer.

	Farmers		Skilled workers		Landless	
	HR	p	HR	p	HR	p
Age of woman						
15–24	1.571***	0.000	2.497***	0.000	1.917***	0.000
25–29	1		1		1	
30–34	0.732***	0.000	0.602**	0.001	0.635***	0.000
35–39	0.495***	0.000	0.486***	0.000	0.493***	0.000
40–44	0.305***	0.000	0.379***	0.000	0.321***	0.000
45–49	0.228***	0.000	0.413**	0.007	0.285***	0.000
Age at 1st birth						
<20	0.831*	0.013	0.547**	0.005	0.719***	0.000
20–24	1		1		1	
25+	1.387***	0.000	1.412*	0.042	1.443***	0.000
Previous child						
Alive	1		1		1	
Died in <2 years	4.196***	0.000	2.012***	0.000	5.266***	0.000
Dead in >2 years	0.426***	0.000	0.354*	0.012	0.795*	0.028
Estate type						
State estate	1		1		1	
Noble estate	1.158*	0.032	1.192	0.264	1.235***	0.000
N of migrations	1.094+	0.054	1.071	0.395	0.963	0.146
Period						
1834–1864	1		1		1	
1865–1884	1.098+	0.086	0.831	0.173	1.027	0.525
Rye price	1.006	0.853	0.944	0.553	0.999	0.986
Rye price lagged	0.967	0.325	1.081	0.414	0.958	0.124
Quarter						
1st	1		1		1	
2nd	1.024	0.677	1.134	0.433	1.013	0.789
3rd	1.075	0.193	1.176	0.293	1.054	0.258
4th	0.965	0.542	1.036	0.830	0.938	0.197
Quarter*Price						
2nd	0.991	0.841	0.976	0.854	0.962	0.321
3rd	0.955	0.310	1.051	0.694	0.990	0.791
4th	0.901*	0.030	1.052	0.703	0.967	0.407
Quarter*Price lagged						
2nd	1.046	0.331	0.857	0.247	1.063	0.110
3rd	1.069	0.143	0.925	0.536	1.002	0.964
4th	1.110*	0.033	0.957	0.749	1.030	0.463
Theta	0.382	0.036	0.317	0.094	0.327	0.027
LR test	287.8		20.0		304.34	
N	3,574		523		5,247	

Source: see Table 1.
Notes: + p<0.1, * p<0.05, ** p<0.01, *** p<0.001.

Table 3. Relative risks of second- and higher-order child conceptions by SES including price*quarter interaction, 1834–1884

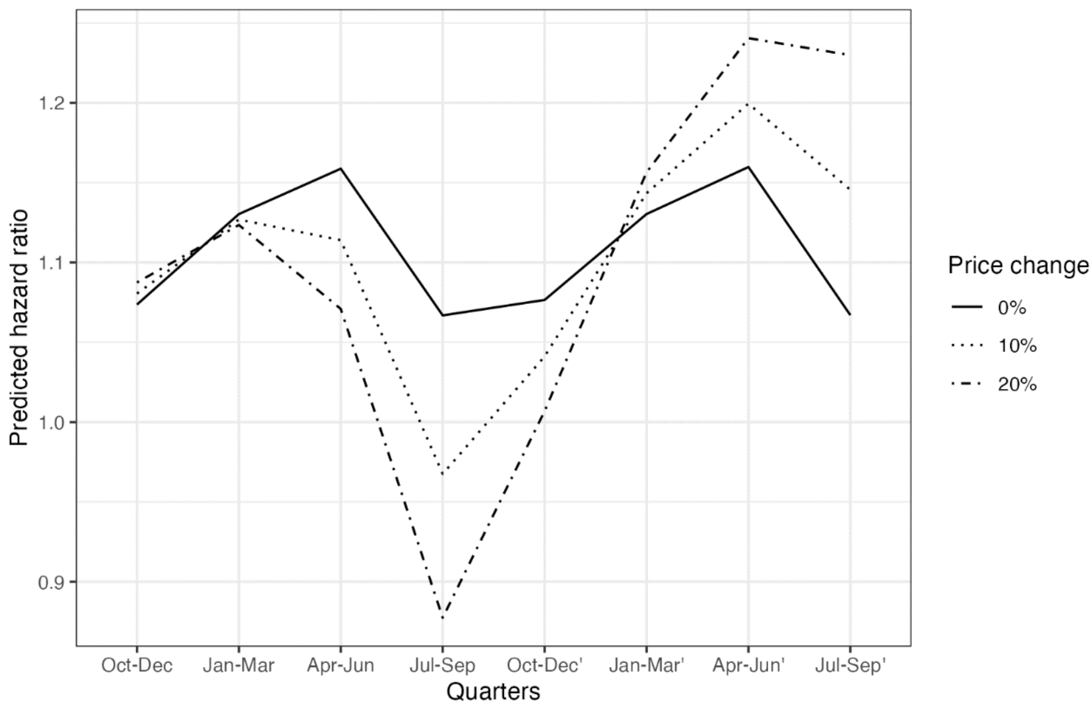

Figure 5. Predicted hazard ratios of conception by quarter interactions with price and lagged price

Source: farmers' model in Table 3. Other variables set at their means for prediction. For the prediction of quarters 5–8, based on lagged price of rye and quarter interaction, change in the non-lagged price of rye was set to 0.

The effects of our models' control variables are mostly in line with expectations. The mother's age has a strong negative association with conception hazard, which is highest in the 15–24 age group. For women aged 40 and over, the likelihood of conception is only one-third or less of what it was in the 25–29 age group. Mothers who had their first child at a relatively late age have a higher conception risk than those who became mothers before age 25. As previous studies do, we also control for the life status of the previous child; the reference group is defined as those instances in which that child is alive. The risk of another birth is higher if the previous child died within two years of birth. The overall risk of conception is higher on noble estates in Helme, where the fertility decline started later than on the state estate of Holstre. The number of migrations and the later calendar period are both weakly positively associated with the conception risk, but only for farmers in the interaction model in Table 3.

6. Conclusion

Our analysis of the association between fertility and grain price variation in the tsarist Russian province of Livonia revealed that an increase in the price of rye resulted in the drop of conceptions within the next year. This negative relationship is in accordance with the earlier research on several European settings. Alternatively, we also considered the effect of harvest failures, as this is a more direct indicator of nutritional conditions, and found the relationship to be similar.

In the area under study, the landless did not emerge as more vulnerable to price fluctuations than farmer peasants until the mid-1860s. According to our models, farmers were more sensitive to grain price changes than other social groups were, and in the event of a price hike, their conception risk declined most in the summer following the price increase. The conception hazards of farmers returned to their previous level, and even exceeded it, in the summer of the next year. That is, there was some recuperation (shortening of birth intervals) after the period of depressed fertility, which our models pick up using a 1-year lagged grain price variable. However, in the era of agricultural transformation, starting in the 1860s, the picture changes. At this point, the farmers' fertility started to show a more positive response to price increases, whereas the landless on the noble estates decreased theirs. Socioeconomic differences between the farmers and rural workers, which were weak or invisible in the pre-transformation phase, become increasingly evident starting in the 1860s. As long as the manorial system and *corvée*-based economy existed, socioeconomic differentials in fertility as well as mortality were either negligible or the farmers were more vulnerable to short-term stress (for mortality, see Klesment and Lust 2021, Lust et al. 2023). In the 1860s and 1870s, the mutual economic dependence between manors and farms declined, so that only a cash nexus in the form of rent or mortgages between the estate owner (or state) and the farmer peasant remained. As a result, the farm economy became more commercialized. Our results on socioeconomic fertility differentials in the later period corroborate several earlier findings on western and northern Europe.

Our results further undermine the claim that the magnitude and pattern of the impact of price fluctuations on fertility were similar across “all countries and all periods” throughout historical Europe (Galloway 1988), lending strong support to the assumption that the size of the price effect varied over time and across settings. Furthermore, our findings suggest that in a manorial economy, the landed could be more affected than the lower classes. In East Frisia, the lack of interaction between socioeconomic status and the price of rye in fertility response has been associated with the protective effect of the “table communities”, i.e., arrangement between landowner and his workers (Willführ and Störmer 2015). In Russia proper, the lack of effect on mortality has been linked to the protection afforded by the commune and multiple-family households (Hoch 1988). By contrast, in Scania, social differences in fertility response have been explained by the increasing inequalities in landowning and income in the era of agricultural transformation (Bengtsson and Quaranta 2024). We assume that until the mid-1860s, Estonian landless and semilandless rural workers were less affected by high rye prices and poor harvests due to the levelling effect of the manorial exploitation on the social differentiation, the small share of cash in their remuneration, and the habit of eating together with the farmers. Among the landless, birth intervals were also normally longer. The social pattern of fertility (and mortality) response in a manorial economy occurs to be different, but this difference can be hardly associated with the protective effect of the manor against short-term economic stress.

Our analysis of the timing of the fertility response reveals no deliberate postponement of conceptions immediately before or after the low harvests or price increases. In the previous literature, linear response to price variation has been interpreted as an indication of deliberate fertility control, whereas involuntary response related to malnutrition is expected to be clearly non-linear, because only severe malnutrition is expected to reduce fecundity (Dribe and Scalone 2010). Our analysis suggests that the negative reaction in conception risks occurred only in the spring and summer season of the next year, when stored grain began to run out and the workload was the heaviest for both men and women. The timing of the response lends support to the idea that the response was non-deliberate and spontaneous.

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