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Fertility responses to expectations of child mortality in a Tuscan village 1700-1913: a micro-data approach. [1]

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Abstract: This paper exploits microdata from parish registers in a rural Tuscan village to trace the relationship between experienced and expected child mortality on household fertility strategies. It turns out that spacing of births and hence completed fertility are not only linked to economic risks and infant mortality but also to expected mortality risks as proxied by past child mortality in the village and in previous generations. The results indicate that before the demographic transition households made sequential fertility choices within marriage as a response to economic shocks as well as expected child mortality.

Keywords: Fertility, Child mortality, Historical demography, Hazard model

JEL codes: J13, N33, C41

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Introduction

One of the major un-resolved issues in historical demography is whether households deliberately and intentionally planned within marriage fertility events before the demographic transition and the advent of modern contraceptive techniques. The historical existence for the so-called (Western) European marriage pattern is well established and suggests that human choice impacted upon age at marriage and first birth. Households adjusted age at marriage as a response to changes in resource constraints (Hajnal 1961). The age at marriage worked as a regulatory mechanism because births out of wedlock were rare and because fecundity falls with age making a high marriage age correlate with a lower marital fertility. There is no consensus as to the role of deliberate planning and spacing of pregnancies *within* marriage, however. We address that issue and argue that fertility decisions within marriage should be seen as sequential choices impacted upon by past and current events and expectations of future risks.

In this paper, we use a model where households have preferences regarding family size in terms of *surviving* children and their quality in terms of health and capabilities Given the resource constraints faced by the household the choices involve trade-offs between the number *and* quality of children *and* other uses of resources such as consumption. Target size differs over time and geography and social class. These differences can be explained by differences in resource constraints and preferences and by implication human intention and choice (Barro and Becker 1989; Doepke 2005). Attaining a desired target size is difficult without sequential adjustments to events such as own experience of child mortality and expectations of future child mortality. We follow the idea by Ben-Porath (1976), but see also Wolpin (1997), and distinguish between two channels through which child mortality can affect fertility: hoarding and replacement. The precautionary hoarding motives arise because fecundity falls with age and because of the uncertainty of the incidence of child mortality. Risk averse households can be expected to increase total fertility if expected child mortality is increasing to hedge against the risk of not getting the desired number of surviving children at the end of the reproductive period. In this theory, *expected* child mortality plays a central role. Expectations of child mortality can be formed on the basis of past child mortality in the village and in previous generations. In the original article by Ben Porath (1976) he shows that Israeli immigrants from Asia and Africa had higher fertility even though they had the same experienced mortality, and their expectations were probably influenced by family histories or child mortality in their home country. The other channel is replacement, i.e. parents who experience the death of a child will try to replace the child with a new child and shorten waiting time. In this case it is the *experienced* child mortality that matters for fertility. A novelty of this paper is that we explicitly model the effect of *expected* child mortality. We assume that parents form their expectations of child mortality based on the overall level of child mortality in the local area, that is the village, and the incidence of child mortality in previous generations of the family. The *experienced* child mortality is measured as the mortality affecting the present household. Since fertility choices are sequential in nature experienced child mortality can trigger off immediate replacement effects, i.e. a new pregnancy [4]. Given the strong contraceptive effect of breast feeding at least during the first six months after delivery it is difficult to ascertain whether a reduction in waiting time to next pregnancy is a biological rather than behavioural effect. The detailed data enable us to construct measures of both *expected* and *experienced* child mortality.

Previous studies on the link between child mortality and fertility have mainly been based on aggregate national or regional demographic data. However, the results are far from conclusive and cover in most cases only the 19th and 20th centuries (van der Walle 1986: Galloway et al. 1998). D. Reher (1999) forcefully argues that new insights need a closer scrutiny of micro-data provided by family reconstitution data and genealogies. Most studies in this tradition cover short time periods and do not include the entire demographic transition. Studies using more recent individual data to assess the effect of child mortality on fertility, in general, find modest effects. However, recent studies have raised the concern that these conclusions are due to empirical problems. The two main empirical issues are the measures of fertility and mortality and the potential endogeneity problem of the child mortality rate. This problem can arise if we have reverse causality, if e.g. fertility, especially spacing of children, affects child mortality (Palloni and Rafalimanana 1999). Endogeniety of the mortality rate can also arise because there might be important omitted factors such as economic conditions affecting both fertility and mortality (Ben-Porath (1976)).

This study relates to another strand of literature in historical demography which investigates whether households deliberately and intentionally planned within marriage fertility events. There is a strong, perhaps still dominant, tradition advocating that within marriage fertility can be characterized as a 'natural fertility' regime, that is un-affected by intentional adjustments to experienced and/or expected child mortality. If economic stress had any effect it was mainly through fecundity and spontaneous abortion. There is a large literature inspired by Henry (1961), for example Knodel (1978), Manfredini and Breschi (2008) making that point in relation to a study of the Tuscan village of Casalguidi and Livi Bacci and Breschi (1990) surveying pre-demographic transition Italian fertility. That survey of Italian demographic research also indicates differential fertility linked to social position. In urban areas upper class households had much lower fertility, while from rural areas there is some evidence indicating that the reverse relationship held (Manfredini and Breschi 2008). Total marital fertility at the age of 25 was down at 3 to 4 for upper class families while it was 6 to 7 for peasant and artisanal households. It is noteworthy that there were great regional and local differences and ethnic differences in fertility patterns and family structure in pre-transitional Italy. Jewish families had much lower fertility than the Catholic majority in Pitigliano, a Tuscan village. Some but not all of these differences might be assigned to deliberate birth control, although Livi Bacci and Breschi (1990) argue that fertility control was limited to a few well defined groups before the demographic transition. Upper class households married earlier but they also had early stopping so that the reproductive period was about the same

[4] Wolpin (1997) demonstrates in a series of theoretical models that an unambiguous prediction of the impact of child mortality on fertility is only valid in simplified models. As soon as models include several time periods, uncertainty, sequential decisions and allowing child and infant mortality to be different the connection between mortality and fertility becomes more complex.

independently of age at marriage. (Cf. Table 1 in Livi Bacci and Breschi 1990) These groups, called 'forerunners', had lower marital fertility and early stopping or a shorter period between first and last birth even if they married relatively young. Interestingly these descriptive characteristics of the 'forerunners' fit well into the pattern revealed by our sample as is demonstrated by Table 2 below.

We will challenge the natural fertility hypothesis and add to a growing 'revisionist' literature (David and Mroz 1989, Bengtsson and Dribe 2006, Dribe and Scalone 2010, van Bavel 2004). Much of this literature is concerned with economic shocks which seem to affect not only age at marriage but also the spacing of child births, and potentially also the completed fertility. These practices reveal some intentional human agency linked to deliberate birth control. (Cinnirella et als 2013). We address that issue and argue that fertility decisions within marriage should be seen as sequential choices impacted upon by past and current events and expectations of future risks.

In the paper we used detailed data from a village in Tuscany in the period of 1700-1913. The data are family reconstitutions and cover the entire village, but have the usual problems with migration in and out of the village. With these data, we are able to observe the entire birth history as well as the deaths of children of married couples. We construct measures of experienced (death of a child) and expected child mortality (the child mortality rate in the village in the preceding five year period). We use these measures to disentangle the effect of expected and experienced child mortality on fertility.

The empirical analysis is carried out as a duration analysis and the length of the birth interval is our measure of fertility. Our results indicate that the length of the birth interval between first and second birth is negatively influenced by both experienced child mortality, here measured as the death of the first born, and expected child mortality measured as the child mortality in the local area and in the previous generation.

This paper contributes to two different strands of literature. First it adds to the literature on the effect of child mortality on fertility, by complementing the study by Ben-Porath (1976). We show that expected child mortality impacts on fertility even when controlling for intergenerational transmission of fertility and mortality patterns. Second, we contribute to the literature providing additional and new evidence that households planned fertility before the demographic transition and the advent of modern contraceptive techniques. Previous studies have provided evidence of this hypothesis by showing that fertility was affected by shocks to living standards as proxied by the price of grain. That hypothesis is corroborated by our study. We show that fertility also reacted to expected child mortality.

The paper is organized as follows. In the following section we describe our data source and provide information on the historical context for this study. Then we outline the empirical approach and describe the econometric model used in this paper. In the next section we present and discuss the estimation result and in the final section we conclude.

Data and context

We possess a unique data set hitherto not used for scientific inquiry. It is based on a family reconstitution study of *Buriano*, a predominantly agrarian village in the Maremma region of Tuscany. This impressive family reconstitution from parish registers was performed by an amateur historian, Renzo Ronchi, and published as *Le Radice e la memoria. Buriano e le sue famiglie* (Rome 2004*).* The data set consists of information on gender and year of birth, marriage and death of some 5000 individuals over the period 1650 -2000. For the mid 19th century there are also *Stato delle anime* reports which give limited socio-economic information. These reports were performed at Easter time by the parish priest and contained information on occupation, age and sometimes literacy of all household members in the village. Only a few reports, all from the mid 19th century remain, however.

The published data set was however incomplete and we have completed it using the parish registers, copies of which were generously put at our disposal by Renzo Ronchi. Furthermore we have checked the consistency of the registers and adjusted for obvious errors. However, we still face the problem of incomplete registration typical of parish registers. For the years 1811-1816 we do not have any information on deaths because the death registers have been lost. For people moving into the village birth dates were as a rule not registered and for people leaving the village permanently we lack death dates.

Buriano is situated on a hilltop in the La Maremma Toscana, a region with a hostile disease environment. The Maremma region had higher mortality rates than other part of Tuscany less exposed to the unhealthy environment (del Panta 1993, 154-57). Marshland and swamps made malaria endemic in the area until land reclamation had been completed in the 20th century. There was a sustained decline in population in the Maremma during most of the Medici rule (1559-1737) when infrastructure investments in water control were neglected from the 17th century. Most villages in this coastal area experienced declining population, by about 30 percent, from the end of the 17th century to the mid 18th century. Attempts to repopulate the area by forced migration failed because of the heavy toll of diseases. A period of reform with land reclamation, the abolition of servitude, the liberalization of grain trade, and redistribution of church land accompanied a period of rapid population growth from the mid 18th century until the onset of the demographic transition. Population increased faster than in other parts of Tuscany because of its initial low level of population density, which also attracted immigrants from other past of the region. Population in Buriano tripled between the 1760s to the 1850s to some 500 inhabitants.

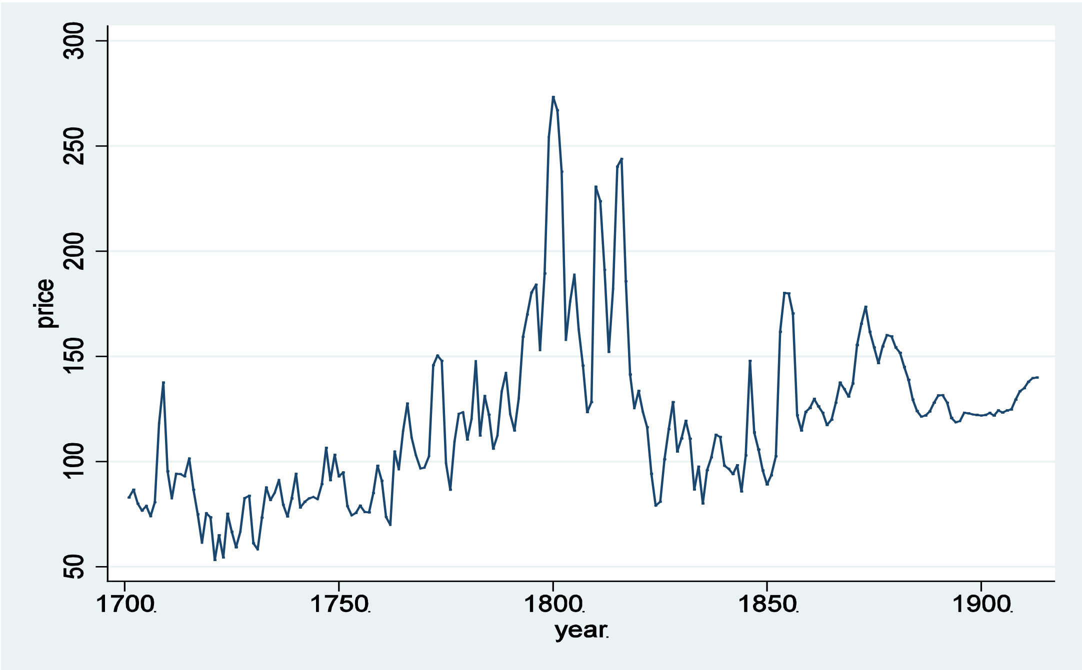
The population consisted, as revealed by mid-19th century *Stato delle anime* registers, of farm workers, herdsmen, tenants and a small number of land-owners. Households were predominantly nuclear, one generation households, and not of the complex nature found elsewhere in Italy and including many parts of Tuscany (Viazzo 2003). Less than 10 percent of households were joint households by mid 19th century, another 10 percent were nuclear families with a widowed parent living in-house. The remaining 80 percent of the households were strictly nuclear. Age at marriage had about the same level and trends as in the rest of Tuscany. It increased up to the end of the 18th century before a fall was setting in. (Breschi and Rettaroli 1995 as cited in Viazzo 2003). Fertility and mortality were slightly higher in the Maremma in the early 19th century but converged to average Tuscan rates at the close of the 18th century.

The social composition indicated a strong presence of tenants and unskilled farmworkers with only 18 per cent of households owning land (1841). With less than a handful of exceptions landowners possessed only small parcels of land for horticulture and pasture. Unskilled workers dominated among men marrying into the village, 52 per cent in 1842, while tenants and landowners constituted about 80 per cent of households headed by a male born in the village. Outsiders were also more frequent among artisans, or about a quarter of men marrying into the village. Almost half of the artisans had some literacy skills against a quarter for landowners. Tenants, herdsmen and unskilled workers (bracciante) had a very low literacy rate, just 2 per cent in 1841.

We do not have income or tax data but we can use wheat price data as an indicator of transitory economic shocks. The price series we use refer to prices in Pisa, about 140 kilometers north of Buriano, see Figure 1.

Tuscan grain markets were fairly well integrated in this period. The price volatility is high but that was the case for wheat prices all over Europe in this period including the spike during the Napoleonic wars. Grain price shocks can have differential effects on rich and poor. Producers who have a surplus to sell will benefit from the high prices. However, net consumers will in general be adversely affected by a price increase. Buriano was, as indicated above, a socially rather homogenous village of unskilled farmworkers and herdsmen and in times of grain shortage most households relied on grain markets for provisions and only a small number , less than 20 per cent, were suppliers to the grain market.

Figure 1: The price of wheat in Pisa. Soldi per staio.



Sources:P. Malanima (1976) After 1861 we have used an all-Italian consumer price index from S. Fenoaltea (2002)

The sample

For this paper we have selected a sample of mothers who gave birth to their first child in the period 1700-1913. The sample contains 873 mothers, but for 225 of them we do not have any further information on births of additional children, the date of death or the date of death of their husband. We exclude these women and end with a sample of 648 women. The number of mothers at different periods can be seen from the graph A1 in the appendix.

In Figure 2 we look at the completed fertility of this sample. We consider two measures of fertility: number of child births and number of surviving children. We group the mothers into 20 year intervals depending on the year of first birth. Because of missing data on deaths we cannot calculate surviving children born from 1800-1820. From the figure it is clear that the average completed fertility varies over the years. There is a sustained increase from the mid 18th century until the demographic transition sets in in the 20th century. It is possible that it reflects an upward shift in the target size of households triggered off by easing resource constraints due to the successive campaigns of land reclamation, an improvement of the legal status of tenants and redistribution of church land which were implemented over the following century. However, by the middle of the 18th century population in the area was at a historical low, perhaps just 2/3 of the level 150 years before. It seems as if the marital fertility was in the lower end in comparison with other Italian local studies. We also see a substantial gap between the number of surviving children and child births, suggesting a high level of child mortality. The gap widens from 1820 to 1840, where the average completed fertility was above 5 children but only around 3.5 children survived to the age of 5. In a comparative Italian perspective completed fertility is low and similar to what has been recorded for upper class families which presumably practiced fertility control.

In figure 3 we calculated the average age at marriage and average age at first birth and again we group the mothers into 20 year bands according to the year of first birth. For many women in our sample we have no information on the year of birth, which means that both age at marriage and at first birth is missing. The two curves refer to slightly different sample sizes, which explains the counter-intuitive result that age at marriage is above age at first birth around 1900.For 33 percent of the sample we do not have mother’s age at firth birth and for 65 percent we do not observe the age at marriage.

Figure 2: The average number of children and surviving children

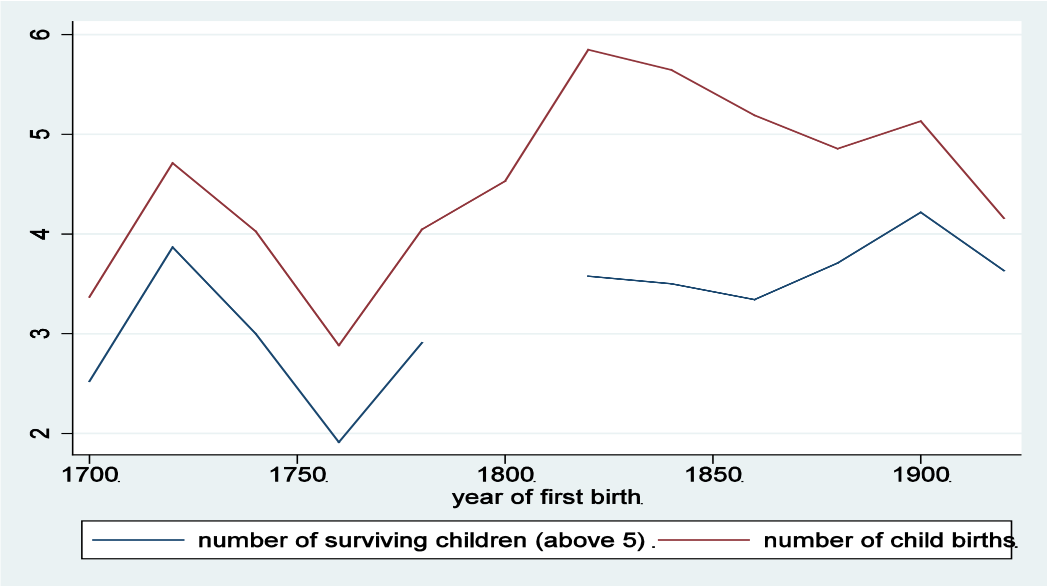
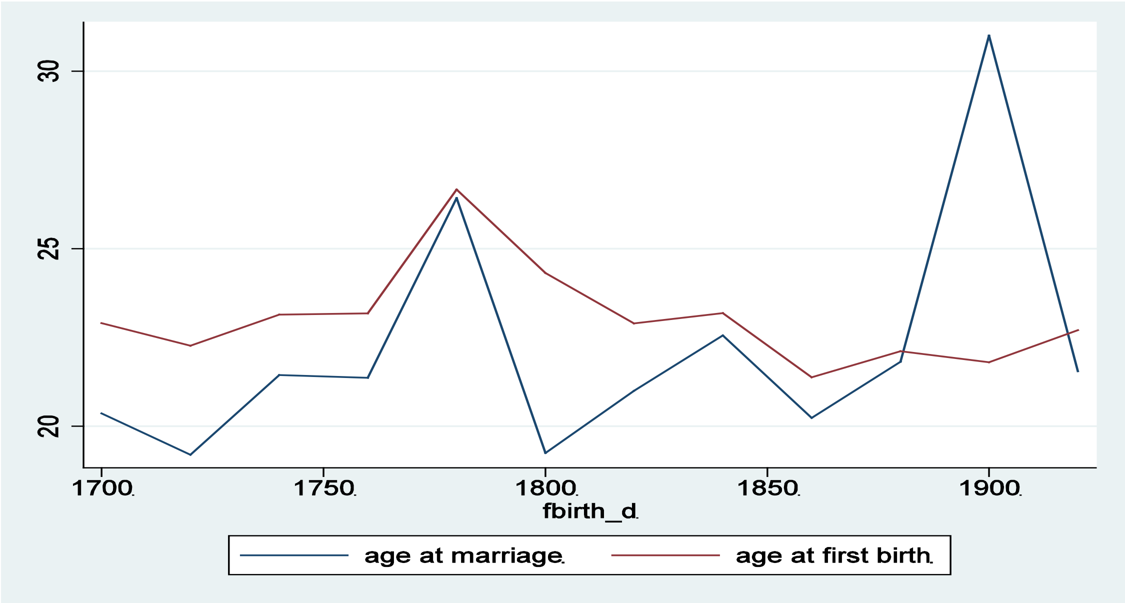


Figure 3: Average age of first birth and average age of marriage



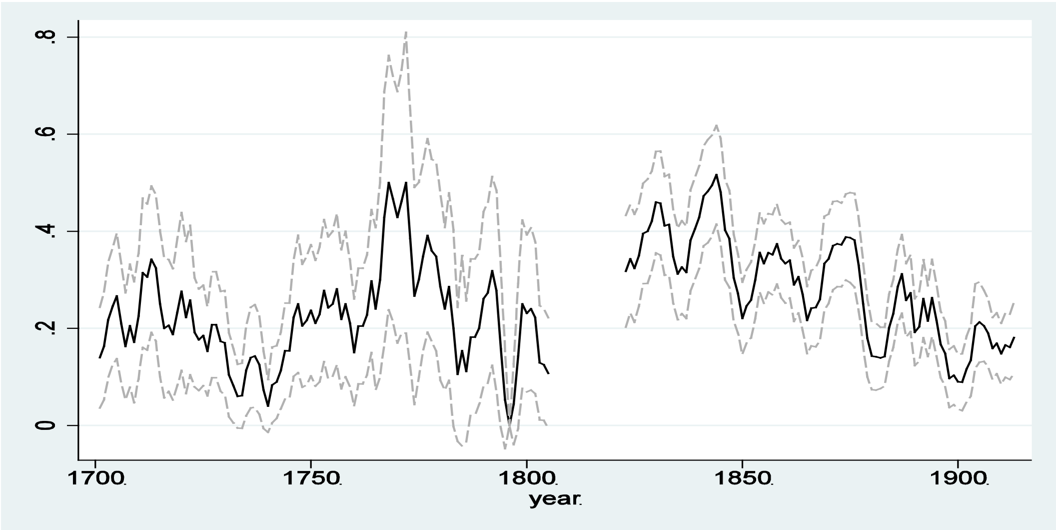
Three measures of child mortality

The key issue in this paper is to get measures of expected child mortality. We propose to use the child mortality in the local area and in the previous generation as such measures. The underlying assumption is that households formed their expectations on child mortality based on what they had observed. These measures are not without limitations and we will return to this issue.

We use three different measures for child mortality: the village child mortality rate, family child mortality and an indicator of if the first child of the family dies. For all the measures we define child mortality as death before the age of 6.[5] In the analysis we will examine how these different measures of child mortality affect fertility. The idea is that both the village child mortality and family child mortality will affect the expectations about future child mortality and impact on hoarding behavior while the death of the first child will trigger replacement efforts.

We construct the village mortality rate as a 5 years moving average of the number of children dying in the village. Unfortunately, the death registers from 1811-1816 are missing, which means that there are no reported deaths in this period. Therefore we exclude this period from our calculations of the village mortality rate. The village mortality rate is shown in figure 4. We use this measure as a proxy of expected fertility.

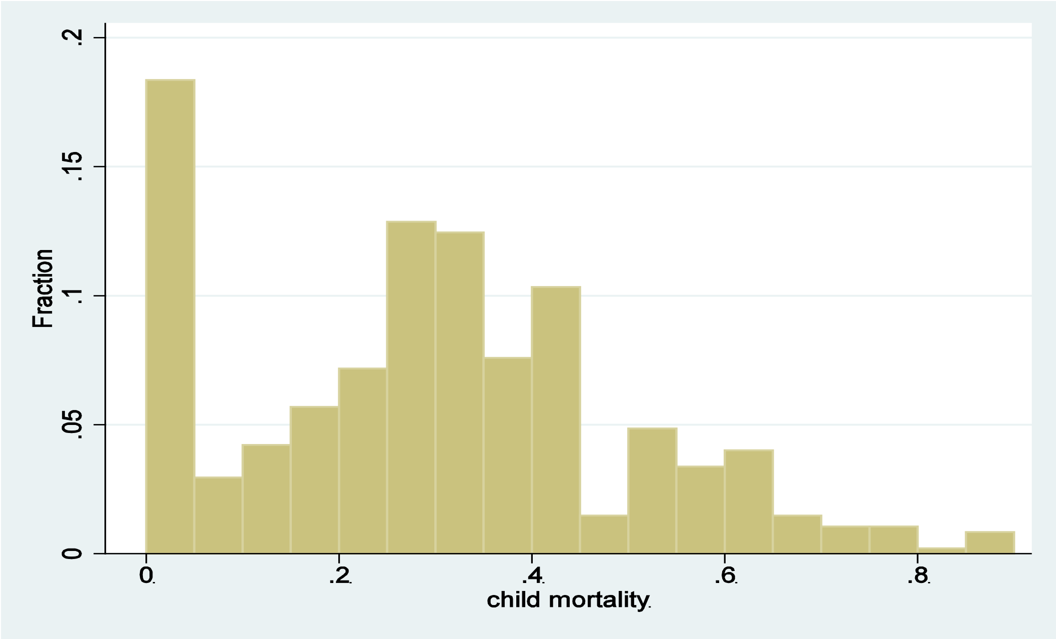
Figure 4: Village child mortality rate and confidence bands



The second measure is defined as the fraction of siblings that died for the mother and the father. If the information on the father is missing the information for the mother is used and likewise if the information for the mother is missing. If couples form their expectations about child mortality by looking at the child mortality experienced by their parents this measure should impact on fertility. Family specific knowledge about healthcare and hygiene may be captured by this measure. If we look at this measure for our sample of mothers we see a lot of variation in the incidence of child mortality even within the same time period. In figure 5 we show the family child mortality fraction, which indicates an enormous variation; some families do not experience child mortality while others do.

[5] We have also tried defining child mortality as mortality that occurs before the age of 10. The results are almost unchanged.

Figure 5: Family child mortality rate



E.g. in the period 1881-1900 there were 59 women who gave birth to their first child. Of these women 5 percent had no family history of child mortality, while for 10 percent of the women 2/3 of their siblings had died before the age of 6. So this measure exploits the variation between families.

Finally we also use an indicator of whether the first child had died as a measure of child mortality. This is the traditional measure which has been widely used to estimate the replacement ratio (see Wolpin (1997)), The descriptive data of the three measures based on our sample of mothers are summarized in Table 1. The table shows the sample means of the three measures. The village and family mortality rates are both around 28 percent while the rate of death of the first child is slightly higher, 30 percent. This could be because the child mortality rate is higher for the first born child. Furthermore, Table 1 indicates a small correlation between village and family child mortality and death of first child. The lack of correlation might be due to the fact that the mortality is measured in different time periods: family mortality typically about 25 years earlier and village mortality about 5 years earlier than death of first child.

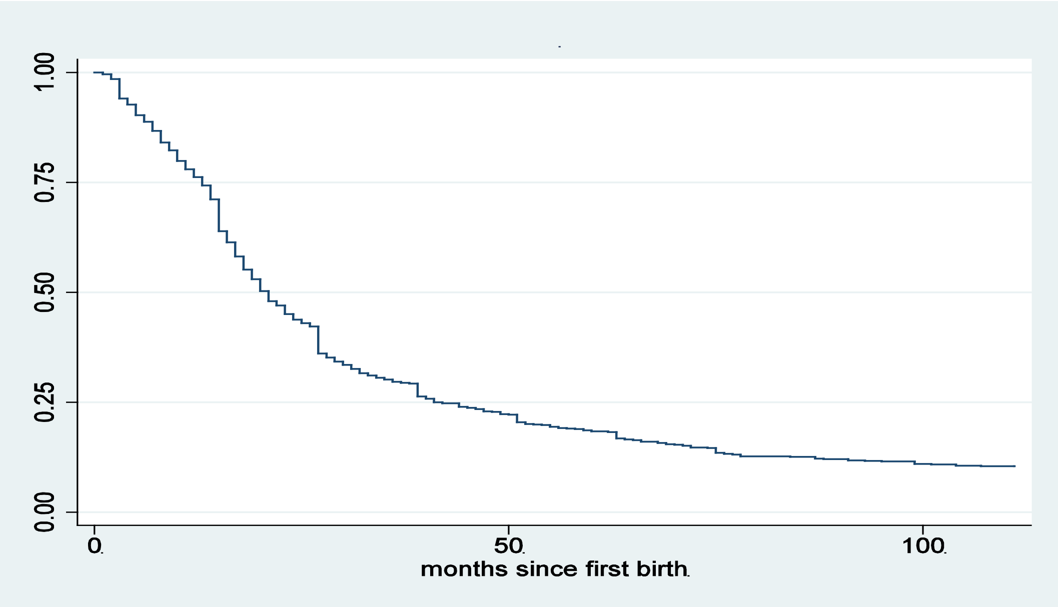
Table 1 Sample statistics with correlation coefficients.

	Village child mortality	Family child mortality	Death of first child
Mean	0.28	0.28	0.30
Corr Village	1	.	.
Family	-0.06	1	.
First child	0.12	0.06	1
No. obs.		383	

Measures of fertility

In the literature on fertility a number of different measures have been suggested. The measure we primarily use is the spacing between first and second child or more precisely the waiting time from first birth until conception of the second child or the mother dies. There are three reasons why we prefer this measure. First, we can take account of maternal mortality, which is substantial in this period. Surprisingly, maternal mortality has been ignored in much of the existing theoretical and empirical literature on child mortality. Therefore it is unclear how the results are affected by ignoring maternal mortality. Furthermore the empirical papers considering the link between child mortality and fertility have not controlled for mortality of the mother. However, a study on recent data from Haiti suggests that the death of the mother is associated with higher risk of child mortality (see Anderson et al (2007)). Therefore it might be important to take mortality among the mothers into account. Second, we can take account of the timing of the first child's death and model that the hazard changes at the time of the death of the first child. Third, we can exploit a larger part of the original sample if we look at waiting time between first and second birth rather than waiting time between marriage and first birth or age at first birth. The reason is that for many women in our sample the year of birth is missing, as noted above. The waiting time after first birth is measured in months. When constructing the birth intervals we use the dates of two subsequent births. As often done when modeling birth intervals we prefer to model the time from birth to next conception. Therefore we subtract 9 months from the waiting time and thus model the conception rather than the birth of the second child. If the month of birth is missing but year of birth is observed the month of birth is set to June. The waiting time is censored at 120 months. Furthermore if the mother dies the observation is censored at the time of death. The Kaplan-Meier survival function is shown in Figure 6. The discrete jumps at 3, 15, 27 and 39 are caused by the missing data of months of birth. The data show that around 10 percent of mothers do only get one child. In the sample there are 18 women who only get one child and die within 10 years after the birth of the first child.

Figure 6. The Kaplan-Meier waiting time to conception of second child



When we correlate the spacing between first and second child with completed fertility we detect a high negative correlation of -0.42, suggesting that waiting time has an impact on the completed fertility.

In figure 7 we show how the median waiting time has changed over the period. The median waiting time varies between 23 months up to 35 months and is highest in the period 1750-1800 and increases again from 1880.

Figure 7: Median spacing between first birth and conception of the second child.

The method

To model the waiting time between first and second birth we use a duration model. In order to control for expected and experienced child mortality we estimate a Cox proportional hazard model. The hazard is given by

$$\ln h_i(t) = \ln h_0(t) + X_i\beta + \gamma Z_i(t),$$

where $h_i(t)$ is the hazard for woman *i* with duration *s* observed in year *t*. $h_0(t)$ is the baseline hazard, and X_i is a vector of characteristics measured at the time of the first birth (including gender of first child, age at first birth, family fertility and child mortality, and the level of the village mortality and wheat prices). $Z_i(t)$ contains the time varying covariates, which in our case is a dummy for the death of the first child.

In the model we take account of censoring, which can occur either because the woman dies or at ten years after first birth. The model is estimated using maximum likelihood estimation. To allow for the fact that there might be association between the death of a mother and the death of a child we also estimate the model as a competing risk model where conception of the second child and death of the mother constitute the two possible termination events.

In the estimations we also estimate a model where we are using birth intervals for subsequent births. This implies that each mother will be observed with multiple birth intervals. To take account of unobserved heterogeneity across mothers we allow for an unobserved component ε_i, which is capturing the unobserved time invariant factors e.g. fecundity. The model we use here is given by the hazard function

$$\ln h_{ij}(t) = \ln h_0(t) + X_{ij}\beta_j + \gamma_j Z_i(t) + \varepsilon_i$$

where *j* refers to parity. In this model we can allow for unobserved heterogeneity across mothers. The model is estimated as a shared frailty model, where we assume a specific distribution on the term ε_i.

Our preferred model is the model where we focus on the birth interval between the first and the second child. There are two reasons why we prefer this model over the model that uses all birth intervals. First, as mentioned earlier, there is a potential problem of reverse causality. If short birth intervals increase the likelihood of mortality among all the children (not only the last born), this will imply that we have feedback effects in a model where we consider all the birth intervals, which can bias the results. Second, it is not clear that impact of child mortality is the same across parities (see Wolpin (1997) for an elaborated discussion). We will return to this issue when discussing the results.

Estimation results

In this section we present the results of our analyses from the proportional hazard model.

In addition to our three child mortality variables we also include other explanatory variables. The variables we include are:

- Mortality variable: The death of the first child, the family specific child mortality and village child mortality.
- A dummy for the first child being a girl
- Variables indicating if the mother and/or father were born outside the village
- Age at first birth: age dummies including a dummy for unknown age.
- Family fertility measured as the average family size of father and mother
- The deviation of log price of grain from the long run trend.
- A general time trend model as a second order polynomial

In Table 2 we present descriptive statistics of the explanatory variables. Notice that missing values occur and therefore the sample will be reduced when these variables are included. In the data 47 percent of the first born are girls, which is as expected. When looking at the pattern of migration it is clear that the mothers are much more likely to have migrated into the village, since 62 percent are born outside the village. The similar number for the fathers is 37 percent. We speculate that this pattern is due to a patrilinear society where the men typically stay in the village and marry women from surrounding villages. The average age at first birth is 22.6. In our sample the average number of births is 4.8 per women. One reason for the relatively low fertility was that average age of last birth was low. Table 2 indicates that the time between first and last birth is in the lower part of the interval found for Italy and that is also true for the number of births. A possible explanation could be that maternal mortality was high. In our sample we find that 14 percent of mothers die within 10 years after their first birth, and the average number of children of those mothers is 2.3 children. However, if we compare the age at last birth for our sample with the numbers in Livi Bacci and Breschi (1990) we find that our data for the age of last birth is within the range of what other studies have found. In Appendix Figure A2 we have regressed age at last birth on marriage age using the data from Table 1 in Breschi and Livi Bacci (1990). It turns out that a delay of marriage age has only a marginal effect on the reproductive period defined as the time between marriage and last birth. A decrease in the age at marriage of 5 years, say from 25 to 20 increases the reproductive period by just 9 months. Buriano's marriage and last birth patterns fit very well into the general picture in Appendix Figure A2 with a marriage age approximately at 21.4 and last birth at 35.5. Early marriage means early stopping and late marriage late stopping.

The completed family fertility in the previous generation is 6.8 children. This number is higher than the completed fertility shown in the table. There are two reasons for this. First, the fertility of the previous generation refers to older cohorts than our estimation sample. Second, family fertility is only based on families that lived in the village for at least two generation. As we later will show the fertility of "stayers" was considerably higher than the fertility of "movers". We will return to this issue when we discuss the estimation result.

Table 2: Descriptive statistics for the control variables

	Mean	Std. dev	Min	Max	No obs.
First child a girl	0.47	0.50	0	1	648
Mother from outside	0.62	0.49	0	1	648
Father from outside	0.37	0.48	0	1	648
Age at first birth	22.6	5.43	11	44	421
Number of children	4.85	3.04	1	18	648
Time between first and last birth (yrs)	10.17	7.51	0	38	648
Age at last birth	34.51	7.47	16	62	421
Mother dies within 10 years after first birth	0.14	0.34	0	1	648
Family fertility	6.8	2.88	1	14	427

In Table 3 we present the estimation results from a Cox model of the spacing between first and second child. We present three different specifications of the model. In the first column we include our basic set of controls. In the second column we have added the fertility pattern of the couples' parents (the average number of births of the grandmothers). We do this in order to control for intergenerational transmission of fertility patterns. In the third specification we include prices of grain as a control variable to capture the impact of economic conditions. The table presents the estimates of the Relative Risk (RR), where coefficients above one indicate that the variable will increase the likelihood of having the second child and decrease the birth interval.

Table 3: Estimation results from Cox proportional hazard model

	Model 1 RR (p)		**Model 2 RR (p)**		**Model 3 RR (p)**	
First child dies (0-2 years old)	2.13**	(0.00)	2.12**	(0.00)	2.15**	(0.00)
First child dies (3- years old)	0.79	(0.19)	0.81	(0.37)	0.81	(0.39)
Family child mor.	1.59*	(0.10)	1.35	(0.34)	1.60*	(0.10)
Village child mor.	3.44*	(0.06)	3.17*	(0.08)	1.97*	(0.32)
First born girl	0.90	(0.34)	0.90	(0.36)	0.90	(0.35)
Father born outside	0.49**	(0.05)	0.52*	(0.07)	0.55*	(0.10)
Mother born outside	0.99	(0.97)	1.00	(0.96)	1.06	(0.61)
Price	-	-	-	-	0.37**	(0.00)
Fam fertility	-	-	1.03	(0.20)	-	-
Other controls	Age dummies/ time trend		Age dummies/ time trend		Age dummies/ time trend	
No. obs	568		568		568	
No. mothers	380		380		380	

Note: * significant at 10 percent level, ** significant at 5 percent level
(.) standard error

The results in Table 3 suggest that households which experienced infant mortality (First child dies variable) shortened the waiting time to next birth and this variable is significant in all three specifications. This suggests a replacement effect. We have in our specification allowed for that the effect might differ if the first child dies before the age of two or after. Doing this it is clear that the effect was only found for the death of an infant. This may be interpreted as evidence of a biological effect rather than a behavioural effect, since normal fecundity returns soon after breastfeeding has ceased.

The family child mortality variable suggests that high mortality in the previous generation can impact on expectations of own child mortality risk and hence reduce the waiting time. In this interpretation it is a behavioural, hoarding response.[6] As mentioned earlier we may also expect an intergenerational transmission of fertility patterns. To account for this we include the fertility pattern of the previous generation (see column 2). The effect of family child mortality becomes smaller and is not significant when also controlling for family fertility (see column 2). This suggests that part of the effect may be due to intergenerational transmission of fertility patterns.

The most important support for the role of a deliberate hoarding strategy is the strong impact of the village child mortality. If village child mortality declines the waiting time is increasing and vice versa. This makes sense in the framework we have presented in the introduction. If households have formed a target size a decline in expected child mortality as indicated by the low village mortality will permit households to postpone the next conception and still be able to attain the target size.

We will now briefly comment on some of the other controls. We find no evidence of a gender effect, and hence no indication of gender preferences. We have also investigated if there was a differential impact of the death of the first child depending on the gender but we did not find this either.[7] We do find strong effects of the age of the mother, however. Younger mothers have short birth intervals. This is consistent with fecundity declining with age.

The 'father born outside' variable indicates that waiting time is increasing for households with an 'outsider' husband. It is significant in all the specifications. A plausible interpretation is that a male outsider is not holding land or property and is probably in the poorer end of the social stratification. If so the results seem to confirm results found elsewhere in Tuscany that poorer households had lower marital fertility. In other words such households faced a stiffer budget constraint which reduced the target size relative to more affluent households. We do not find any effect of the mother born outside the village, however. Being born outside the village is the case for the majority of the wives in the sample.

In specification three we have included a measure of family specific fertility (the fertility of the previous generation). The estimation result shows that a high fertility in the previous generation did not have a significant impact on the birth interval.

[6] We cannot exclude the possibility that the effect is caused by a genetic factors.

[7] These results are not shown.

The price of wheat variable, as suggested above, can also be interpreted as triggering a behavioural fertility response through two mechanisms. An increase in food prices with labour supply constant will reduce real income and might therefore induce parents to increase waiting time. The income effect and substitution effect (the costs of raising a child increase) will have the same sign. It might also induce women to increase their labour supply to supplement household income and that will again lead to households postponing next child. The results are consistent with both interpretations.

Robustness check

In this section we present results from a number of different specifications and models. We start by presenting the variations of the specification. In the table below we only present estimates of our measures of child mortality. In each row we vary the specification. The first row corresponds to our preferred specification. In the second row, we have replaced village mortality by deviations from the trend in child mortality. The result shows that birth intervals react less to deviations although high child mortality still leads to short birth intervals. Perhaps it is not surprising that the effect is weaker when we consider deviations from a trend. From a behavioural point of view deviations from trend are not that easy for inhabitants of the village to estimate. Villagers could easily observe the incidence and number of infant deaths rather than deviations from trend. In the third row we included the overall mortality in the village measured as the number of deaths in the village. The measure has been smoothened to avoid huge fluctuations from year to year. This measure is strongly positively correlated with village child mortality and the effect of village child mortality becomes smaller and insignificant when including a general measure for mortality. As in the previous specification, the overall mortality makes less sense in determining child mortality risk since overall mortality is determined by deaths of the old and frail in the village. In the fourth row we have included lagged price deviations from a trend in prices. The impact of this variable is almost the same as including the prices directly: the impact of village mortality becomes smaller. In the fifth row we estimate a competing risk model instead where we explicitly model the likelihood that the mother dies before she has her second child. This happens for about five percent of women in our sample. In the competing risk model we find that the impact of child mortality is smaller but still significant, which is also the case for village child mortality and for the effect of having an infant who dies.

Table 4: Robustness checks

	First child dies 0-2		First child dies >2		Family child mortality		Village Mortality	
Baseline model (column 1 in Table 3)	2.13**	(0.00)	0.79	(0.34)	1.59*	(0.10)	3.44*	(0.06)
Deviations from Village mortality	2.17**	(0.00)	0.79	(0.38)	1.58	(0.11)	1.49	(0.58)
Include over all mortality	2.18**	(0.00)	0.81	(0.38)	1.53	(0.14)	1.39	(0.68)
Lagged Price Deviation	2.13**	(0.00)	0.80	(0.36)	1.63*	(0.27)	2.15*	(0.25)
Competing risk model	1.51**	(0.01)	0.96	(0.83)	1.47	(0.165)	2.23*	(0.06)

Note: * significant at 10 percent level, **significant at a 5 percent level
(.) standard error

Below in Table 5 we also present results of the estimation from the frailty model where we consider birth intervals up to the fifth birth. In these analyses we find almost the same impact of a death of an infant, but we do not find any significant effect of the other measures of child mortality. As mentioned earlier a possible explanation for these results could be that there is a feedback effect from short birth intervals to higher child mortality. This will happen if a short birth interval between the first and the second child increases the likelihood that the first or second child dies. It will then have an impact on the timing of the birth of the third child, which will be affected by the mortality of the first and second child. In this set up it will be difficult to disentangle the effect of child mortality because child mortality in it self can be affected by the length of the previous birth intervals. When examining the data more closely we do see some indication of such a feedback effect. We find e.g. that the likelihood that the third child dies is negatively affected by the birth interval between the second and the third child. An alternative way to illustrate it is that the birth interval between the second and third child is on average 26 months for those mothers where the third child survives while it is 21 months for those mothers where the third child dies. The implication is that the length of the previous birth interval does affect mortality.

Table 5: Estimation results from the frailty model

	Model 1 RR (p)		**Model 1 RR (p)**		**Model 3 RR (p)**	
First child dies (0-2)	2.28**	(0.00)	2.27**	(0.00)	2.25**	(0.00)
First child dies (3-)	0.99	(0.98)	1.00	(0.99)	1.00	(0.99)
Family child mor.	1.02	(0.99)	0.89	(0.61)	1.05	(0.79)
Village chd mor.	1.14	(0.74)	1.10	(0.82)	0.89	(0.79)
First born girl	1.00	(0.83)	1.01	(0.86)	1.00	(0.92)
Father born outside	0.67*	(0.09)	0.68*	(0.10)	0.71	(0.15)
Mother born outside	1.06	(0.49)	1.07	(0.43)	1.05	(0.79)
Price	-	-		-	0.50**	(0.00)
Fam fertility	-	-	1.02	(0.27)		-

Other controls	Age/time trend/parity	Age/time trend/parity	Age/ time trend/parity
No. obs	1786	1786	1786
No. mothers	380	380	380

Note: * significant at 10 percent level, *** significant at 5 percent level
(.) standard error

Concluding remarks

In the present study we examine the impact of child mortality on fertility. We test the hypothesis that not only *experienced* child mortality but also *expected* child mortality affected fertility. Our empirical analysis is based on data from a village in Tuscany and contain data on eight generations from 1700-1913. Expected child mortality is proxied by past child mortality in the village whereas experienced mortality is measured as the death of the first child. As a measure of fertility we use the spacing between births, and we focus on the birth interval between first and second child rather than using all birth intervals. The reason to focus on spacing between the first and second child is that there might be feedback effects from the length of the birth interval on child mortality and they can potentially invalidate our estimation strategy. Furthermore, we show that spacing between first and second child is correlated with completed fertility. We estimate our model using a Cox proportional hazard model for the spacing between first and second child. Our results indicate that both experienced and expected child mortality have a strong impact on fertility. We also find evidence that prices of grain affected fertility.

Our results support the hypothesis put forward by Ben-Porath (1976) that both experienced and expected child mortality matters for fertility. As an addition to Ben-Porath (1976) we can explicitly address how expected child mortality affects fertility since we use two proxies for expected child mortality. Our empirical strategy also enables us to test for competing hypotheses which we do in our robustness check. Furthermore, we find evidence for this hypothesis in a very different context than Ben-Porath (1976), which to our knowledge has not been done before. Our study contributes to the ongoing debate about whether households deliberately and intentionally planned within marriage fertility events before the demographic transition and the advent of modern contraceptive techniques. We have found strong evidence of deliberate adjustment of fertility strategies within marriage as a response to economic shocks as well as expected child mortality. Recent research has indicated the effect of economic shocks but the impact of expected infant mortality as proxied by past village mortality is a new and unique result.

Reference

Barro, R. and G. Becker (1989), 'Fertility choice in a model of economic growth', *Econometrica* 57(2) 481-501.

van Bavel, J. (2004) Deliberate birth spacing before the fertility transition in Europe: Evidence from 19th century Belgium, *Population Studies* 58(1), 95-107

Bengtsson, T. and Dribe, M (2006) Deliberate control in a natural fertility population: Southern Sweden 1766-1860, *Demography*, 43(4) 727-46

Ben-Porath, Y. (1975), 'First-generation effects on second-generation Fertility', *Demography*, 12(3), 397-405.

Ben-Porath, Y.(1976), 'Fertility response to child mortality: micro-data from Israel', *Journal of Political Economy*, 84(4), 163-178

Cinnirella, F., M.P.B. Klemp and J.Weissdorf, (2013) Malthus in the Bedroom: Birth Spacing as a Preventive Check Mechanism in Pre-Modern Britain, CEPR Discussions Papers 9116

David, P.A. and Mroz, T.A. (1989) Evidence of fertility regulation among rural French villagers, 1749-1789, *European Journal of Population* 5 (1) 1-26, and 5 (2) 173-206

Del Panta, L, La popolazione delle champagne in etá moderna. Atti del convegno della Societá Italiana di Demografia Storica, Bologna 1993.

Doepke, M. (2005), 'Child mortality and fertility decline: Does the Barro-Becker model fits the facts?', *Journal of Population Economics*, 18:337-366.

Dribe, M. and Scalone, F.(2010) Detecting deliberate fertility control in pre-transitional populations: Evidence from six German villages 1766-1863, *European Journal of Population*, 26: 411-434

Fenoaltea, S. (2002) Textile production in Italy, 1861-1913, *Rivista di Storia Economica*, 18.

Guinnane, T.W. (2010), 'The Historical Fertility Transition and Theories of Long-Run Growth: A Guide for Economists', Journal of Economic Literature, 49,3,pp.589-614.

Galloway, P.R. et al. (1998), 'Infant mortality and the fertility transition: Macro evidence from Europe and new findings from Prussia', in M.RR. Motgomery (ed.*), From death to birth: Mortality decline and reproductive change*, Washington: National Academy Press.

Henry, L (1961) Some data on natural fertility, *Eugenics Quarterly*, 8, 81-91.

Knodel, J (1978) Natural fertility in pre-industrial Germany, *Population Studies*, 32 (3), 481-510

Livi Bacci, M. and Breschi, M (1990) Italian fertility : An historical account, *Journal of Family History*, 15(4) , 385-408

Manfredini, M. and Breschi, M.(2008*)* Socioeconomic structure and differential fertility by wealth in a mid-nineteenth century Tuscan community, *Annales de demographie historique*, 115, 15-33

Malanima, P. (1976) "Aspetti di mercato e prezzi del grano e della segale a Pisa dal 1548 al 1818 in *Ricerche di storia moderna* I, pp. 288-327, Pisa: Pacini.

Palloni, A, and H. Rafalimanana (1999), 'The effects of infant mortality on fertility revisited: new evidence from Latin America', *Demography*

Reher, D. (1999), 'Back to basics: mortality and fertility interaction during the demographic transition', *Continuity and Change* 14(1), 9-31.

Ronchi, R. *Le Radice e la memoria. Buriano e le sue famiglie,* Rome 2004.

van der Walle, F. (1986), 'Infant mortality and the European demographic transition' in A.J. Coale et al. (eds*), The decline of fertility in Europe,* Princeton: Princeton University Press, 201-233.

Viazzo,P. P. (2003) What is so special about the Mediterranean? Thirty years of research on household and family in Italy, *Continuity and Change*, 18,1, pp.111-137.

Wolpin, K (1997): 'Determinants and consequences of the mortality and health of infants and children' Chaper 10 in Rosenzweig and Stark (ed) *Handbook of Population and Family Economics*.

Appendix

Figure A1: The number of mothers in the sample

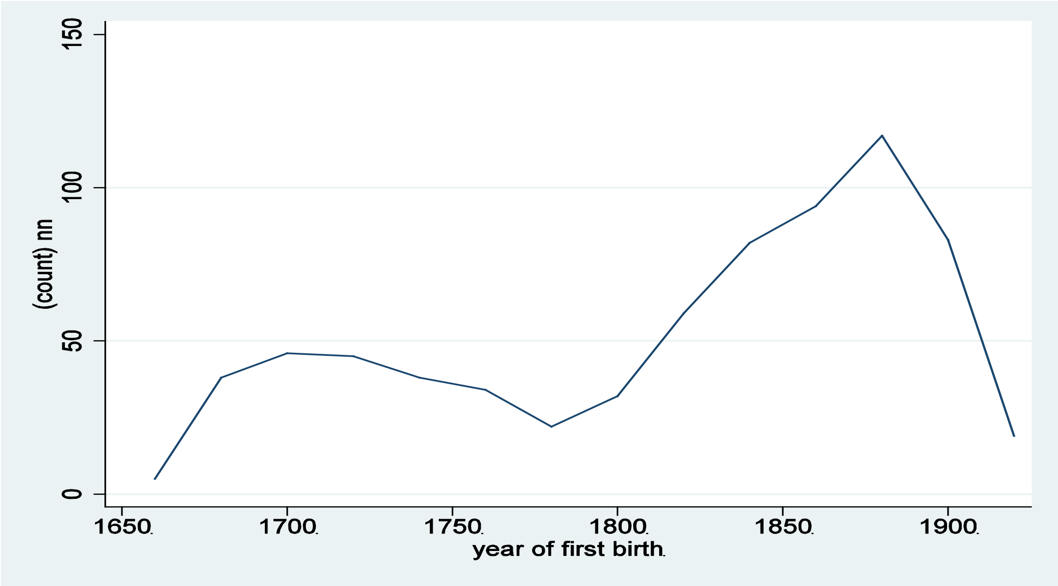


Figure A2: Fertility in Italy, summary of studies of age at marriage and age at last birth.