Maternal Longevity and the Sex of Offspring in Pre-Industrial Sweden

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Abstract

Background: Helle et al. (2002) argued that giving birth to sons reduced maternal longevity in pre-industrial societies due to higher physiological costs of bearing sons and the elevated testosterone levels observed in mothers carrying male foetuses.

Aim: To examine this hypothesis using a more comprehensive dataset and evaluate the merits of the statistical approach used in previous studies to identify the cost of giving birth to sons in terms of maternal old-age longevity.

Subjects and Methods: We extend the analysis in Helle et al. (2002) using a considerably larger dataset of pre-industrial Swedish women, and with careful consideration paid to methodological problems of sample selection and omitted variable bias. We argue that previous literature has underestimated the difficulties in quantifying the tradeoff between parity and longevity due to unobserved heterogeneity in health. However, under less restrictive assumptions, one can estimate the marginal impact of a son for a fixed family size.

Results: We find no evidence of a negative relative impact of sons. Neither do we find any evidence in favour of the male biased intra-household resource competition hypothesis proposed elsewhere in the literature, despite the poverty of the study population. These results are robust to a wide range of specifications tested.

Conclusion: The failure to reproduce earlier findings and the fact that studies in this area of research seem to continue to yield conflicting results warrant a lot of caution in discussing and evaluating results. It is likely that the negative effect of sons, if it existed, only manifested itself under conditions that are not yet fully understood. We also argue that the previous literature on this topic has not fully acknowledged the inference problems associated with omitted variable bias and sample selection.

Keywords: maternal longevity; sons; demography

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1 Introduction

Helle *et al.* (2002) noted that the physiological costs of childbearing are higher for sons than for daughters, as evidenced by the higher intrauterine growth rate and birth weight of boys (de Zegher *et al.* 1999; Loos *et al.*, 2001; Marsal *et al.* 1996) and the greater maternal energy intake during male pregnancies (Tamimi *et al.* 2003). They also suggested that the elevated levels of testosterone, a known immunosuppressant (Kalben 2000; Owens 2002), observed in mothers carrying male foetuses (Meulenberg & Hofman 1991) could be associated with negative long term effects on maternal health. Further, insofar as mothers with daughters receive more assistance in the household, such "helpers-at-the-nest" (see e.g. Hames & Draper 2004; Turke 1988) could alleviate the burden of domestic tasks. Together, these observations led Helle *et al.* (2002) to hypothesize that the sex composition of offspring should have long term effects on maternal longevity. Using a sample of 375 Sami women identified from Finnish parish records, they tested this prediction by regressing the longevity of post-menopausal mothers born between 1640 and 1870 on the number of sons produced, the number of daughters produced and husband's age at death. Their principal finding was that there appears to be a significant negative effect of sons on post-menopausal longevity.

So far, the few attempts made to replicate the findings in Helle *et al.* (2002) have failed to generate equally robust results. In a rejoinder, Beise and Voland (2002) repeated the analysis on two German and Canadian pre-modern populations and found no statistically significant effects. They did, however, report some tentative evidence suggesting that the effects of sons may differ depending on family wealth, and thus ventured the proposition that the results may be modulated by factors of sociocultural nature. Similarly, Van de Putte et al. (2004) found conflicting evidence studying women born in the Flemish agricultural village of Moerzeke between 1700 and 1870. In their baseline regression there was only weak evidence for a negative effect of sons, but when restricting their attention to women born before 1815 married to "ordinary labourers" (as opposed to the "well-to-do", see p. 291), the association between number of sons born and maternal longevity became statistically significant. Based on these findings, Van de Putte et al. proposed a theory of male biased intra-household resource competition as a complementary explanation to the physiological arguments made in Helle et al. (2002). Specifically, they suggested that male offspring are able to obtain a larger share of survival related resources within the household, primarily food, and thus have a detrimental effect on maternal longevity in families where scarcity of food is a problem.

More recently, Jasienska et al. (2006) found childbearing to significantly reduce maternal longevity in rural Poland, but no evidence for differential effects by sex of offspring were uncovered. In contrast, studying contemporary data from the Bangladeshi village of Matlab, Hurt et al. (2006) found evidence of a significant reduction in mortality for women with the number of surviving sons. However, controlling for surviving sons, the number of sons born was found to significantly increase mortality. No evidence of interactions between socioeconomic variables and the number of sons was uncovered, contrary to the findings in Van de Putte et al. (2004).

These recent works raise interesting questions about the generality of the findings reported in Helle *et al.* (2002). In this paper, we use data from a pre-industrial, largely agrarian, Swedish population in the Skellefteå region to re-examine their analysis in the light of recent research. We further highlight some potential inference problems in all of the above studies, problems which may bias the estimate of the absolute effect of an extra son or daughter on longevity. In particular, we argue that parity is likely to be correlated with maternal health status. If so, the causal effect of parity on longevity cannot be estimated unless health is perfectly controlled for. However, for a fixed family size one can plausibly argue that the number of sons is exogenous and study the relative impact of a son on maternal longevity. In other words, we investigate whether for two mothers with the same number of children, the mother with more boys has a different life expectancy. Pursuing this approach, our results, which are based on a sample roughly ten times larger than that used in Helle *et al.* (2002), are in line with those in Beise and Voland (2002) in the sense that we do not find any evidence for a differential relative impact of sons on longevity. Somewhat intriguingly, our results do not agree with the chief finding in Van de Putte *et al.* (2004) either, as we do not find that the effect of number sons born varies by social stratum. Whereas this is in no way sufficient to reject the intra-household resource competition hypothesis, it does cast some doubt on it. Northern Sweden was an impoverished region during the period of study and it is not unreasonable to expect that the intra-household resource competition hypothesis, if true, would have been corroborated at least in the lower social strata.

2 Data and Selection Criteria

Data was obtained from the Demographic Database at Umeå University, Umeå, Sweden. The retrieval covers the Skellefteå region (approx. 750 km. north of Stockholm), which was a largely agrarian area during the period of study. According to Maddison (2006), Swedish gross domestic product (GDP) per capita during the 19th century fluctuated around approximately 70 % of Belgian and 80-90 % of German levels. Of course, these figures only convey a very rough estimate of the income gap between our population and those studied by the previously cited authors. If anything, it is likely that they understate the relative poverty in Northern

Sweden as the conditions for agricultural production in our area of study were particularly harsh (Hellström 1917). For instance, the average annual temperature is only slightly above freezing and the average number of days of vegetation is a mere 160, compared to more than 250 in Southern Sweden, which is situated on approximately the same latitude as Scotland (Ahlman 1921).

The data sources are separate registers of catechetical examinations, births and baptisms, banns and marriages, migration, deaths and burials. There are, of course, uncertainties concerning the completeness of the data, for instance regarding the accuracy of some of the 18th century birth dates. However, we do not believe that faulty or missing information has affected the data in any way that will introduce a systematic bias.

The sample consists of all recorded, parous women in the Demographic Database born before 1831 with a known date of birth, known date of death and only one marriage (defined as having both a marriage date and an identified husband in the region). These selection criteria are equivalent to those used by Helle *et al.* (2002) and Beise and Voland (2004), with the exception that they restricted their attention to women who reached the age of fifty. Furthermore, we only consider children with a certain or presumed biological relation to the mother, i.e. we ignore stepchildren. The first recorded woman was born in 1658, but the date of birth for most women in the sample is between 1720 and 1831. In total, the dataset comprises 3,549 married couples and their 22,642 children, 182 of whom are registered as stillborn.[1] The average number of children per woman is 6.20 and the average age at first reproduction is 27.0 years. As shown in Figure 1, the average birth interval is stable around 2.5 years up to the tenth child. From then on, the average birth interval falls to approximately 2.2 years.

In one important respect, the Skellefteå sample does not satisfy the definition of a natural fertility population; the average age of marriage for women is 26.6 years, and even though there are incidences of prenuptial births, it is clear that the delaying of marriage was an important source of parity control. Stenflo (1994) examines the issue more generally and finds no indication of the use parity-dependent family limitation methods in our study population.

[1] The low proportion of stillbirths suggests that there was, unfortunately, substantial underreporting.

Figure 1. Interbirth intervals.

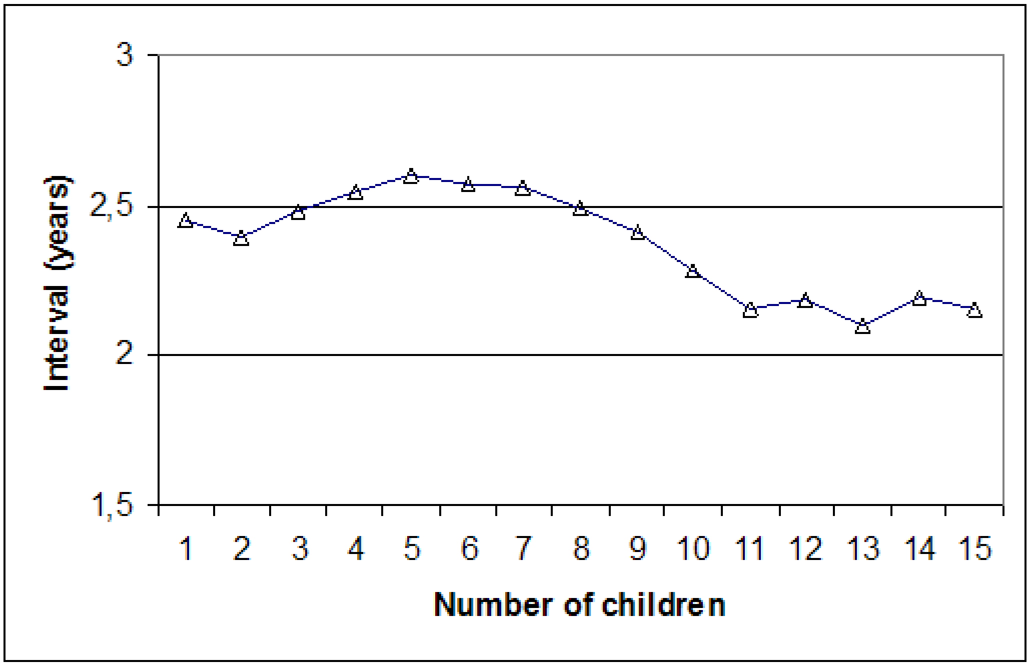

FIGURE 1 shows the average interval between births measured in years disaggregated on birth order.

The Skellefteå dataset contains some limited information on occupational status. Individuals can be classified as unskilled workers, skilled workers, freehold farmers, tenants, crofters, higher and lower officials and/or some empirically irrelevant miscellanea categories which we ignore. By necessity, we are forced to use the husband's occupational status as our point of departure, since biographical notes on females were fairly uncommon. It is worth emphasizing that there is substantial unobserved heterogeneity within any occupational category. Moreover, some men may have had numerous occupations during the course of their lives and consequently appear in several occupational classes. The most informative socioeconomic classification in terms of health status is the distinction between "skilled" and "unskilled" workers. Women whose husband is classified as an unskilled worker (1,471 in our sample) had an average longevity of 63.24 years compared to 68.08 for women married to a skilled worker (174 in our sample). The difference is statistically significant at the 0.1 percent level.

3 Estimation

The regression run by Helle *et al.* (2002) and Beise and Voland (2002) is of the following form,

$$Y_i = \beta_0 + \beta_1 x_i + \beta_2 z_i + \beta_3 d_i + \epsilon_i \tag{1}$$

where Y_i is the longevity of mother i, x_i is the longevity of the husband of mother i, z_i is the number of sons of mother i and d_i is the number of daughters of mother i.

One problem with this regression is that there may be some unobserved underlying variable, such as health, which pollutes the estimates. Suppose women with better health, on average, have greater fecundity and, *ceteris paribus*, a greater propensity to live long. Then, the above specification suffers from an omitted variable bias. If, on average, women with better health have more children, then the estimated effect of number of offspring on longevity will be upward-biased. This might explain why the epidemiological literature on the association between parity and longevity has yielded contradictory results. Such studies typically treat family size as exogenous. For instance, Müller et al. (2002) and Korpelainen (2000) found a positive association between parity and longevity, whereas other studies find no effect (Le Bourg *et al.* 1993). Both results are surprising; evolutionary theory would predict that a trade-off does exist (Kirkwood 1977; Kirkwood & Austad 2000). It simply seems implausible that mothers of twelve children (85 in our sample) and mothers with one child (228 in our sample) do not differ systematically in terms of health in a way that will influence longevity through channels other than the number of children born (similar arguments are made in Doblhammer & Oeppen 2003 and Samuelsson & Dehlin 1993). One proposed solution to this problem has been to study sisters – or preferably twin sisters – who should not differ systematically in terms of socioeconomic status, health, genetics, cohort or other environmental conditions, and then use simple non-parametric testing procedures (Mueller 2004). Using this approach, Mueller finds evidence of a "moderate trade-off between parity and lifespan" (p. 13), as theory would predict. In light of these findings, and the fairly compelling theoretical reasons to expect a negative causal effect of family size on longevity, we suggest that it is inappropriate, like Helle *et al.* (2002), to interpret a positive coefficient on number of daughters as saying that "giving birth to daughters had a positive, but statistically insignificant, effect on maternal longevity" (p. 1085). Unless it can be convincingly demonstrated that the proclivity to live long is independent of fecundity, such inference is not justified. This problem also arises in studies documenting a relationship between late reproduction and longevity (e.g. Müller *et al.* 2002). If, for instance, age at last reproduction is correlated with age at menopause, and age at menopause is determined by health, then any estimated relationship between age at last reproduction and longevity is spurious (Dribe 2004).

Another problem with the regression is that the number of children a woman can give birth to depends on longevity. The previous literature, including Helle et al. (2002), were able to overcome this problem by restricting their attention to post-menopausal women. By definition, a woman who has reached menopause cannot have children, and thus we need not to worry about a simultaneous relationship between age at death and number of children. One might, however, worry that such an approach introduces selection problems into the dependent variable. If giving birth to boys is indeed a greater peril to the mother's life also in the short run, then frail women who give birth to boys will be more likely to die before fifty and thus not be present in the sample. This would introduce a systematic overrepresentation of healthy women with many boys when we restrict our attention to women surviving until post-menopausal age. If the relative effect of boys is negative, then restricting the sample to post-menopausal women will bias the estimated effect of number of sons toward zero. Hence, even though the restriction to post-menopausal women does solve the simultaneity problem, it potentially introduces another source of bias due to selection in the dependent variable.

To conclude, we cannot draw any reliable inference about the absolute effects of number of boys and number of girls on maternal longevity without finding a plausible source of exogenous variation in the number of children. Omitted variables and potential sample selection problems complicate the analysis in a way that much of the previous literature has not fully acknowledged.[2]

Yet even though the estimates in Helle et al. (2002) might be biased, they are not meaningless, for any significant difference in the regression coefficients such that $\hat{\beta}_2 \neq \hat{\beta}_3$ can be interpreted as reflecting a difference in the *relative* cost of producing a son or a daughter.[3] Fixing the number of children, one can study the relative impact of sons on longevity. Our baseline regression is therefore a simple rearrangement of Equation 1 as follows,

$$Y_i = \alpha_0 + \alpha_1 x_i + \alpha_2 z_i + \alpha_3 n_i + X\gamma_4 + \epsilon_i \tag{2}$$

where n_i is the parity of mother i (i.e. $n_i = z_i + d_i$) and X is a vector of controls including the husband's occupational status and dummies for region and parish of birth. Note that without X, our baseline regression is equivalent to Equation 1 with α_0=β_0, α_1=β_1 and α_2=β_2-β_3.

In light of the concerns raised, our favoured interpretation of the regressions is that we are estimating

[2] Even though we frame much of our methodological discussion using Helle et al. (2002) as our point of departure, we want to emphasize that most of the literature, in our view, is plagued by similar problems.

[3] In the restricted sample, the potential sample selection problem still persists, however.

the relative excess cost in terms of longevity of producing sons vis-à-vis daughters. This approach still rests on the strong assumption that the marginal relative effect of a son is constant. In terms of Equation 2, the estimated coefficient of interest is $\hat{\alpha_2}$ which measures the marginal effect on longevity of an extra son for a fixed number of children. The relevant comparison to the results in Helle et al. (2002) and Beise and Voland (2002) is then $\hat{\beta}_2 - \hat{\beta}_3$.

As we are controlling for the number of children, we do not need to restrict the sample to post-menopausal women in order to overcome the problem of simultaneity between maternal longevity and the number of children. This in turn implies that we can avoid potential sample selection problems – which would be present if sons do indeed have a negative relative effect on longevity – by considering the unrestricted sample with all mothers. However, to facilitate comparison with the previous literature, we will also report results for the restricted sample.[4]

For this estimation strategy to make sense, one has to assume that in the set of women with n children, those with many sons are not unobservably healthier than those with few sons. This assumption, whilst fairly plausible, is certainly not innocuous. For example, if parents have a preference for either sex, parity will be a function of the sex composition of the previously born children. Suppose that parity is indeed a function of gender composition of offspring and consider two otherwise identical mothers where one gives birth to a son and the other to a daughter. Then, if parents have a preference for sons, the woman with a daughter is more likely to continue reproduction in the hope of giving birth to a son. Hence, for a given number of children, women with few sons will have a lower health status than women with many sons as they did not continue reproduction despite the fact that they had few sons. Such an effect – if it exists – should be detectable by a regression of family size on fraction of sons, since – on average – larger families will have a larger fraction of daughters. Thus, we regress

$$n_i = \gamma_0 + \gamma_1 \frac{z_i}{n_i} + \epsilon_i. \qquad (3)$$

The coefficient on the ratio of sons in this regression is insignificant ($p = .437$) and the adjusted R^2 is negative. Hence, our data suggests that the "decision" to continue reproduction does not depend on the sex composition of the previously born children.

A related concern is that the proclivity to bear sons may be in part genetically or environmentally determined, and that this proclivity is correlated with other factors which affect longevity, e.g. a robust

[4] However, it is possible that a selection bias - if it exists - differs in severity across samples, implying that our results are not fully comparable. We ask the reader to bear this caveat in mind in interpreting our results.

immune system or family wealth. Yet the literature on the genetic determinants of the sex of offspring is fairly voluminous and virtually all modern work suggests that no relationship exists (see Rodgers & Doughty 2001). In contrast, the literature on "non-genetic" causes of the sex of offspring has produced contradictory findings. In a famous paper, Teitelbaum (1972) reported numerous correlates to the likelihood of having male children, including parental age, status, birth order and, in the aggregate, war. Similarly, Gibson & Mace (2003) found that women in southern Ethiopia who had recently given birth to a son were better nourished than those who had recently given birth to a daughter. However, these results were not corroborated in a recent study of 550,000 Scottish births, where no statistically significant relationships between sex of offspring and parental social status, maternal age and birth order were found (Maconochie & Roman 1997).

Our data supports the notion that the proclivity to bear sons is independent of the mother's health status. Whereas women married to skilled workers live longer than women married to unskilled workers – indicating that they have better health status – we find no significant difference in the likelihood that they give birth to sons.[5]

4 Results

In Table 1, we report results from the regression of maternal age on the number of boys, family size, husband's age at death and various controls. Results are reported separately for the full sample, which includes all parous women, and the restricted sample with parous women who reached the age of fifty. Estimates of the relative effect of a son range between -0.078 and -0.125 and are never statistically significant. Clearly, the coefficient estimates on number of sons are far from the estimate of -1.09 in Helle *et al.* (2002), but fit in well with the estimates from the Krummhörn (-0.23) and Quebec (-0.12) populations.[6], [7] The Variance Inflation Factors (VIF) of 2.50 to 2.62 indicate a modest level of multicollinearity. A VIF of 2.62 implies that the standard error for the number of boys is 62 % larger compared to what it would have been had the number of boys been uncorrelated with all the other regressors. Still, standard errors are modest and the estimates are robust to changes in the specification, indicating that multicollinearity is not a serious concern. In interpreting the

[5] We test this by restricting the sample to workers and running a logistic regression with sex of offspring on a skilled worker indicator variable. Standard errors are clustered at the family level. The skilled worker indicator variable is not statistically significant, despite a sample size of over 10,000 children. Repeating the same analysis on a sample of farmers, tenants and crofters, we find that a freehold farmer dummy variable is statistically insignificant as well.

[6] The estimates we here cite from other studies were obtained simply by calculating $\hat{\beta_2} - \hat{\beta_3}$ from Equation 1. However, since neither Beise and Voland (2002) nor Helle *et al.* (2002) report the covariance between $\hat{\beta_2}$ and $\hat{\beta_3}$, we cannot calculate the standard error of $\hat{\beta_2} - \hat{\beta_3}$, and so we are unable to comment on statistical significance in these studies.

[7] We have also run regressions (1) to (3) in Table 1 with father's longevity as the dependent variable. The estimated coefficient varies between -.129 and -.148 and is never statistically significant.

results, it is important to note that the coefficient on the number of children cannot be given any casual interpretation, due to simultaneity between number of children and age at death in the full sample and potential omitted variable bias in both samples.

Our results are robust to various specification tests. The estimated effect of sons on longevity varies between -0.051 and -0.105 when we add age at first and age at last reproduction as additional control variables, and it is never statistically significant.[8] Including quadratic terms for number of boys and number of children to control for nonlinearities, we find indications of a negative and convex relationship between number of boys and longevity, but the coefficients are never statistically significant. Further, as shown in Figure 2, running the regressions disaggregated on parity for families between one and sixteen children, the results do not indicate a differential relative impact of sons on longevity.[9] The estimated coefficient of the number of boys on longevity has a positive sign in nine out of sixteen regressions.

Table 1. The effect of sons on maternal longevity (OLS).

	Full Sample (all women)			Restr. Sample (50+)		
	(1)	(2)	(3)	(1)	(2)	(3)
Constant	52.036*	55.903*	54.854*	66.431*	68.195*	68.047*
	(1.518)	(1.670)	(1.570)	(1.134)	(1.244)	(1.164)
Number of boys	-.100	-.125	-.123	-.078	-.100	-.097
	(.194)	(.192)	(.194)	(.148)	(.148)	(.149)
Number of children	.901*	.890*	.895*	.141	.146	.145
	(.134)	(.134)	(.135)	(.100)	(.100)	(.101)
Longevity of husband	.121*	.119*	.120*	.070*	.068*	.069*
	(.021)	(.021)	(.021)	(.016)	(.016)	(.016)
Born in Skellefteå region		-1.205			-.156	
		(.718)			(.537)	
Socioeconomic dummies	No	Yes	Yes	No	Yes	Yes
Parish born dummies	No	No	Yes	No	No	Yes
Observations	3,549	3,549	3,549	2,858	2,858	2,858
R^2	.042	.062	.066	.009	.026	.030
VIF (No. of boys)	2.60	2.60	2.62	2.51	2.51	2.52

Heteroskedasticity robust standard errors in parentheses. A star denotes statistical significance at the one percent level.

The results are also robust to controlling for cohort effects, by introducing dummy variables for quarter-century of birth.[10] With these additional controls, the coefficient on number of boys is stable around -0.10

[8] Henceforth, any results cited in the text which are not reported in the tables are available from the authors on request.

[9] The results in Figure 2 refer to the simplest specification with only the number of children and the husband's age at death as control variables. We have also run the regressions with the full set of control variables, obtaining very similar results (not reported here but available from the authors upon request). We choose not to report the results for families with seventeen or more children since, due to the very small sample size (five families with seventeen children and two with more), the results are very imprecise.

[10] To avoid sample selection on the dependent variable, we here restricted the sample to women born prior to 1790. Separate dummies of birth were recorded for women born 1658-1689, 1690-1714, 1715-1739,1740-1764 and 1765-1789.

for the full sample and around 0.04 for the restricted sample, but never statistically significant.

Figure 2. The effect of sons on maternal longevity disaggregated on parity.

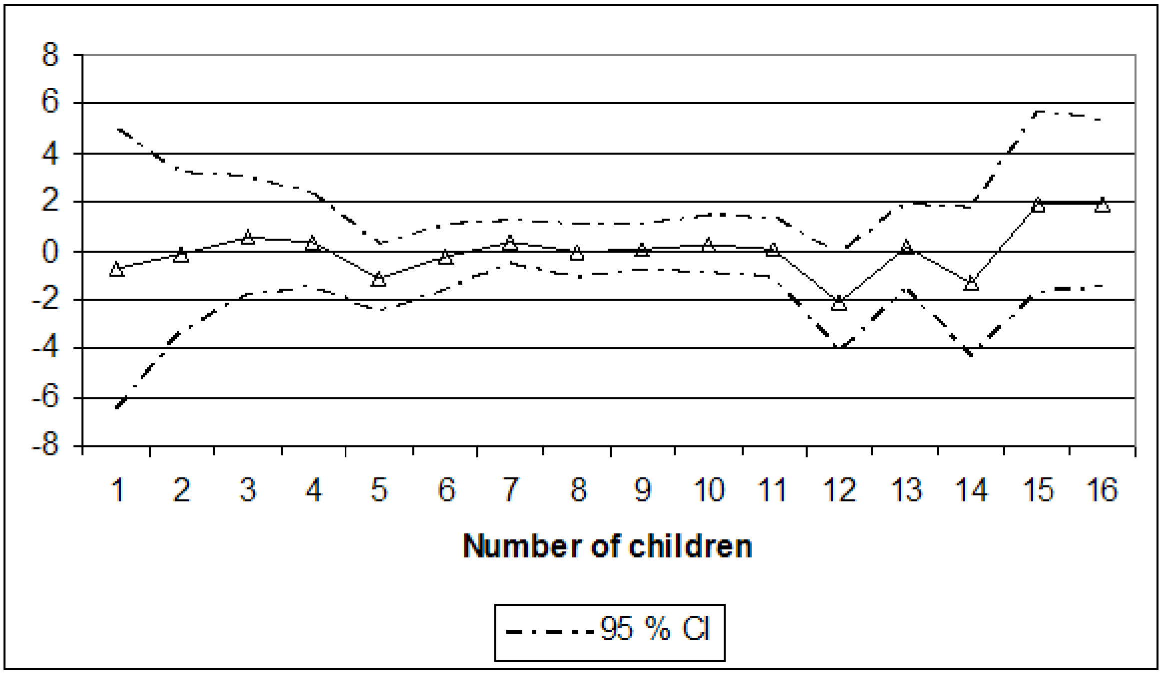

FIGURE 2 gives the coefficients for number of boys on maternal longevity for a given family size. All regressions are estimated using OLS with heteroskedasticity-robust standard errors. Longevity of husband is included as a control variable in all regressions.

To explore the resource availability hypothesis, we compare women whose husbands were registered as skilled workers to women whose husbands were registered as unskilled workers, hypothesizing that the former could be presumed to have been more affluent.[11] We investigate whether the relative effect of sons varied with occupational category by including interaction terms between the skilled worker dummy and the number of boys, and between the skilled worker dummy and number of children. As shown in Table 2, the coefficient on the skilled worker dummy is quantitatively important and highly statistically significant, indicating that women married to skilled workers were indeed more affluent and healthier. However, the interaction effect between skilled workers and number of boys is statistically insignificant and has the wrong sign compared to what we would expect if the resource availability hypothesis were true.

A potential explanation for our failure to corroborate the resource availability hypothesis is that we consider births, whereas Van de Putte *et al.* (2004) consider sons surviving until the age of eighteen. To

[11] We also ran the same regressions comparing freehold farmers to tenants and crofters, with similar results. Even though the coefficient of the freehold farmer dummy variable had the anticipated sign, it was fairly small and not statistically significant. Since this suggests that the socioeconomic classification is uninformative, we opt not to report these results.

make our analyses as comparable as possible, we redo the analysis restricting our sample to children that were present in their home parish at the age of eighteen, hence excluding children who died or migrated out of their home parish. This restriction implies that we, in line with Van de Putte et al. (2004), focus more directly on post-natal resource competition. As shown in Table 2, the interaction effect between number of sons and the skilled worker indicator variable is negative and statistically insignificant also in this case.

Table 2. The effect of sons on maternal longevity, controlling for socioeconomic interaction effects (OLS). Sample restricted to women whose husband was classified as worker.

	All children			Children in parish at 18		
	(1)	(2)	(3)	(4)	(5)	(6)
No of boys	.025	.023	.030	.425	.423	.430
	(.327)	(.327)	(.331)	(.435)	(.435)	(.440)
No of boys*Skilled worker	-.676	-.659	-.687	-.546	-.518	-.559
	(.900)	(.900)	(.904)	(1.048)	(1.049)	(1.055)
Skilled worker	10.080*	10.051*	10.354*	7.388*	7.353*	7.625*
	(3.337)	(3.341)	(3.359)	(2.787)	(2.793)	(2.807)
Number of children	.970*	.973*	.990*	.442	.445	.470
	(.221)	(.221)	(.223)	(.283)	(.283)	(.285)
No. of children*Skilled worker	-.557	.571	.575	-.478	-.495	-.499
	(.655)	(.655)	(.657)	(.680)	(.681)	(.684)
Longevity of husband	.121*	.121*	.119*	.129*	.129*	.127*
	(.032)	(.032)	(.033)	(.033)	(.033)	(.033)
Region born	No	Yes	No	No	Yes	No
Parish born dummies	No	No	Yes	No	No	Yes
Observations	1,645	1,645	1,645	1,645	1,645	1,645
R^2	.050	.050	.057	.031	.031	.037
VIF (No. of boys)	2.90	2.90	2.93	3.26	3.26	3.29
VIF (Interaction effect)	8.20	8.21	8.22	6.54	6.56	6.57

Heteroskedasticity robust standard errors in parentheses. A star denotes statistical significance at the one percent level.

5 Concluding Remarks

Evolutionary theory predicts that there exists a trade-off between reproduction and soma maintenance, which are both energetically expensive for females. Insofar as sons are more costly to produce than daughters, the proposition that sons relative to daughters reduce post-menopausal longevity therefore has a certain theoretical attraction. Helle et al. (2002) tested this proposition and found evidence in favour of it both in an absolute sense (sons reduce post-menopausal longevity and daughters increase it) and in a relative sense (a mother who gives birth to a girl will live longer than if she had given birth to a son).

However, in this paper we have argued that the effects found in Helle *et al.* (2002) were not necessarily a general feature of life in pre-industrial populations but rather manifested themselves only under conditions that are not yet fully understood. Using a comprehensive dataset on pre-industrial women born in the Skellefteå region, we find no evidence of a significantly different impact of sons, relative to daughters, on longevity. These results fit in nicely with the work by Beise and Voland (2002) on two other pre-modern populations. On balance, the results suggest that it is the Sami population which is an outlier in need of an explanation and not the Krummhörn, Quebec, rural Polish or Skellefteå populations.

Further, there are some methodological problems in this literature which complicate analysis. Whereas the statistical methods used may allow researchers to draw some conclusions about relative cost of bearing sons, it is much harder to quantify the trade-off between longevity and reproduction. The primary reason for this is that it is difficult to control for the health status of the mother, which can be presumed to influence both fecundity and the propensity to live long. It seems unlikely that women with twelve children and women with one child do not systematically differ in ways other than the number of children they have given birth to and the age at death of their husband.

Finally, we were unable to corroborate the findings in Van de Putte *et al.* (2003) in the sense that we find no evidence for the relative impact of sons being different by occupational category. If the resource availability hypothesis is true, one would expect fairly strong effects of sons on longevity in the impoverished Skellefteå region of Northern Sweden, at least in the lower social strata. However, it is possible that this discrepancy could be accounted for by differences in the definition of the "surviving sons"-variable. It is also possible that the adverse consequences of giving birth to sons, if they exist, only manifest themselves in "frail" women, or that the effect arises in some unknown interaction with the disease environment. But, without richer datasets, including a larger number of potentially influential covariates, tests of such hypotheses will be underspecified. Indeed, methodological issues coupled with the failure to reproduce earlier findings and the fact that studies in this area of research seem to continue to yield conflicting results warrant a lot of caution in discussing and evaluating findings.

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