The Child Quality-Quantity Tradeoff, England, 1770-1880: A Fundamental Component of the Economic Theory of Growth is Missing

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A quantity/quality tradeoff in children is central to theorizing about the transition to modern growth. Smaller families allegedly increased human capital and created faster productivity growth. Yet modern evidence in favor of a significant quality-quantity tradeoff is minimal. For England 1770-1880, the first economy to achieve sustained modern growth, the fertility regime allows us to measure well the tradeoff. Before 1880 in England there is no evidence of fertility control within marriage, huge natural variation in family sizes, and no association between family size and parent "quality." Yet family size had no effect on educational attainment, occupational status, or adult longevity. Larger family size did significantly reduce child wealth: physical capital. But the wealth effect disappears by the next generation. The quality-quantity tradeoff is a myth. Growth theory must proceed in other directions.

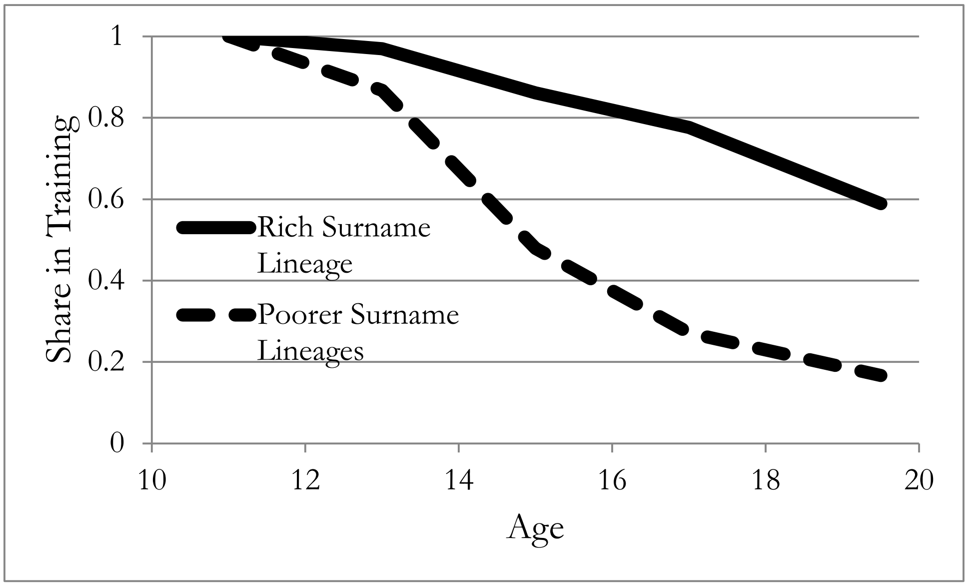
Introduction

Modern high income societies have a combination of low fertility levels and high levels of nurture and education for children. There is a lot of human capital. Modern poor societies have high fertility levels, lower levels of nurture for children, and less education. Recent economic theory has taken this regularity, and made it central to the theory of economic growth. Growth, it is argued, stems at base from higher levels of human capital (see, for example, Becker, Murphy, Tamura, 1990, Galor, 2011, Galor and Moav, 2002, Galor and Weil, 2000, Lucas, 2002, O'Rourke et al., 2013, Willis, 1973). But only when circumstances arose in which parents chose to have smaller family sizes was it possible to increase human capital. Parents have limited time and money. The more children parents choose to have, the less input each child receives, and the less effective they will be as economic agents. Economic growth did not come to the world until the last 250 years because before then women gave birth to many children, and these children received little nurture or education to create effective economic agents.

Yet this crucial underlying assumption - that the more children a given set of parents have, the less productive the children will be – rests on the flimsiest empirical evidence. In modern high income societies there is often a negative correlation between family size and measures of child quality. But modern family sizes are determined by parental choices, choices that correlate with unobservable features of parents which influence child quality. Tests of the quality-quantity tradeoff using the accident of the twining of second births have failed to detect a significant tradeoff – though here the range of variation in family size is 2-3, while we shall see that preindustrial families has much greater size variance.

In this paper we utilize a dataset containing the histories of a set of English families which had rare surnames 1770-2012, described below. Using birth, death and marriage records, probate records, censuses, and other sources we reconstructed the histories of 58,000 individuals dying 1770 and later. In England for marriages commencing 1770-1879 there is no significant association between fertility and parent "quality". But more importantly nearly all family size variation lay outside the control of parents, so that the bias caused by correlations between family size and "quality" is minimized. We thus get largely unbiased estimates of the correlation between size and education, occupation, longevity and wealth. The conclusion is that family size has no effect on education, occupation, longevity, or even on wealth, though in this case it is wealth at death relative to wealth inherited.

Figure 1: Fraction of males in education or training, ages 10-20, 1881-1891



Sources: See Data Description below.

The period of study, marriages 1770-1879 is already one where there were considerable investments in education and training. Figure 1 shows, for example, the percentage of males born 1860-80 described as "scholars", "apprentices," or with no occupation, in the censuses of 1881 and 1891.[1] For families from richer lineages this was 86% at ages 14-15, while for the poorer ones it was still 48%. Even at ages 16-17 78% of those from wealthier lineages had not entered the regular labor force, while 27% of those from poorer families were still not in regular employment. The age we are looking at here is already the modern one of significant human capital.

[1] In some cases children still clearly in school had their occupations left as blank by the census enumerators, so we have counted all people not in regular employment in figure 1.

Measuring the Quality-Quantity Tradeoff

The empirical evidence for a quality-quantity tradeoff is based on negative correlations between family size and the measurable 'quality' (educational attainment, health) of offspring. Studies of modern populations show a negative correlation between child numbers and educational and economic achievement.[2] These studies also recently highlighted differing trade-offs for groups at different socioeconomic levels. Grawe (2009) for the US, and Lawson and Mace (2009) for Britain, for example, find a stronger quality-quantity tradeoff for richer families.

However, to capture the causal quality-quantity trade-off, researchers must control for the endogeneity of modern family size. Parent influences on child "quality" can follow two potential routes, as in figure 1. Since in the modern world high 'quality' parents also have smaller numbers of children, the observed negative correlation between N and child quality may stem just from the positive correlation of parent and child quality. Estimates $\hat{\beta}$ of β in the regression

$$q = \beta N + u, \qquad (1)$$

where q is child quality, N child numbers, and u the error term are biased towards the negative, because of the correlation between N and u.

To uncover the true relationship investigators have followed a number of strategies. The most important is to look at exogenous variation in family size caused by the accident of twin births (e.g. Rosenzweig and Wolpin, 1980a, Angrist et al., 2006, Li, Zhang, and Zhu, 2008). In a world where the modal family size is 2, there are a number of families who accidentally end up with 3 children because their second birth is twins. What happens to the quality of children in these families compared to two child families? This however, allows for any very modest variation in family size, and variation well below the typical average family size of pre-industrial Europe where the average pre-industrial marriage would produce 6 births.

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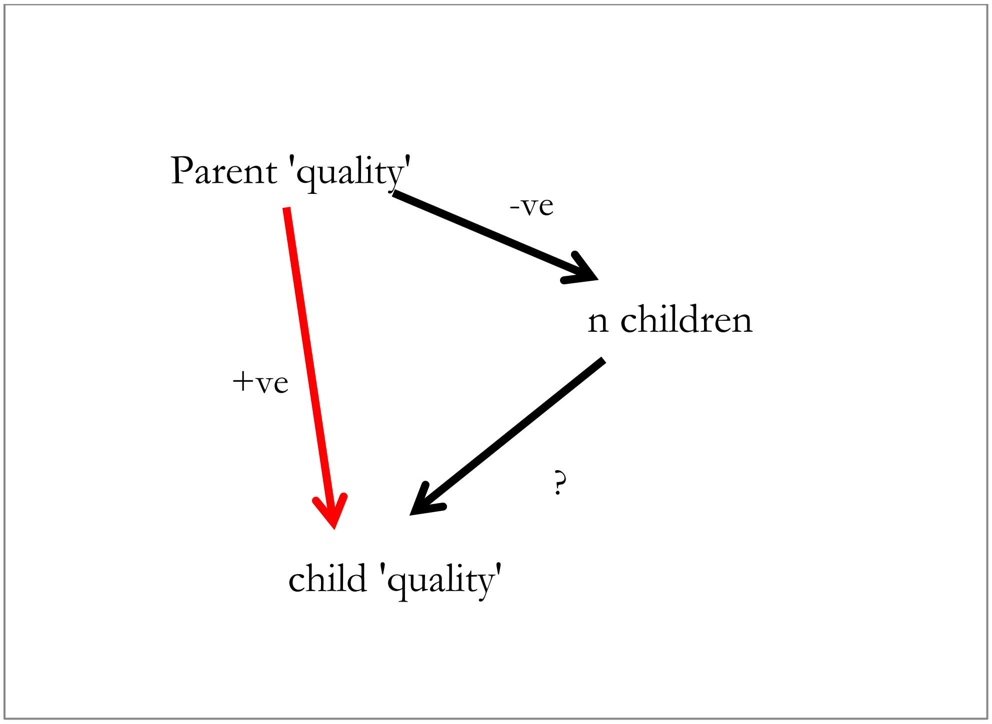
[2] See Grawe (2004), Lawson and Mace (2009) for Britain, Rosenzweig and Wolpin (1980b), Kaplan et al. (1995) for the US, Rosenzweig and Wolpin (1980a), Jensen (2005) for India, Lee (2004) for Korea, Grawe (2003) for Germany, Desai (1995) for 15 developing countries (using heights as a measure of child quality).

Figure 2: Parent influences on child quality – modern world



Twin studies find the uncontrolled relationship between quantity and quality decreases, and is often insignificant and even positive (Schultz, 2007, 20). Angrist, et al. (2006), for example, find "no evidence of a quality-quantity trade-off" for Israel using census data. Qian (2006) similarly finds no quality-quantity tradeoff in China. Li, Zhang, and Zhu, 2008, however, do report the expected relationship instrumenting using twins, but only in the Chinese countryside. But in China there are government policies designed to penalize couples who have more than the approved number of children, so we may not be observing anything about the free market quality/quantity tradeoff.

Others have sought to control for selection bias using parental human capital, the sex composition of the first two births (e.g Lee 2004, Jensen 2005) and also the birth order of the child (e.g Black et al. 2005). Black et al. report the standard negative family size–child quality relationship for Norway, but find that it completely disappears once they include controls for birth order (quality here is educational attainment) (Black et al. 2005, 670). Again Li, Zhang, and Zhu, 2008, however, do report the expected relationship even controlling for birth order.

In summary, there is a clear raw negative correlation in modern populations between child numbers and various measures of child quality. However, once controls to deal with the endogeneity of child quality and quantity are included, there is little sign of a substantial quality-quantity relationship. The quality-quantity tradeoff so vital to most theoretical accounts of modern economic growth is, at best, unproven.

Fertility in England, 1770-1879: A Natural Experiment

We can measure the quality quantity tradeoff well for marriages in England 1770-1879 because there is evidence for a complete absence of any conscious fertility control within marriage, there was huge natural variation in family sizes, and there was no association between completed family size and parent "quality." Family sizes were from the perspective of parents mainly random draws. The bias in estimating β in the equation

$$q = \beta N + u$$

by OLS, is the ratio of the covariance of N and u, relative to the variance of N.

$$E(\hat{\beta}) = \beta + \frac{cov(N,u)}{var(N)}$$

With the fertility pattern in England 1770-1879 *cov(N,u)* was close to 0, and *var(N)* was very large, so that any potential bias will be inconsequential.

Before 1880 the only element in determining family size that parents chose was their age at marriage. Here there is a very modest tendency for higher status men to marry slightly older women, as is shown in figure 3 which shows the age of the wife at men's first marriage by wealth decile of men, from lowest to highest.[3] But that tendency explains less than 1% of the variance in the age of marriage of women. And the slightly higher age of women at marriage for richer families again explains less than 1% of the variance in family sizes. And we can show that within marriage the numbers of children born or numbers of children surviving to age 21 is uncorrelated with other attributes of families. From the perspectives of parents it is random variation.

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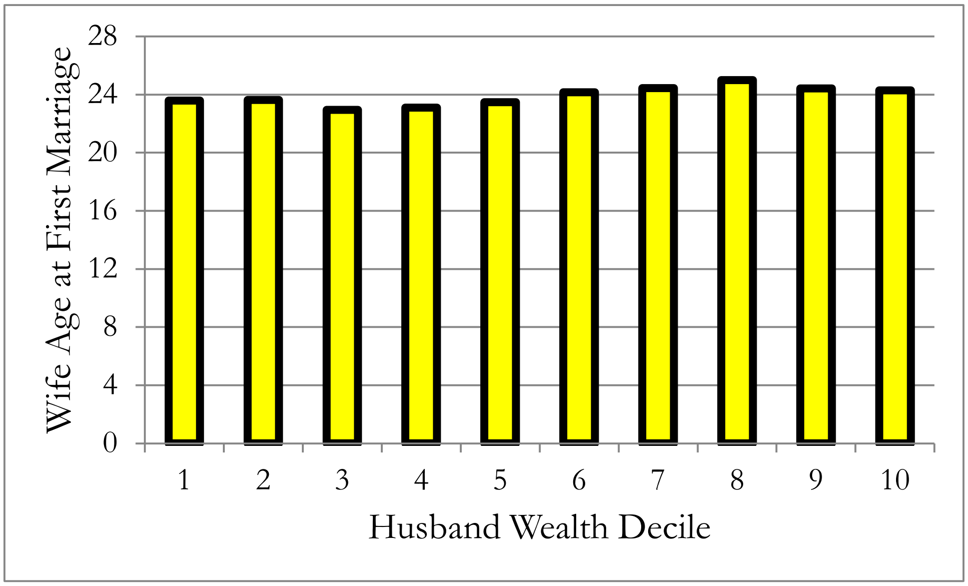
[3] The wives of the richest men in the sample averaged about 1.5 years older than those of the poorest men.

Figure 3: Wife Age at First Marriage by Wealth Decile, Marriages before 1880



Note: Based on 1,578 marriages 1879 or earlier.

The Variation in Family Sizes. Figure 4 shows the distribution of children (21+) by family size for marriages in the rare surname sample 1770-1879.[4] The median child in this period had 5 adult siblings. Average sibship sizes in 19th century England at the time of the Industrial Revolution were thus among the largest observed across all societies with well recorded demographies. There is also a huge variance in average family size in this period. 10% of children were in families of 2 or less, 13% of children in families of 9 or more.

Figure 3 also shows the distribution of sibship sizes (21+) for UK marriages 1960-1989. As can be seen this is much more concentrated. The variance in sizes then was just 1.43. Thus in terms of the distribution of family sizes 19th century England presents an ideal case for testing the quality-quantity tradeoff.

[4] Significant numbers of men and women had more than one marital partner in the course of their lifetime because of the early death of a spouse. We take family size throughout as the total number of children per father. We do this because earlier and later husbands of wives in our sample often had common surnames, making their children much harder to identify in the various records. The nature of our sources mean that in earlier years some children are missed, daughters in particular. In this data, at least 13% of daughters are missing. Appendix 1 discusses the imperfections in the data, and their significance.

Figure 4: Share of Children in each Family Size, 1770-1879, 1960-89

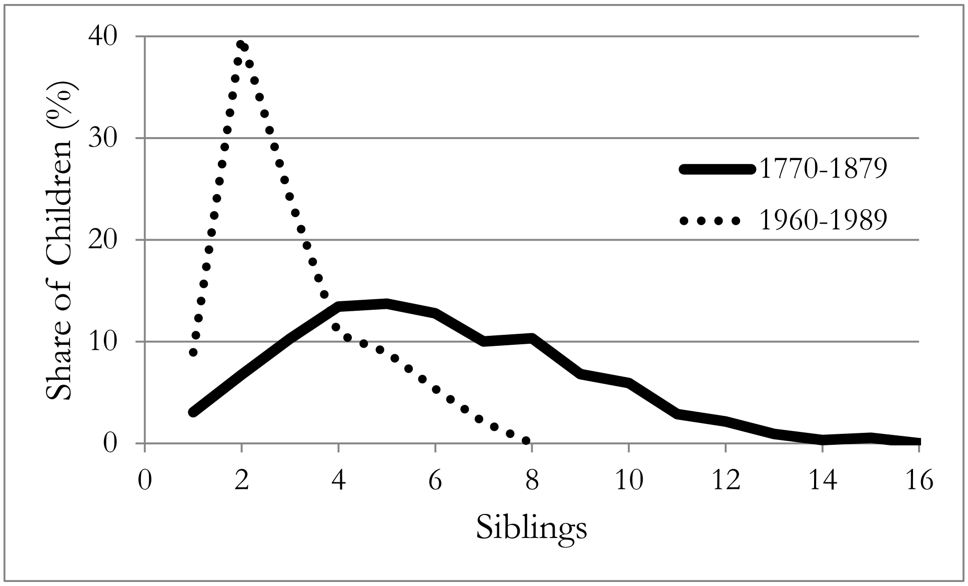


Figure 5: Family Size versus Father Wealth, England, marriages 1770-1879

Note: Family size is children per father, and may involve children with more than one wife.

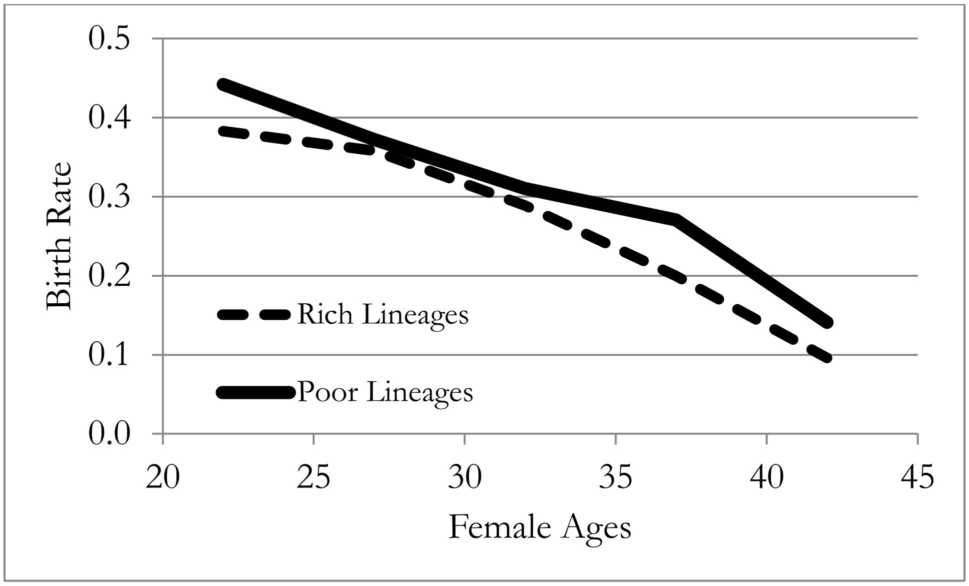
Family Size and Parent "quality". Measured in terms of children surviving to adulthood, there is no significant correlation in this period between parent quality and family size. Figure 5, for example, shows family size (21+) versus the logarithm of father wealth at death. The figure illustrates the absence of any connection between these two variables. Confirming this if we regress family size on the log of wealth, the coefficient of wealth is not statistically or quantitatively significantly different from 0.

If we measure family size as births, however, a statistically significant negative association appears between family size and wealth. Here the coefficient on the logarithm of wealth is -0.070 (standard error 0.020). This implies that while the average for families with births was 5.2 births, for the poorest families there are on average 5.7 births, and for the richest only 4.7. But this difference in fertility pre 1880 is driven largely mechanically by the fact that birth spacing is closer when the previous child dies in infancy, since breastfeeding suppresses fertility. Poorer families had higher infant mortality rates, and this in turn induced higher levels of fertility, when measured as births. There is no evidence that the lower birth rate within higher status families was the product of any attempt to deliberately control fertility.

Evidence that this difference in rich and poor birth rates is just the mechanical product of higher infant death rates among poor families comes if we look at fertility by age for rich and poor married women for marriages before 1880, as in figure 6. Fertility at any age is higher for poorer women, but fertility declines at the same rate with age for rich and poor.

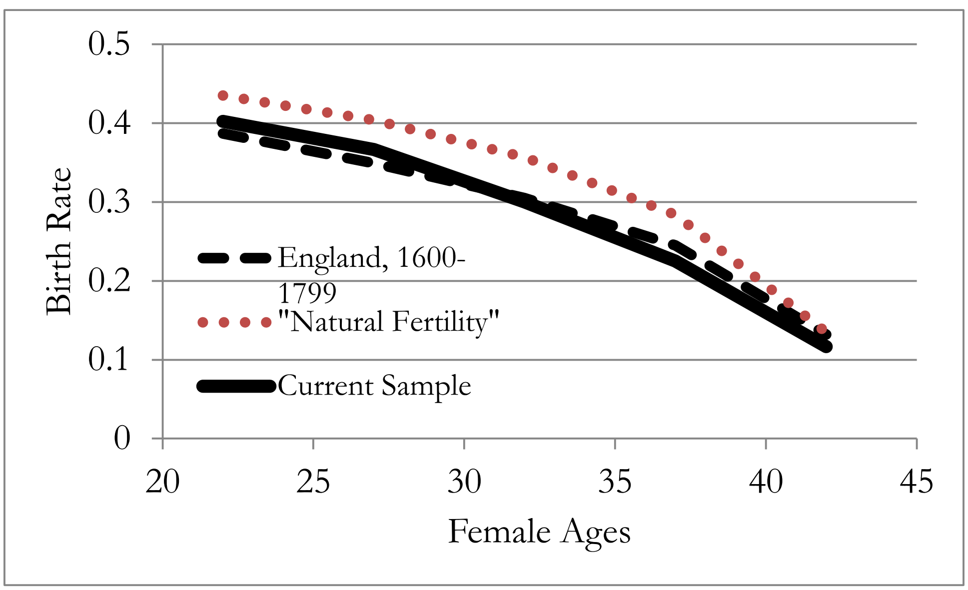
Evidence again of the absence of conscious fertility control in either group comes if we compare, as in figure 7, fertility rates by age for marriages pre 1880 in our sample with the Wrigley and Schofield family reconstitution sample for births 1600-1799 in England, and with the average pattern for pre-industrial populations believed not to control births. Fertility by age in our sample has a very similar profile to that of the Wrigley and Schofield reconstituted parishes in England 1600-1799. There is wide acceptance that pre 1800 England displayed a natural fertility regime, marked by a distinctive age-specific set of relative fertilities (Wilson, 1984). Fertility is somewhat lower than the average of a sample of populations believed not to control births. But the average birth rate within this group of populations varies substantially, as a product of factors such as nutrition and sexual practices. However, there is no sign in England of the more rapid decline in fertility with age that was characteristic of populations which began to control fertility. For our sample of marriages pre 1880 the relative fertility at age 40 is even higher than for the average "natural fertility" society.

Figure 6: Fertility by Age, Rich and Poor, Marriages pre 1880



Note: Because there are more missing female children, fertility rates are estimated from male births for our sample.

Figure 7: Fertility by Age, all marriages pre 1880



Note: Because there are more missing female children, fertility rates are estimated from male births for our sample.

Sources: England, 1600-1799 and "Natural Fertility", Wilson, 1984, tables 1-2, 227-8.

Thus if we try and predict the numbers of children, either as gross or net fertility, associated with a father we are able to explain only tiny amounts of variation. Table 1 shows the coefficients of a negative binomial regression of child numbers on a variety of predictors. For marriages before 1880 the pseudo R^2 is 0.01, and the only things that matters statistically significantly are the ages of husband and wife at the husband's first marriage. In comparison, for marriages 1880-1919 wealth at death becomes a significant negative predictor of fertility, though the R^2 is still only 0.03.

Compelling evidence that fertility for marriages before 1880 was random with respect to family "quality" comes if we look at the correlation in characteristics across brothers. In most characteristics – wealth, occupational status, educational status, child mortality rates, husband and wife ages at marriage, even age at death – brothers correlate significantly. This is shown in table 2. But for both gross and net fertility there is no correlation, even though in table 1 men's and women's age at first marriage does predict fertility. If higher fertility is the product of some unobserved characteristic of parents, then brothers would share that characteristic to some degree (all other behaviors correlate across brothers), and their fertility would correlate. It does not.

If we turn, however, to Europe post fertility transition then we find that siblings do correlate in fertility (White and Bernardi, 2008, table 9). In Sweden, for example, for brothers born 1940-1953 the correlation in fertility is around 0.10, and highly significant statistically (Dahlberg, 2014). Table 2 reveals a very similar correlation between brother fertility for marriages in England 1880-1949. The absence of any brother correlation in fertility for marriages before 1880 implies fertility cannot be a choice in this period as it was after the demographic transition. We also see in table 2 that for marriages in our sample 1880-1949 a significant brother correlation in fertility now appears, and is similar to the modern Swedish brother correlation reported above.

If we look at father-son correlations in characteristics for men born before 1850 (or marrying before 1880), as in table 3, we again see the inheritance of all characteristics except fertility. For fathers marrying after 1880, when there is fertility control within marriage, we again see a father-son correlation in fertility. So if fertility for marriages before 1880 represents a choice, it has to be based on completely non hereditable characteristics of individuals, characteristics uncorrelated with observed quality, but correlated with an unobserved quality than is inherited, but inherited in children now as observed quality. Occam's razor strongly supports the inference that instead parents simply did not make any

Table 1: Determinants of Children per father, England

	Pre 1880 Gross	Net (21+)	1880-1919 Gross	Net (21+)
Ln(Wealth)	-0.002	0.011	-0.049	-0.043
	(0.006)	(0.006)	(0.011)**	(0.011)**
Number of Wives (under 40)	0.069	0.047	0.089	0.098
	(0.062)	(0.067)	(0.094)	(0.100)
Oxbridge Enrolled	-0.019	0.001	0.140	0.175
	(0.064)	(0.066)	(0.107)	(0.112)
Age at Marriage (man)	-0.010*	-0.010*	-0.009	-0.007
	(0.004)	(0.004)	(0.005)	(0.006)
Age at Marriage (wife)	-0.008**	-0.009**	-0.039**	-0.042**
	(0.003)	(0.003)	(0.007)	(0.007)
R^2	0.01	0.01	0.03	0.03
N	1,402	1,382	1,511	1,489

* $p<0.05$; ** $p<0.01$

attempt to limit fertility within marriage before 1880, and physiological factors unconnected to parent quality determined the outcomes.

The complete lack of correlation between father and son fertility means that we can also measure the effects of family size in the first generation by looking at the outcomes for grandchildren.

Table 2: Brother Correlations

Characteristic	Correlation Married pre-1880	Number of Pairs	Correlation married 1880-1949	Number of Pairs
Occupational Status	0.621**	239	0.599**	730
	(0.052)		(0.051)	
Ln Wealth	0.587**	988	0.453**	2,641
	(0.038)		(0.032)	
Oxbridge Matriculation	0.252**	1,243	0.302**	4,737
	(0.035)		(0.039)	
Age at First Marriage	0.251**	896	0.212**	4,073
	(0.043)		(0.029)	
Wife Age at First Marriage	0.127**	478	0.086**	1,657
	(0.055)		(0.027)	
Child Mortality Rate	0.165**	782	0.193**	2,261
	(0.049)		(0.033)	
Lifespan	0.125**	1,177	0.109**	3,606
	(0.034)		(0.022)	
Ever married	0.065*	2,313	0.197**	10,524
	(0.029)		(0.014)	
Children 21+	0.005	1,251	0.087**	4,845
	(0.025)		(0.017)	
Births	0.006	1,251	0.109**	4,845
	(0.025)		(0.020)	

* $p<0.05$; ** $p<0.01$, robust standard errors clustered on fathers

Table 3: Father-Son Regression Coefficients

Characteristic	Correlation Married pre-1880	Number of Pairs	Correlation married 1880-1949	Number of Pairs
Occupational Status	0.681**	290	-	-
	(0.041)			
Ln Wealth	0.634**	1,221	0.430**	1,526
	(0.020)		(0.022)	
Oxbridge Matriculation	0.325**	1,660	0.208**	2,251
	(0.032)		(0.043)	
Age at First Marriage	0.135**	1,310	0.164**	2,093
	(0.044)		(0.024)	
Wife Age at First Marriage		---	0.147	1,232
	(0.055)		(0.036)	
Child Mortality Rate	0.209**	1,425	0.084**	1,708
	(0.041)		(0.030)	
Lifespan	0.163**	1,742	0.080**	3,086
	(0.030)		(0.020)	
Children 21+	0.014	1,783	0.081**	2,318
	(0.024)		(0.017)	
Births	0.012	1,783	0.075**	2,318
	(0.026)		(0.017)	

* $p<0.05$; ** $p<0.01$, robust standard errors clustered on fathers

The Quantity-Quality Tradeoff

We have five measures of child quality for children born from English men first married in the years before 1880. Table 4 shows the numbers of observations for each outcome

- For sons and sons-in law we have a set of measures of educational attainment. The most comprehensive of these is enrollment at Oxford or Cambridge, where the data exists throughout the period of observation.[5] But we can also construct a more comprehensive measure of high educational status, though with some gaps in the period, from the following sources: enrollment at London or Durham universities; enrollment at the Army Officer training school at Sandhurst; training as an attorney (1756-1874); enrollment as a registered doctor (1859-1956); membership in engineering societies (Civil Engineers, 1818-1930, Mechanical Engineers, 1847-1930, Electrical Engineers, 1871-1930). We thus have two measures of higher educational status: Oxbridge enrollment, and a broader measure of higher educational attainment.
- For a subset sons we also have measures of their still being in school or training ages 10-19 for cases where they appear in a census 1841-1901 at these ages.
- For sons there are measures of occupational status from the censuses of 1841-1911. The occupations are translated into a status score using a report from 1858 of the average wealth at death by occupation in England.
- For all children we have measures of child mortality rates, and adult longevity. In this period social status was strong associated with infant and child mortality. It was more weakly associated with adult mortality, though there was still a positive association. Table 4 shows child survival rates and adult life expectancy by rare surname groups. Survival rate 0-2 is the fraction of those born who live to age 3 or greater. Survival rate 3-21 is the fraction of those at age 3 who live to at least age 21. e_{21} is expected further years of life at age 21.
- For all children we have whether they were probated or not, and estimated wealth at death for the probated and non-probated.

[5] The data for Cambridge is comprehensive for the years 1900 and before, and thereafter has omissions. For Oxford the data is comprehensive 1892 and earlier, with more significant omissions later.

Table 4: Observed Survival Rates and Social Class, Births 1840-79

Group	Births 1860-79	Survival Rate 0-2	Survival Rate 3-21	e_{21}
Richest	1,796	0.959	0.954	46.9
Rich	1,726	0.938	0.935	45.5
Average	1,090	0.886	0.922	43.4
Poor	2,295	0.906	0.910	44.4

Note: Since we are less successful in linking children who die in the early years of life to their parents the survival rates here are biased upwards.

Given their educational status, longevity and wealth did parents with more children produce children who were of lower "quality" on the above five dimensions in terms of human capital?

Family size in this period is measurable in at least three different ways. There are the number of children born per father (N0). But a child who dies immediately after birth, as would most of the children dying in childhood, makes few claims on parent time and attention. So another measure is children surviving to age 21 (N21). But as we see above there are significant numbers of deaths in the ages 3-20. Thus we also use as a measure of numbers of children, based on their demands on family resources, the number of child-years per father. For children dying ages 0-14, the child years is the age at death. For those dying 15+ it is 14. We normalize this variable, N14, by dividing by 14. It is thus the number of age 14 equivalent children a father has.

Family Size and Human Capital

As noted above we have three measures of educational attainment: Oxbridge enrollment, a more general measure of educational attainment, and whether someone was already in work ages 11-20. The first two measures are a good proxy for educational success for higher status families. Thus among the richest and the rich surname lineages 25% of men born before 1850 who lived to age 21 attended Oxford or Cambridge. But for the poor group they are not such a good measure. 0.5% of men reaching age 21 in the average and poor surname lineages born before 1850 attended Oxford or Cambridge. The third measure, however, measures education well across the whole social spectrum.

The basic regression we estimate for educational attainment is

$$S_s = a + \sum b_i X_{if} + c_1 N + c_2 BORDER \tag{2}$$

where S_s is an indicator variable for sons either for Oxbridge attendance, for more general educational attainment, or for being at work, N is one of the three child measures, and BORDER is son's birth order. X_{if} is a set of characteristics of fathers or grandfathers: educational attainment, log of wealth at death, occupational status. The key parameter of interest here is c_1, but the value of c_2 is also interesting. On a theory where parental inputs matter to success, the oldest child would be expected to receive more such inputs than later children, and to have better outcomes in terms of education.

Table 5 reports the results of this estimation, using logit, for the dependent variable an indicator of whether a son is ascribed an occupation when observed in the censuses of 1881 or 1891. We classify anyone described as scholars, students, and apprentices, or given no occupation, as not in work. The average age is 15.3, and the average share at work 0.23. We control for whether a father attended Oxford or Cambridge, the log of their wealth at death, and the occupational status of fathers, all of which are significant predictors of son's work status. As can be seen there is no significant association between family size measured either as births or as numbers of children attaining age 21 and the likelihood of being in work before age 21. The estimated coefficients translate into one more child born or attaining age 21 creating a less than 1% increase in the odds ratio of a sibling being at work. The standard errors are low enough that we can rule out an additional sibling creating more than a 2% increase in the odds of being at work.

Table 5: Family Size and Work Status 11-20, Marriages pre 1880

Dependent Variable	Child at work	Child at work	Grandchild at work	Grandchild at work
Oxbridge Enrolled Father	-1.943* (0.837)	-1.961* (0.835)	-0.591 (0.530)	-0.592 (0.530)
Ln(Wealth) of Father	-0.242** (0.051)	-0.246** (0.051)	-0.254** (0.038)	-0.254** (0.038)
Occupational Status father	-0.413** (0.134)	-0.422** (0.136)	-	-
N	0.034 (0.040)	-	0.010 (0.044)	-
N21	-	0.036 (0.052)	-	-0.003 (0.050)
N14	-	-	-	-
Birth Order	-	-	-	-
Pseudo R^2	0.38	0.38	0.28	0.28
N	762	762	639	639

* $p<0.05$; ** $p<0.01$, controlling also for son age, and census year. Standard errors clustered by father (grandfather)

Because Oxford and Cambridge attendance is only indicative of educational attainment for the upper end of the status distribution, for this measure table 6 reports just the effects of family size for Oxbridge attendance for families from the richer lineages. Father's attending Oxbridge, and father's wealth are strong indicators of son's attendance. But the number of children in the family is not significantly associated with any son's chance of attending Oxbridge, whether family size is measured by children attaining age 21, or by the number of child-years to 14. When we measure children as those 21+ then there is a modest association between birth order and Oxbridge attendance, with older sons more likely to attend. But the birth order effect becomes insignificant if we measure children as child years.

Table 6 shows the same estimates for son's of fathers first marrying 1880-1919 when there is a strong negative association between fertility and social status. Even in this period, where family size will likely be correlated with unmeasured aspects of family quality, there is no significant association between child numbers and educational outcomes.

Table 6: Family Size and Educational Attainment

	Pre1880		1880-1919	
Dependent	Doxb	Doxb	Doxb	Doxb
Oxbridge Enrolled Father	0.978** (0.126)	1.374** (0.281)	1.361** (0.282)	1.374** (0.281)
Ln(Wealth) of Father	0.231** (0.032)	0.248** (0.065)	0.245** (0.064)	0.248** (0.065)
N21	0.000 (0.022)		-0.037 (0.083)	
N14		-0.079 (0.075)		-0.079 (0.075)
Birth Order	-0.076* (0.032)	-0.051 (0.117)	-0.091 (0.117)	-0.051 (0.117)
R^2	0.10	0.18	0.18	0.18
N	2,356	1,044	1,037	1,044

* *p*<0.05; ** *p*<0.01, sons from richer lineages only, controlling also for father's age at son's birth

Family Size and Occupational Status

Occupational status of fathers and children is measured from the censuses of 1851, 1881 and 1911, taking the measure from the age closest to 40. A status score is assigned to each occupation based on the logarithm of average wealth at death by occupation in 1858. This score ranges from 4.19 (sawyer) to 9.53 (banker), with a mean for sons of marriages pre-1880 of 5.99.

The basic regression we estimate for occupational status is, as for education,

$$S_s = a + \sum b_i X_{if} + c_1 N + c_2 BORDER \qquad (2)$$

where S_s is the occupational status of sons and grandsons. Table 7 shows the estimates for N21 and for N0. In both cases the coefficient on quantity is negative, but only statistically significant in the case of N0. But more importantly, both the estimated coefficients are very small in magnitude. An increase in family size (N21) from 1 to 11 is predicted here to reduce occupational status, averaging 5.99, with a standard deviation of 1.32, and ranging from 4.19 to 9.4, by 0.11, only 8% of a standard deviation. Thus a change in average completed family size from 4 to 2 circa 1900 would reduce estimated occupational social status by a mere 2% of a standard deviation in occupational status. Size matters little to child quality in terms of occupations.

Table 6: Occupational Status and Family Size

Variable	Occupational Status	Occupational Status
Family Size (N21)	-0.0113 (0.0134)	
Family Size (Births)		-0.0269* (0.0108)
Age of son at occupational measure	0.0124** (0.0024)	0.0125** (0.0024)
Occupation Status Father	0.571** (0.025)	0.567** (0.025)
R^2	0.462	0.466
N	1,326	1,326

* *p*<0.05; ** *p*<0.01, standard errors clustered by father, controls also included for wealth of father, educational status father, and age at measurement of father's occupation

Family Size and Longevity

As shown above adult longevity in this period is associated significantly with family wealth. Similarly if we look just at adult males, for those born 1845-1880 who enrolled in Oxbridge average longevity was 67.2 years (21+), compared to 63.7 for those who did not enroll.[6] Since enrollment was typically at age 18 or less, there are clearly longevity differences by social class.

This implies that the adult longevity of children can be used as a proxy for child quality. This proxy unlike the previous two, also applies for daughters as well as sons. Table 6 shows

[6] The t statistic on this difference in average longevity is 3.2, so the difference is statistically highly significant.

the results on this. Since average lifespan, and also the variance of lifespan was changing over time in all cases a standardized lifespan was created for individuals. This was defined as

$$Norm(AgeDeath) = \frac{AgeDeath_i - \overline{AgeDeath}}{std(AgeDeath)}$$

Where $\overline{AgeDeath}$ is average age of death in the decade of death of the person, and $std(AgeDeath)$ is the standard deviation of age of death in that decade, estimated using a large sample of deaths in the years 1866 onwards. Pre 1866 years of death are normalized using 1866-79 values.

Since there is a biological inheritance of longevity also we control for the average age of death of the parents, normalized in the same way. There is always a moderate, though statistically very significant, connection between child age at death and parent age at death, whether we take the average of the parents or each parents individual longevity. Child lifespan is also positively associated with the social status of the father as measured by wealth and education. However, when we add to the regression the number of children in the family, there is never any significant quantitative association with adult longevity, whatever measure of family size is used.

In estimating the effects of family size on child mortality rates, the situation becomes a bit more complicated. Since a child death before age 2 will be associated with a higher chance of a subsequent birth, there is an endogeneity between the mortality rate 0-2 and the total number of births. And if mortality rates 0-2 and 3-20 are correlated within families because of unobserved family characteristics, then higher total births will also correlate with higher mortality rates 3-20. The reverse will also potentially be true for completed family size, N21. Better child survival rates can potentially raise the completed family size.

Table 8 shows how the two different measures of family size, births and N21, connect to mortality rates 0-2 and 3-20 for births 1840-1899. Completed family size is positively associated with lower mortality rates both 0-2 and 3-20. But births are negatively correlated with survival rates both 0-2 and 3-20. Thus the evidence here is inherently ambiguous on whether the numbers of children in a family reduce the quality of children as measured by their survival rates.

Table 8: Adult Longevity and Family Size

	Pre 1880	Pre 1880	1880-1919	1880-1919
Average Lifespan Parents	0.179** (0.027)	0.182** (0.027)	0.203** (0.035)	0.204** (0.035)
N21	0.005 (0.006)		0.004 (0.010)	
N14		-0.000 (0.005)		0.002 (0.009)
Ln(Wealth) of Father	0.016** (0.004)	0.016** (0.004)	-0.007 (0.009)	-0.007 (0.008)
Educated Father	0.042 (0.034)	0.041 (0.034)	0.126 (0.067)	0.125 (0.067)
Female	0.296** (0.026)	0.296** (0.026)	0.398** (0.037)	0.398** (0.037)
Constant	0.046	0.089	-0.038	-0.024
R^2	0.05	0.05	0.05	0.05
N	5,688	5,688	3,314	3,314

* $p<0.05$; ** $p<0.01$, controls also for father and mother age at childbirth, and birth order. SEs clustered on fathers

Table 9: Child Mortality and Family Size, births 1840-99

	Mortality Rate, 3-21	Mortality Rate, 3-21	Mortality Rate, 0-2	Mortality Rate, 0-2
N21	-0.00798**		-0.00657**	
	(0.00115)		(0.00123)	
N0		0.00218*		0.00549**
		(0.00100)		(0.00114)
Ln(Wealth) of Father	-0.00198*	-0.00256**	-0.00493**	-0.00528**
	(0.00088)	(0.00092)	(0.00094)	(0.00094)
Educated Father	-0.00884	-0.00840	-0.00822	-0.00682
	(0.00917)	(0.00928)	(0.00928)	(0.00951)
Year of birth	-0.00085**	-0.00104*	0.00105**	0.00086**
	(0.00022)	(0.00023)	(0.00028)	(0.00028)
R^2	0.013	0.005	0.015	0.015
N	7,086	7,086	7,723	7,723

* $p<0.05$; ** $p<0.01$. SEs clustered on fathers

Family Size and Wealth

We have estimates of wealth at death for all fathers dying 1799 and later. For those dying 1858 and later this comes from the Principal Probate Registry, and is from 1858-1893 a statement just of the personalty of the deceased (assets aside from real estate), and after 1894 a statement of all assets. For those not probated we have to attribute a probate value. In each period there was a minimum estate value at which probate was legally required: £10 (1858-1900), £50 (1901-1930), £50-500 (1931-1965), £500 (1965-1974), £1,500 (1975-1983), and £5,000 (1984-2012) (Turner (2010 p.628)). We thus took as the value of estate for those not probated as typically half the minimum requiring probate: £5 (1858-1900), £10 (1901-9), £15 (1910-019), £20 (1920-30), £25 (1931-9), £50 (1940-9), £100 (1950-9), £250 (1960-1974), £750 (1975-1983), and £2,500 (1984-2012). We did not increase the attributed value in 1901 to £25 because the rise in the probate limit to £50 in that year had little effect on the implied value of the omitted probates in 1901 compared to 1900. Thus whatever the exact cutoff the bulk of the omitted probates were closer to 0 in value than to £50.

Since wealth at death has a very skewed distribution, we use the logarithm of estimated wealth to produce a distribution closer to normal. Also since the nominal value of average wealth increased greatly between 1858 and 2012 we normalized by the estimated average wealth at death in each decade. We thus construct for each person i dying in year t a measure of normalized wealth at death which is

$$w_{it} = \ln(Wealth_{it}) - \overline{\ln(Wealth_t)}$$

where $\overline{\ln(Wealth_t)}$ is the estimated average wealth at death by decade.[7] For each decade w_{it} will thus have an average expected value for the population as a whole of 0.

In the years 1799-1857 information on the value of personalty is available for wills probated in the highest of the ecclesiastical probate courts, the Prerogative Court of the Archbishop of Canterbury. However, only about 4% of men were probated in this court, and quite wealthy men might be probated elsewhere. Thus for this period we only included men as fathers in the wealth regression if they had a probate value in this court. Since this involves selection just on the Xs it should not lead to bias in the results.

In this period the best indicator of family wealth is the estate of the husband at death, since looking at the value of estates 1860-1949 the value of those of husbands greatly exceeded that of their wives, especially in earlier years. We can thus estimate the effect of family size on wealth through

$$lnW_c = b_0 + b_1 lnW_f + b_2 lnN + b_3 DFALIVE + b_4 DIFF \qquad (4)$$

Where:

N	=	number of surviving children
lnW_c	=	log wealth each children of a given father
DFALIVE	=	indicator for when the father is still alive at the time of the son's death
DIFF	=	years between death of father and son

[7] This was estimated 1895 and later from aggregate probate values reported by Atkinson (----), -----. 1858-1894 this was estimated from the average probate rates and probated wealth of people with the surname *Brown*. *Brown*, like most common surnames, is a surname of average social status.

DFALIVE is a control for the effects of sons who die before fathers, and thus likely receive smaller transfers of wealth from fathers. Such sons will also tend to be younger. And in this data wealth rises monotonically with age until men are well past 60. DIFF measures the time between the death of the father and the death of the son, which would allow the bequest to grow.

With this formulation, b_2 is the elasticity of son's wealth as a function of the number of surviving children the father left. N varies in the sample of fathers and children from 1 to 18. The coefficient b_1 shows the direct link between fathers' and sons' wealth, independent of the size of the fathers' family.

The second column of table 10 shows the estimated coefficients from equation (4). For wealth the coefficient on numbers of children is negative and strongly statistically significant. However, wealth is an imperfect indication of child "quality" since it derives in part from child earnings and social status, and partly just from inheritance. Are children of larger families poorer at death because they ended up with less human capital, in a broad sense, or just because they inherited less? One way we can measure this is by substituting in equation (4) for father's wealth at death the expected bequest of each child, which is that wealth divided by N21, the number of adult children. The third column of table 10 then shows the effects of family size on wealth at death, controlling for bequests. Now the effect of family size is positive and statistically significant. Relative to the bequests they receive, children of larger families accumulate more wealth by the time they die. They act as if they have had a negative shock to their wealth relative to their social position, and are restocking wealth.

Table 9: Child Wealth and Family Size

Dependent Variable	Ln Child Wealth	Ln Child Wealth
Ln Wealth Father	0.465** (0.011)	-
Ln Bequest	-	0.465** (0.011)
lnN21	-0.330** (0.067)	0.135* (0.067)
Dfalive	-1.436** (0.131)	-1.436** (0.131)
Years since bequest	0.0129** (0.0020)	0.0129** (0.0020)
Dfem	-0.264** (0.069)	-0.264** (0.069)
Observations	6,719	6,719
R-squared	0.385	0.385

* p<0.05; ** p<0.01. SEs clustered on fathers

The multigenerational nature of our data allows us to address this issue further. In table 11 the third column shows estimates of the wealth of the grandchildren of men who first married before 1880, as a function of the family size in the first generation, when family size was a random shock. The wealth of grandchildren is still strongly associated with the wealth of the grandfather, but interestingly by the time of the third generation, initial family size has no significant association with wealth. Whatever shock was received to wealth in the second generation as a function of family size has disappeared by the third generation. Thus family size creates transitory shocks to wealth for the next generation, but these shocks dissipate quickly over time.

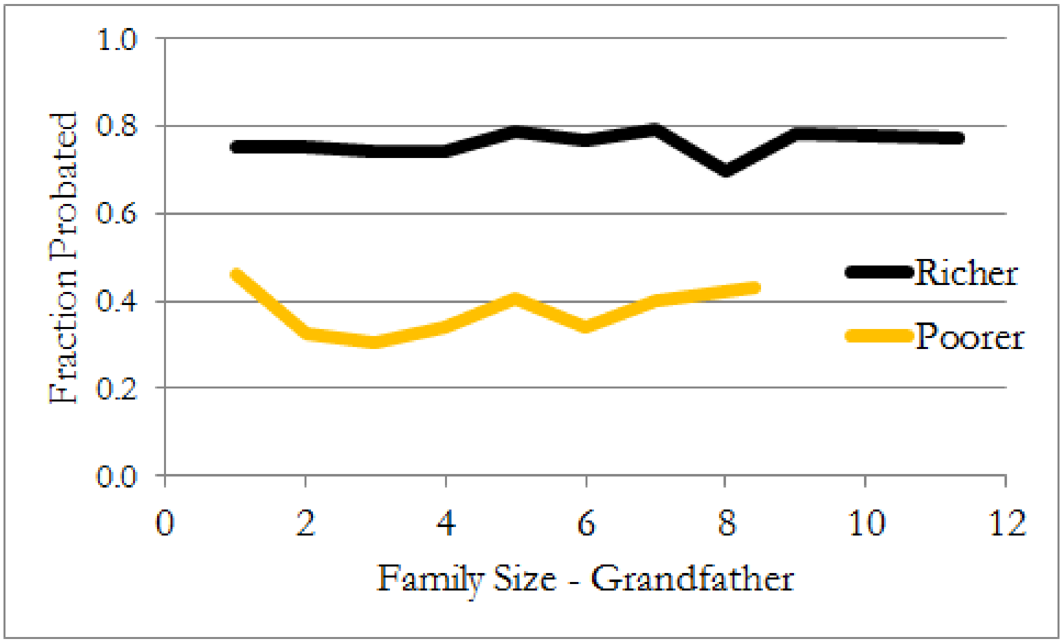
Table 11: Grandchild Wealth and Family Size

Dependent Variable	Ln Son Wealth	Ln Grandchild Wealth	Grandchild Probate rate
Ln Wealth Grandfather	0.550** (0.016)	0.325** (0.012)	0.205** (0.010)
lnN21	-0.236* (0.112)	-0.042 (0.083)	-0.083 (0.069)
Dfalive	-0.852** (0.272)	-0.128 (0.225)	-
Years since bequest (son)	0.0092** (0.0035)	0.0170** (0.0026)	-
Years since bequest (grandchild)	-	0.0247** (0.0018)	-
Dfem	-	-0.257** (0.073)	0.132* (0.065)
Observations	1,918	5,434	5,986
R-squared	0.45	0.30	0.14

* $p<0.05$; ** $p<0.01$. SEs clustered on grandfathers

We can confirm the transitory effects of shocks to grandparent family size before 1880 on subsequent wealth by also just looking at the probate rates of grandchildren. Probate rates are a good proxy also for family wealth, being close to 100% in the richest families, and 0% in the poorest. The absence of a grandchild wealth effect is confirmed in the last column of table 11, which reports the coefficients of a logit regression of grandchild probate rates on grandfather log wealth, and log family size (N21). Figure 8 shows for the grandchildren of marriages before 1880 the probate rates as a function of the adult family size of the grandfather generation, separately for richer and poorer rare surname lineages. The effects of lineage are clear in the grandchild generation, with the grandchildren of the richer lineages (defined by average wealth at death 1858-1887) still significantly wealthier

Figure 8: Probate Rates of Grandchildren as a Function of Grandfather Family Size, First Marriages before 1880



than those of the poorer lineages. But there is no effect, either among the richer or the poorer lineages, of grandfather family size on grandchild probate rates. Lineage matters strongly, but not family size in earlier generations.

If larger family size at the grandfather level reduces the human capital of children, and this gets transmitted to the next generation, then the grandparent family size should also predict grandchild wealth. If, however, human capital is unaffected, and the transitory effects of inheritance on wealth quickly dissipate then the grandchildren will have a wealth that is independent of family size at the grandparent generation. What we see is that grandparent wealth is still strongly predictive of grandchild wealth. But grandparent family size has no significant effect. The best estimate is that the shock to wealth from a larger family size at the grandparent level is transitory, confined to just one generation.

Implications

The results above are clear. In England before 1880 family size was from the perspective of the parents a random shock, whether measured as births or as children surviving to age 21. Brothers correlate on wealth, occupational status, longevity, age at marriage, age of wife at marriage, the mortality rates of their children, and probability of marriage. But there is no correlation between them with respect to births, or to surviving children. These shocks to child numbers resulted in a huge range of family sizes, from 1 to 18 for children surviving to age 21.

The evidence above shows clearly that the costs to families from having more children were negligible in terms of the human capital of the children. Sons of larger families, among the richer families where we have good measures of educational attainment, were not any less likely to attain education. Occupational status of sons declined by only the most slender amounts when family sizes increased significantly. Children of larger families did not have lower longevity. And given their estimated average inheritance, the wealth at death of children in larger families was not any less than in that of smaller families. Thus the children of larger families show no sign of being less capable or less educated. And even the effect of family size on child wealth was transitory. Grandchildren in families with larger size in the first generation are no poorer relative to their grandfather than grandchildren of smaller families in the first generation. The grandchildren from the larger families are as likely to be probated as those from smaller families.

All of this calls into question the strong reliance of most theories of the emergence of modern economic growth on the quality-quantity tradeoff with children. The whole Beckerian notion finds no counterpart in reality. Modern growth consequently cannot be explained by a switch to smaller family sizes accompanied by more investment in child quality. Modern growth in England began 100 years before there were significant reductions in average family sizes, and indeed was accompanied by an increase in average family sizes.

Appendix: The Data

The data used in this study for marriages pre 1880 comes from a genealogical database of 58,000 English and Welsh people who had rare surnames. To qualify a surname had to appear 40 times or less in the 1881 census. Since the data was collected to study social mobility in England from 1800 to 2012, the initial surnames used were deliberately oversampled from the top and bottom of the wealth distribution for those dying 1858-1887. There are 26,000 individuals from the rich lineages and 32,000 from the poor. We thus estimate separately the effects of family size for the rich and poor families, in case the quality-quantity effect only appears in part of the educational distribution.

All births, deaths and marriages were registered in England from 1837 on. After 1865 the death register also included age at death. So for rare surname individuals we can link their births, deaths and marriages (though less easily for births before 1865). The censuses of 1841-1911 are also available, providing information on parentage. For marriages before 1880 there is considerable information available from parish records of baptisms, which recorded parents' names, and from parish records of marriages, which recorded the names and ages of those marrying as well as their fathers names. There are many ancillary records which show, particularly for higher status families, family relationships: accounts, for example, of all men matriculating at Oxford and Cambridge universities prior to 1893, their fathers and their marriages, and also probate records.

By focusing on rare surnames, and by employing the whole set of records available for England we achieve much higher matching rates than is typical for linking parents and children in the 19th century censuses.[8] But the nature of the sources means we cannot identify parentage for all the people in our sample. Thus for 4,850 recorded births 1860-1879, for we identify the father or mother for 85% of recorded births.[9] The reasons for failing to find the parents are various. In some cases the name likely has been misspelled in the birth record, and the person does not belong in the surname lineages we are using to form the sample. Of those not linked 60% show no further appearance in any record after their birth under the birth name. Likely in most of these cases the name is just misspelled on the birth register. In others the child dies before appearing in a census, or their father dies, or they are living with grandparents in the census, or the family emigrates.[10] Thus one third of those not linked to a parent died before age 10. However, for children identified as living

[8] Ferrie and Long, for example, link only ---% of sons to their fathers between 1851 and 1881.
[9] In some cases, where the child is illegitimate, only the mother is listed on birth records.
[10] We could identify the father by getting the birth certificate, but this is prohibitively costly.

to at least 21, 3,152 for births 1860-79, the match rate is much better, with only 2.1% without a father or mother identified. In part for this reason our preferred measure of family size is the number of children living to age 21.[11] There will be error associated with this measure, but that error will be modest.

Though the numbers of recorded births for men and women is similar, and the match rate to fathers for the births is also similar by gender, the final dataset of family size by father is missing at least 12-14% of girls. This is because children in families can also be identified in families from the existence of a death record, or from their presence in a census or other record, where the birth was not recorded under the correct family surname. But adult women will only appear in a death or census record if they remain unmarried. Thus more sons are identified from such records, absent the birth record. Table 1A shows for men and women of the target rare surnames the numbers linked to fathers in total and by gender and type for births 1860-79, for all births and for those attaining age 21. Though an equivalent number of women are matched to fathers in the births sample, many more men are identified from ancillary records. This implies that at least 12% of girls are missing from the sample of births, and 14% from the sample of those attaining age 21.

Table A1: Share of Men and Women in Family Size Sample, 1860-79

	All	Men	Women
Births – all	4,149	2,208	1,941
Birth record	3,509	1,755	1,754
No Birth record	640	453	187
21+ - all	3,420	1,807	1,613
21+ - birth record	2,862	1,398	1,464
21+ - no birth record	558	409	149

[11] For children identified as dying before age 21 the numbers not matched with a father is 41%.

The evidence, however, is that once we account for omitted daughters, we are capturing most children in these families. Using the dataset we can estimate female fertility rates by age. These fertility rates can then be compared with those calculated by Wrigley and Schofield for England and Wales as a whole from parish records pre 1800, as is done in figure 6. This comparison suggests that the reconstructed families in this dataset are potentially missing about 5% of sons, and 19% of daughters, measured in terms of births. But for children reaching age 21 the percentages of sons and daughters missing will be smaller.

For children reaching age 21 where at least 14% of daughters are missing a factor that limits the error in the data is that a significant number of these missing daughters appear to be in daughter only families, where all the children are missing, so that they not appear at all in our estimations. To see this consider table A.2 below. This shows by family size the number of sons and daughters recorded. The share of women missing from smaller recorded families is much larger. A part of this will be just a statistical effect (missing women make families on average smaller), but a substantial part seems to be that there are significant numbers of missing all-female families of size 1, 2, or 3. Such omissions will not affect the estimated family size effects in the paper.

Table A.2: Missing Women by Family Size, pre-1880 marriages, children 21+

Family Size	All	All Children	Male	Female	% missing females
0	803	0	0	0	0
1	306	306	201	105	48
2	350	700	389	311	20
3	355	1,065	618	447	28
4-5	642	2,853	1,536	1,317	14
6-7	371	2,376	1,250	1,126	10
8+	316	2,962	1,491	1,471	1
All	3,146	10,262	5,485	4,777	13

Table A.3: Observations on Characteristics, Fathers, Children and Grandchildren

Variable	Fathers (with complete fertility)	Sons	Daughters	Grandsons	Grand-daughters
Number	2,428	6,788	6,181	6,604	6,046
N children	2,428	5,201	-	5,125	-
N children, 21+	2,428	5,201	-	5,125	-
Longevity	2,358	6,080	4,350	6,068	4,178
Marriage Age	1,991	3,733	2,975	3,776	3,090
Probate?	2,169	4,760	2,991	4,688	2,651
Wealth at Death	2,054	4,546	2,850	4,237	2,424
Oxbridge Attendance	2,428	6,276	-	6,255	-
Schooling 11-20	-	1,093	-	794	-
Adult Occupation	1,140	2,618	-	1,841	-

Table A.3 summarizes the data available for children in the sample for men with first marriages before 1880, and the most complete fertility information. For marriages before 1837 this requires that there be some local source on births such as the parish register. For daughters there is much less complete information on most characteristics. They largely did not have formal education and occupations for children born from marriages 1879 and earlier. The number of children with recorded numbers of births and children surviving to age 21 is less than the number born, since we only measure fertility for those reaching the age 21 and above. Grandchildren are included here only if they were born before 1920, since otherwise there will be truncation of those dying at greater ages. If we included all grandchildren, the number would be 13,334, about 5% greater than in table A.3.

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