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THE CHILD QUALITY-QUANTITY TRADEOFF, ENGLAND, 1780-1880: A FUNDAMENTAL COMPONENT OF THE ECONOMIC THEORY OF GROWTH IS MISSING

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Abstract

In recent theorizing, modern economic growth was created by substituting child quality for quantity. However evidence for this tradeoff is minimal. In England the Industrial Revolution occurred in a period 1780-1879 of substantial human capital investment, but no fertility control, huge random variation in family sizes, and uncorrelated family size and parent quality. Yet family size variation had little effect on educational attainment, occupational status, or longevity, for both prosperous and poor families. More children reduced inherited wealth, but even that effect largely disappeared by the next generation. There is no quality-quantity tradeoff. Growth theory must proceed in other directions.

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Introduction

Modern high income societies have a combination of low fertility levels and high levels of nurture and education for children. There is much human capital. 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). 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 have, the less input each child can receive, and the less effective will these children be as future 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 capable 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.[1] But modern family sizes are determined by parental choices, choices that correlate with unobservable features of parents which influence child quality. So any observation correlation between quality and quantity will be potentially biased as measures of the causal effects of quantity. Tests of the quality-quantity tradeoff which control for this by using the accident of the twining of second births fail to detect a significant tradeoff. For modern families, however, the range of variation in family size is mostly 1-3. Pre-industrial families had much greater size variance, so more potential of size eventually having significant effects on quality.

In this paper we utilize a dataset containing the histories of a set of English families which had rare surnames 1780-2012, described below. Using birth, death and marriage records, probate records, censuses, and other sources we reconstructed the histories of 61,000 individuals dying 1780 and later. We measure family size with a high accuracy. In England for marriages commencing 1780-1879 there is minimal raw association between fertility and parent "quality". But more importantly, we show that nearly all family size variation lay outside the control of parents, so that the bias caused by correlations between

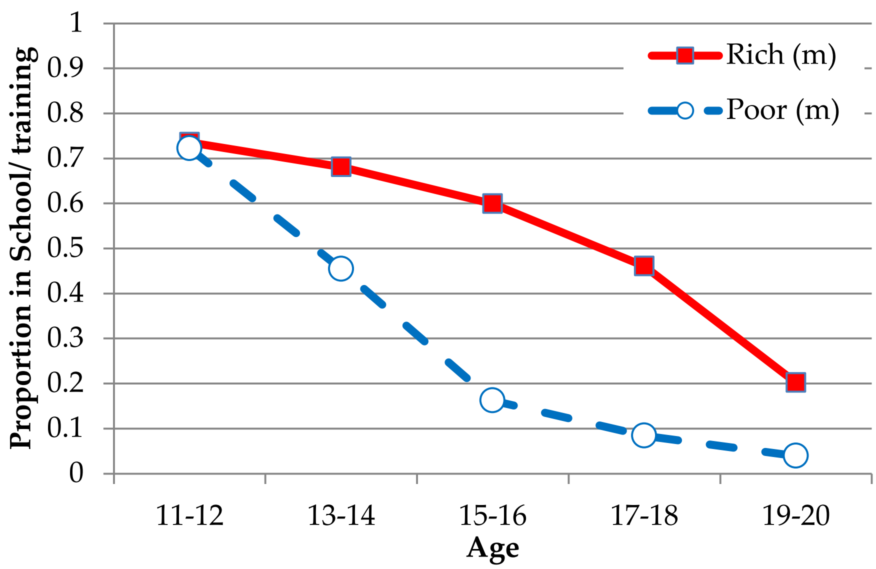
[1] But note that for pre-industrial societies even that raw correlation between quality and quantity is either absent or weak. See Carmichael et al., 2015, Figure 2, p. 21.

family size and unmeasured "quality" is minimized. From the perspective of the parents, family size was an exogenous shock. We get thus get largely unbiased estimates of the causal association between size and education, occupation, longevity and wealth. The conclusion is that family size had little effect on education, occupation, longevity, or even on wealth, though in this case it is wealth at death relative to wealth inherited.

The period of study, marriages 1780-1879 is already one where there were considerable investments in education and training. Figure 1 shows, for example, the percentage of males born from marriages before 1880 described as "scholars", "apprentices," in the censuses of 1851-1911. This number is a lower bound since frequently, even for rich families where we know education would be provided at younger ages, the census enumerators simply left blank the "occupation" column for children without a job or trade, without specifying explicitly "scholar." The families in this sample are divided into those whose rare surnames were on average wealthy, and on average poor.[2] For families from richer lineages 64-80% of sons were still in education or training at age 15. Even for the poor ones it was 22-34%. The age we are looking at here is already the modern one of significant human capital.

[2] The status of each surname lineage as rich, intermediate, or poor was determined by their average wealth at death 1858-1887.

Figure 1: Fraction of males in education or training, ages 11-20, marriages pre 1880



Sources: See Data Description below. Status as reported in the censuses of 1851-1911. As noted in the text this underestimates the fraction in schooling or training for both groups.

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.[3] 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.

[3] 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).

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 2. 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

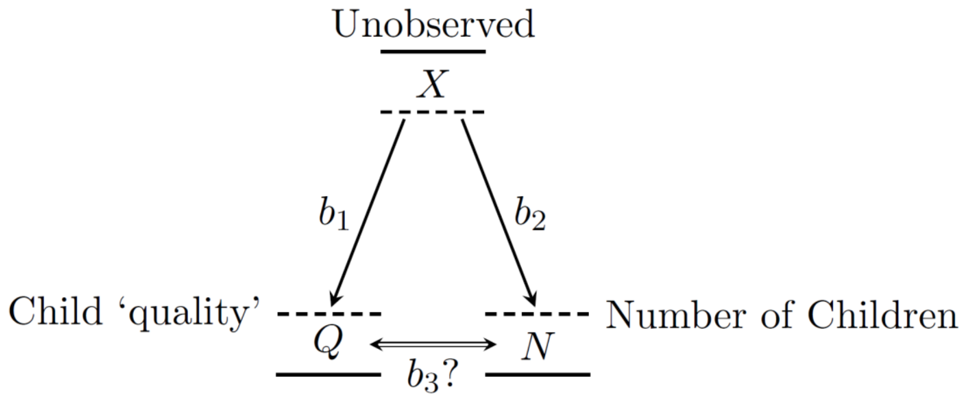
$$q = \beta N + u, \qquad (1)$$

where q is child quality, N child numbers, and u the error term, are biased towards the negative, because of the modern negative 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. The average pre-industrial marriage would produce 6 births.

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.

Figure 2: Parent influences on child quality – modern world



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 often a 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.

Data Description

The data used in this study for marriages pre 1880 comes from a genealogical database of 61,000 English and Welsh people who had rare surnames, born 1750-2012. To qualify a surname had to appear less than 41 times 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.[4] There are 25,000 individuals from the rich lineages, 25,000 from the poor, and 11,000 of intermediate wealth. We thus also 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 and income distribution.

All births, deaths and marriages were registered in England from 1837 on. After 1865 the death register also includes 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, and a 1939 population register, are also available, providing information on parentage (see the list of data sources below). 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 19th century censuses.[5] But the nature of the sources means we cannot identify parentage for all the people in our sample. Thus for 5,252 recorded rare surname births 1860-1879, we identify a father or mother for 86%.[6] The reasons for failing to find at least one parent in the other 14% of cases are various. In some cases the name likely was misspelled in the birth record, and the person does not belong in the surname lineages used 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.[7] Thus one third of those born not linked to a parent died before age 10. However, for children identified as living to at least 21, 3,485 births 1860-79, the match rate is much better, with only 2.1% without at least one parent identified. In part for this reason our

[4] See, for example, Clark and Cummins, 2014a.
[5] Ferrie and Long, 2013, for example, link only 20% of adult sons to their fathers in England between 1851 and 1881.
[6] In some cases, where the child is illegitimate, only the mother is listed on birth records.
[7] We could identify the father by getting the birth certificate, but this is prohibitively costly

preferred measure of family size is the number of children living to age 21.[8] 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 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 1 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.

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 7 below. 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 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.

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

Table 1: Share of Men and Women in Family Size Sample, 1860-79

	All	Men	Women
Births – all	4,149	2,208	1,941
Births – Birth record	3,509	1,755	1,754
Births– 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

Table 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

Note: This assumes equal numbers of sons and daughters born.

Below we will show that for marriages 1780-1880 fertility was a random shock as far as the parents were concerned. We have five measures of child quality for children born from these marriages. Table 3a and 3b shows the numbers of observations for each of these quality measures for fathers, and for children.

Schooling 11-20 - For a subset of all children, male and female, we have a measure of whether they were explicitly in school or in an apprenticeship aged 11-20 then they appear in a census 1851-1911 at these ages. [9] We also have a measure of whether they were explicitly in employment (exclusive of apprenticeships) ages 11-20 for these cases.

Higher Educational Attainment - For sons only we can construct an indicator variable for higher educational attainment. This is set at 1 under the following: the son enrolled at a university (Oxford, Cambridge, or London) [10]; enrollment at the Army Officer training school at Sandhurst; training as an attorney (1756-1874); enrollment as a registered doctor (1859-1956); was a member of an engineering society (Civil Engineers, 1818-1930, Mechanical Engineers, 1847-1930, Electrical Engineers, 1871-1930); was a trained cleric.

Occupational status - For sons there are measures of adult occupational status from the censuses of 1841-1911, from the population register of 1939, or from probate and other records (probate records 1858-1909 frequently give the occupation of the deceased). The occupations are translated into a status score using a report from 1858 of the average wealth at death by occupation in England. For each occupation the average of the natural logarithm of wealth at death for each occupation is used as the status score. This score ranges from 9.41 (Banker) to 4.09 (Pensioner).

Wealth at death - For all children dying 1858 and later we have whether they were probated or not, and estimated wealth at death for the probated and non-probated. We normalize for changes in wealth over time by dividing wealth by the average wealth at death of the entire population for the decade of death. Again we use in the estimations the natural log of this real wealth measure (to have an outcome variable that is closer to normal in distribution).

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[9] In the census some children have their occupational status just left blank.
[10] This measure looks only at those probated. But it does provide a ranking of occupations by wealth.

Table 3a: Summary Statistics, Fathers

	count	mean	min	max
Age at Death	2,555	66.87	20	100
Births	2,628	5.52	1	19
Surviving Children (>20)	2,567	4.49	1	18
Ln(Wealth)	2,295	-0.49	-7.8	8.9
Occupational Status	1,861	6.03	4.1	9.4
Higher Education	2,628	0.18	0	1

Table 3b: Summary Statistics, Children

	count	mean	Min	max
Female	14,424	0.48	0	1
Age at Death	11,629	55.81	0	103
Ln(Wealth)	8,191	-0.54	-7.8	8.9
Child (>20)	13,508	0.85	0	1
Birth Order	14,424	4.20	1	18
Father Alive at Death	14,424	0.19	0	1
Dwork11-20	4,177	0.33	0	1
Ln(Bequest received)	12,621	-2.23	-8.5	8.5
Occupational Status	4,065	5.83	4.1	9.4
Higher Education	14,424	0.08	0	1

Source: QQ Database.

Table 4: Observed Survival Rates and Lineage Wealth Class, Marriages 1840-79

Group	Births 1840-79	Survival Rate 0-21	Avg. Age at Death (death 21+)
Richest	3,932	0.88	66.5
Rich	3,765	0.84	65.5
Average	1,948	0.74	64.5
Poor	4,645	0.72	65.0

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.

Survival Rates and Life Span - For all children we have measures of mortality rates (0-21), and adult longevity. In this period social status was strongly associated with infant and child mortality. It was more weakly associated with adult mortality. Table 4 shows child survival rates to 21 and life expectancy at age 21 by rare surname groups. Survival rate 0-21 is the fraction of those at born known to live to at least age 21. e_{21} is expected further years of life at age 21.

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. First is 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 in this period, makes few claims on parental time and attention. So another measure is children surviving to age 21 (*N21*). This, as noted above, has the advantage of also being measured with the least amount of error as any of the family size measures. Since children die at all ages from 0 to 14, when they can typically begin to support themselves, another measure is the number of child-years per father aged 0-14. 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. *N14* turns out to be typically a weighted average of *N0* and *N21*, so we report most results just for *N0* and *N21*.

Fertility in England, 1780-1879: A Natural Experiment

We can measure the quality-quantity tradeoff well for marriages in England 1780-1879 because there is evidence for an 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 is inconsequential.

Before 1880 the only element in determining family size that parents chose was age at marriage. Marital fertility once the marriage begins is uncontrolled. If we regress for our sample children per father, measured as either gross fertility (*N0*) or children attaining age 21, net fertility (*N1*), on various quality measures, as well as ages at marriage, as in table 5, younger husbands and wifes did produce more children.[11] But even this one element of control was uncorrelated with quality. As figure 3 shows, the age of the wife at the husband's first marriage was not significantly correlated with the husband's wealth at death. It was also uncorrelated with other measures of quality such as occupational status. Also, the amount of the variance in fertility determined by age at marriage before 1880 was tiny, less than 1%. Only after 1880 do we see in table 5 a negative association between gross and net fertility and quality.

As table 5 illustrates measured in terms of children surviving to adulthood, or of births, there is no significant correlation in this period between parent quality and family size. Figure 4, 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 (net) just on the log of wealth, the coefficient of wealth is not statistically or quantitatively significantly different from 0.

As figure 4 illustrates, the range in family sizes for marriages 1780-1879 was enormous. This is further shown in figure 5, which shows the distribution of children 21+ by family size.[12] The median child in this period had 5 adult siblings. Sibship sizes in nineteenth century England at the time of the Industrial Revolution were thus among the largest observed across all societies with well recorded demography. 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

[11] For information on the construction of the sample, see the data description below.

[12] 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.

Table 5: Determinants of Children per father, marriages 1780-1879, and 1880-1919

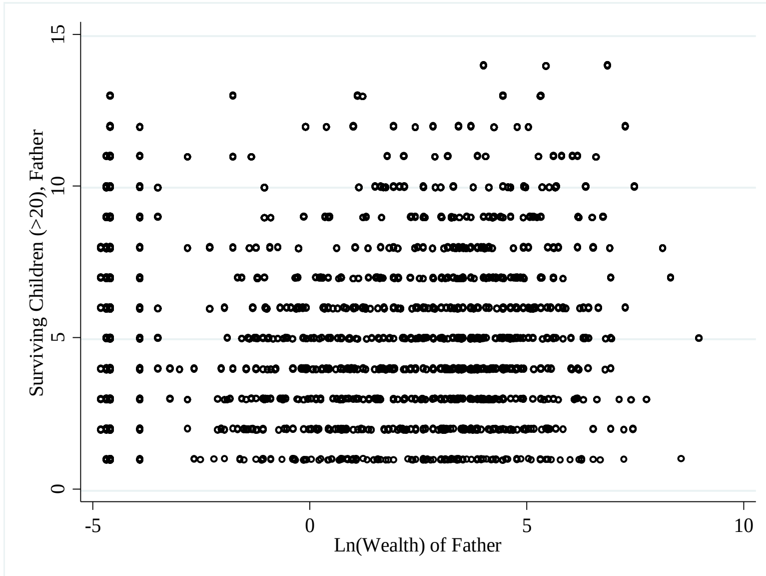
	Marriages Pre 1880		Marriages 1880-1919	
	N0	*N21*	*N0*	*N21*
Ln(Wealth)	0.003	0.010	-0.047**	-0.045**
	(0.007)	(0.008)	(0.012)	(0.013)
Occupational Status	-0.009	0.012	-0.019	0.000
	(0.021)	(0.023)	(0.030)	(0.032)
Number of Wives (under 40)	0.036	0.025	0.063	0.082
	(0.061)	(0.066)	(0.086)	(0.091)
Higher Education	0.027	0.029	0.074	0.083
	(0.061)	(0.064)	(0.100)	(0.105)
Age at Marriage (husband)	-0.009*	-0.008	-0.007	-0.006
	(0.004)	(0.004)	(0.006)	(0.006)
Age at Marriage (wife)	-0.015**	-0.015**	-0.039**	-0.041**
	(0.003)	(0.003)	(0.007)	(0.007)
Pseudo R2	0.01	0.01	0.03	0.03
N	1,364	1,345	1,413	1,390

Negative Binomial Estimation, * $p<0.05$; ** $p<0.01$

Figure 3: Median Age at First Marriage of Wives by Wealth Decile, Marriages 1780-1879

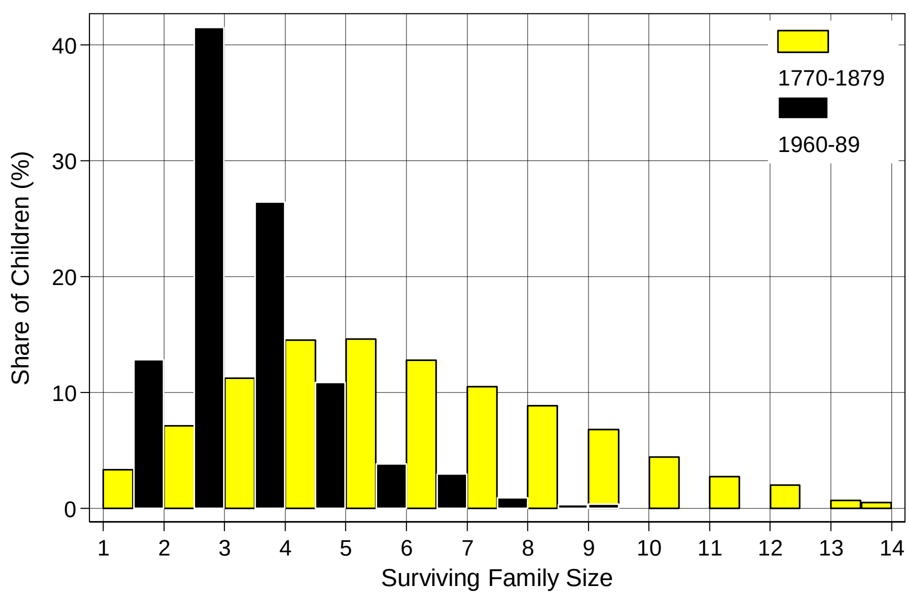
Note: Based on 1,578 first marriages 1780-1879.

Figure 4: Family Size versus Father Wealth, England, marriages 1780-1879



Note: Family size is children per father, and may involve children with more than one wife. Wealth is measured as wealth at death relative to average wealth at death in the decade of death.

Figure 5: Share of Children in each Family Size, 1780-1879, 1960-89



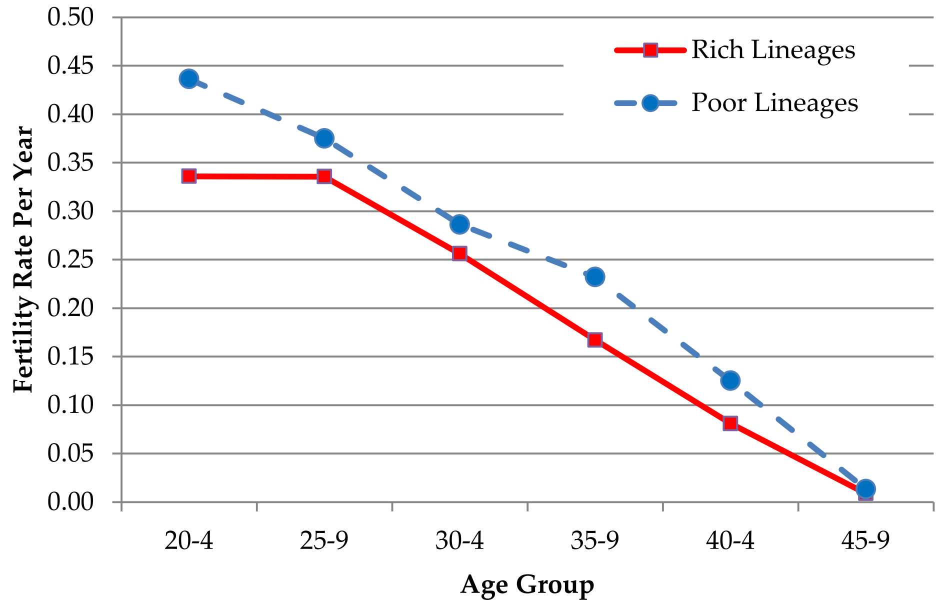
children in families of 9 or more. Figure 5 also shows the distribution of sibship sizes (21+) for UK marriages 1960-1989. This is much more concentrated. The variance in size then was just 1.43. Thus in terms of variation in family sizes nineteenth century England is an ideal case for detecting the quality-quantity tradeoff.

It is true that birth rates were higher in this period for poorer compared to richer families. But this difference in fertility pre 1880 is driven largely mechanically by the fact that birth spacing was closer when the previous child died in infancy, since breastfeeding suppressed fertility. Poor families had greater infant mortality, and this induced higher period 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 all marriages pre 1880 in our sample with the Wrigley and Schofield family reconstitution sample for births 1600-1799 in England. 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). The birth rates by age are very similar. Also, just as in 1600-1799, there is no sign in England 1780-1879 of the more rapid decline in fertility with age that was characteristic of populations which began to control fertility.

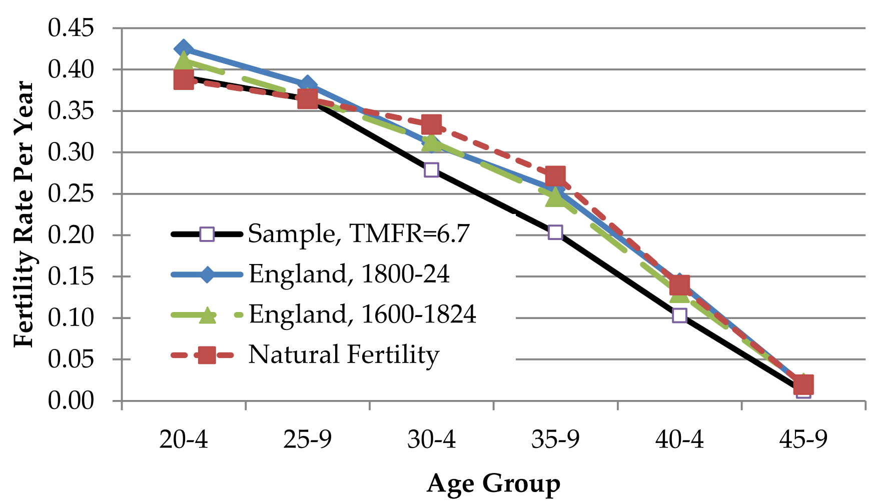
Compelling evidence that fertility for marriages before 1880 was random with respect to family quality, and not the result of some unobserved trait that correlates with unobserved elements of quality, comes if we look at the correlation in characteristics across brothers. In modern data siblings correlate on all behavioral traits, as do parents and children. Table 6, for example, shows the correlations in IQ and the major personality traits of a large panel of German young adults and their parents. For brothers born before 1850 (and thus marrying typically pre 1880) for most characteristics – wealth, occupational status, educational status, child mortality rates, husband and wife ages at marriage, even age at death – they correlate significantly. This is shown in table 7. But for both N0 and N21 there is no correlation, even though in table 5 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

Figure 6: Fertility by Age, Rich and Poor, Marriages 1840-1879



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

Figure 7: Fertility by Wives' Age, all marriages 1840-1879



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

Sources: England, 1800-24 and 1600-1824, Wrigley et al. 1997 p.355, table 7.1.

Table 6: Modern Personality Trait Correlations, Parents and Siblings

Trait	Siblings	Father-son
Openness to Experience	0.29	0.31
Conscientiousness	0.41	0.24
Extraversion	0.22	0.20
Agreeableness	0.35	0.21
Neuroticism	0.31	0.21
Fluid Intelligence	0.54	0.39
Crystalized Intelligence	0.61	0.42
General Intelligence	0.58	0.42

Note: Children were tested as young adults.
Sources: Anger, 2012, table 1. Anger, 2015, tables A1, A2.

Table 7: Brother Correlations, births 1750-1850, 1850-1920

	Born Pre 1850	N	Born 1850-1919	N
Occupational Status	0.628**	506	0.647**	1,157
	(0.033)		(0.024)	
Ln Wealth	0.568**	1,631	0.457**	4,239
	(0.020)		(0.014)	
Oxbridge Matriculation	0.236**	2,419	0.315**	8,067
	(0.019)		(0.010)	
Age at First Marriage	0.269**	1,094	0.203**	4,339
	(0.029)		(0.016)	
Wife Age at First Marriage	0.166**	732	0.108**	1,984
	(0.037)		(0.022)	
Child Mortality Rate	0.166**	873	0.129**	2,392
	(0.032)		(0.020)	
Lifespan	0.134**	2,346	0.131**	5,712
	(0.023)		(0.014)	
Ever married	0.085**	2,435	0.090**	8,303
	(0.022)		(0.012)	
N21	0.012	869	0.117**	2,345
	-0.032		(0.019)	
N0	0.035	903	0.174**	2,494
	-0.032		(0.018)	

* p<0.05; ** p<0.01

would share that characteristic to some degree, and their fertility would correlate. It does not.[13]

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 7 reveals a very similar correlation between brother fertility for men in England born 1850-1920. 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.

Looking similarly at father-son correlations in characteristics for men born before 1850 (or marrying before 1880), as in table 8, 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 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 also means that we can also measure the effects of family size in the first generation by looking at the outcomes for grandchildren.

[13] Brothers do correlate on their wife's age at first marriage, but that correlation is so weak, and the correlation between age at marriage and fertility also so weak, that it produces no significant correlation in fertility between brothers.

Table 8: Father-Son Regression Coefficients, sons married 1780-1879 and 1880-1949

Characteristic	Married 1780-1879	N	Married 1880-1949	N
Occupational Status	0.587**	992	0.393**	1,169
	(0.027)		(0.032)	
Ln(Wealth)	0.654**	1,407	0.423**	2,445
	(34.78)		(22.90)	
Oxbridge Enrolled	0.347**	1,959	0.239**	6,733
	(11.83)		(8.10)	
Age at First Marriage	0.137**	1,470	0.170**	4,032
	(3.70)		(7.80)	
Lifespan	0.162**	1,868	0.117**	3,722
	(5.52)		(5.20)	
N21	0.012	1,118	0.116**	1,716
	(0.33)		(3.92)	
N0	-0.001	1,548	0.074**	2,979
	(0.02)		(5.40)	

* p<0.05; ** p<0.01

Family Size and Human Capital

We have two measures of educational attainment: work and educational status ages 11-20, and a measure of higher educational attainment in adulthood as discussed above. The first measure indicates educational status well across the whole social spectrum, and for both genders. The last measure is a better proxy for educational success for higher status families, but only for men. Thus among the rich surname lineages more than 25% of men born before 1850 who lived to age 21 attended Oxford or Cambridge, or attained some other higher educational qualification. But for the poor group they are not such a good measure. Less than 0.5% of men reaching age 21 in the average and poor surname lineages born before 1850, for example, attended Oxford or Cambridge.

The census reports 1841-1911 give occupations at all ages, including "scholar," "pupil" or "apprentice." Thus for each child we can potentially observe what their occupation was at some time from age 11-20, and whether they were acquiring education or training. In the period we are considering there was no compulsory schooling age until 1880. From 1880-93 the school leaving age was 10, 1893-1899 11, and 1899-1918 12. Only in 1891 did primary education become free for all students at state schools. 85% of our sample of children reached age 11 in the period where there were still school fees, and where education after age ten was voluntary. This was a period with costs for education, and where beyond age ten education was entirely at parental discretion.

For our sample families, 41% of children 11-20 are at school or in training. 33% are at work. However, for a remaining 26% of children the census record is blank. They are not at work, but they are not explicitly at school. For upper class families many of these children are clearly still in education: those of ages 15 or less, for example. For lower class families it is not clear whether these children were receiving education, as opposed to helping around the home of just being idle. So we estimate the effects of family size both for the probability a child is explicitly in employment, and for the probability that they are explicitly in education or training.

For the indictor variables Dwork, 1 if the child is at work, and Dsch, 1 if the child is in education or training, we estimate the effect of family size separately for sons and daughters of rich and poor family lineages. In the estimation we control for the census year, the age of the child, whether their father was dead (about 10% of children), the wealth of their father, the occupational status of their father, and for the rich families whether the father is educated. We used the two measures of family size discussed above: *N0* and *N21*. These two have a correlation of 0.88, so there is meaningful independent variation.

The basic regression we estimate for Dwork and Dsch is

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

where N is one of the three child measures, and Border is a child's birth order. X_{if} is a set of characteristics of fathers: 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 delaying entry to work and of education.

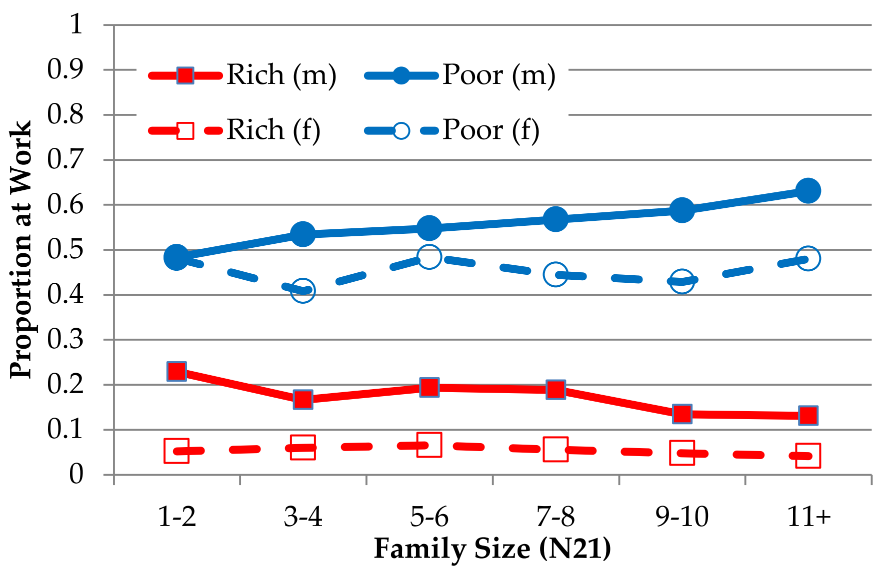
Table 9 reports the results of this estimation, using logit, for Dwork, looking at the sons in the poor surname lineages. Note first that there is a strong connection between economic and occupational status and the probability that a son is observed at work. The higher these

Table 9: Family Size and Probability at Work 11-20, Marriages pre 1880, Sons, Poorer Lineages

	(1)	(2)	(3)	(4)
N21	0.076**		0.116**	
	(0.024)		(0.041)	
N0		0.052**		0.104**
		(0.018)		(0.038)
Father Dead	0.690**	0.677**	0.872**	0.906**
	(0.193)	(0.193)	(0.294)	(0.291)
Ln(Wealth) of Father			-0.178**	-0.183**
			(0.057)	(0.055)
Occupational Status,			-0.525**	-0.505**
			(0.127)	(0.124)
Birth Order			-0.069*	-0.083*
			(0.032)	(0.037)
Pseudo R^2	0.01	0.01	0.39	0.40
N	1,298	1,302	1,142	1,145

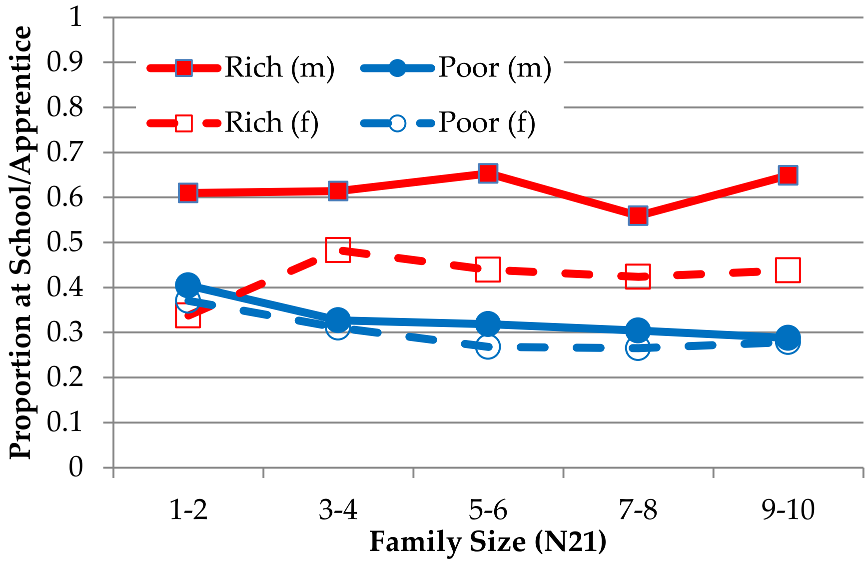
Logit Regression, ses clustered on fathers

Figure 8: Percent at work, by gender and lineage wealth



Notes: Families grouped by sizes 1-2, 3-4, 5-6, 7-8, 10-11, 12+

Figure 9: Percent at school or apprenticeship, by gender and lineage wealth



Notes: Families grouped by sizes 1-2, 3-4, 5-6, 7-8, 9-10, 11+

are the lower the probability that a son enters the work force earlier. If a sons' father is dead that also increases the probability they will be observed at work, by about 16%. In all specifications there is a statistically significant association between family size and the probability a child is at work. However, while this effect is statistically significant, the quantitative effect is still modest. While the average probability of being at work 11-20 is 54%, being from a family of one more child surviving to age 21 increases that probability by 1.8%. Thus going from a family of 1 to one of 10 increases the probability of being at work by 18%.

However, while for the sons from poorer lineages there is the expected effect of family size on the probability of being at work, the equivalent estimate for daughters from poorer lineages, sons from richer lineages, and daughters from poorer lineages shows no effect of family size on work probability. Figure 8, for example, shows the percentage of sons and daughters at work by family size for the poor and rich lineages. Figure 9 shows the percentage explicitly in school or training. Again there is no effect for the rich lineage families. For the poor lineage sons the probability of being in education 11-20 is lower, as implied by the figure, for larger families. For girls from these lineages the effect of family size on schooling probability is also negative.

The fact that in table 9, and in the other estimations, including measures of family quality does not change significantly the estimated effects of size on work probabilities, supports the finding above that in this period quality is not correlated significantly with family size. It also suggests that it is highly unlikely that unmeasured aspects of quality, which would have to be anyway orthogonal to measured quality, would be significantly correlated with family size.

Because our measure of higher educational attainment (Oxford, Cambridge or London University attendance, Sandhurst attendance, medical qualification, engineering qualification, legal qualification, or clergy status) is only indicative of educational attainment for the upper end of the status distribution, for this measure table 10 reports just the effects of family size for families from the richer lineages.[14] The sons of these lineages for marriages pre 1880 had on average a 0.28 chance of attaining some such higher educational training. Both with and without the control variables, neither *N21* nor *N0* has any correlation with such attainment. Figure 10 portrays this absence of correlation with family size both for the broader measure of educational attainment, and for Oxbridge attendance specifically.

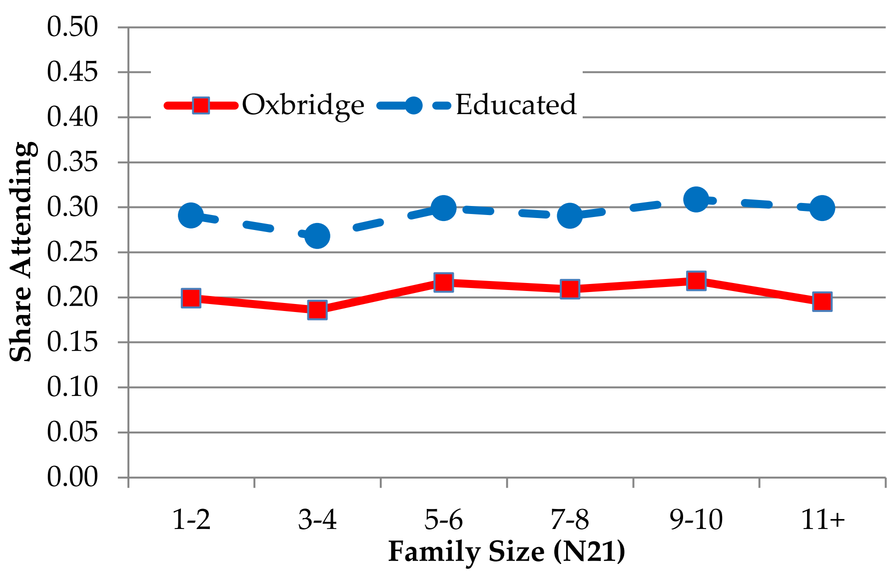
[14] If we estimate the regressions of table 9 on the whole set of families, the results are very similar.

Table 10: Family Size and Higher Education, Rich Lineages, sons, marriages 1780-1879

	(1)	(2)	(3)	(4)
N21	0.009	-0.008		
	(0.010)	(0.011)		
N0		0.113		0.113
		(0.066)		(0.066)
Educated Father			-0.004	-0.010
			(0.008)	(0.010)
Ln(Wealth) of Father		0.103**		0.103**
		(0.009)		(0.009)
Occupational Status, Father		0.221**		0.220**
		(0.029)		(0.029)
Birth Order		-0.026*		-0.024*
		(0.011)		(0.011)
Father dies when child<21		-0.064		-0.065
		(0.067)		(0.067)
Pseudo R^2	0.00	0.24	0.00	0.24
N	2,159	1,661	2,159	1,661

* p<0.05; ** p<0.01

Figure 10: Fraction of sons with higher education attainment, rich lineages, marriages 1780-1879



Family Size and Occupational Status

Occupational status of fathers and sons is measured from the censuses of 1841-1911, and the Population Register of 1939, and from probate records (from the age closest to 40). As noted above a status score is assigned to each occupation based on the logarithm of average wealth at death by occupation in 1858. This score has a mean for sons of marriages 1780-1879 of 6.03, and standard deviation of 1.33.

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

$$S_s = a + \sum b_i X_{if} + c_1 N + c_2 BORDER \quad (3)$$

where S_s is the occupational status of sons. Again we do the estimates separately for the rich and the poor cohorts. As a control we also include the age at which occupational status was measured, which enters strongly positively in the case of the rich lineages. Tables 11 and 12 show the estimated effects of N21 and N0 on occupational status for sons in the rich and poor lineages. What we find for both rich and poor lineages no significant or consistent negative effect of family size - measured as number of births or the number of surviving n children. Figure 11 shows the raw connection between family size and occupational status, for rich and poor lineages where family size is measured as N21 in bins of 1-2, 3-4, 5-6, 7-8, 9-10, and 11+. There is overwhelming evidence for both social groups that family size is having no effect on occupational outcomes of sons.

Table 11: Family Size and Occupation Status, Rich Lineages, sons, marriages 1780-1879

	(1)	(2)	(3)	(4)
N21	0.009	-0.008		
	(0.010)	(0.011)		
N0			-0.004	-0.010
			(0.008)	(0.010)
Higher Education, Father		0.113		0.113
		(0.066)		(0.066)
Ln(Wealth) of Father		0.103**		0.103**
		(0.009)		(0.009)
Occupational Status, Father		0.221**		0.220**
		(0.029)		(0.029)
Birth Order		-0.026*		-0.024*
		(0.011)		(0.011)
Father dies when child<21		-0.064		-0.065
		(0.067)		(0.067)
R^2	0.00	0.24	0.00	0.24
N	2,159	1,661	2,159	1,661

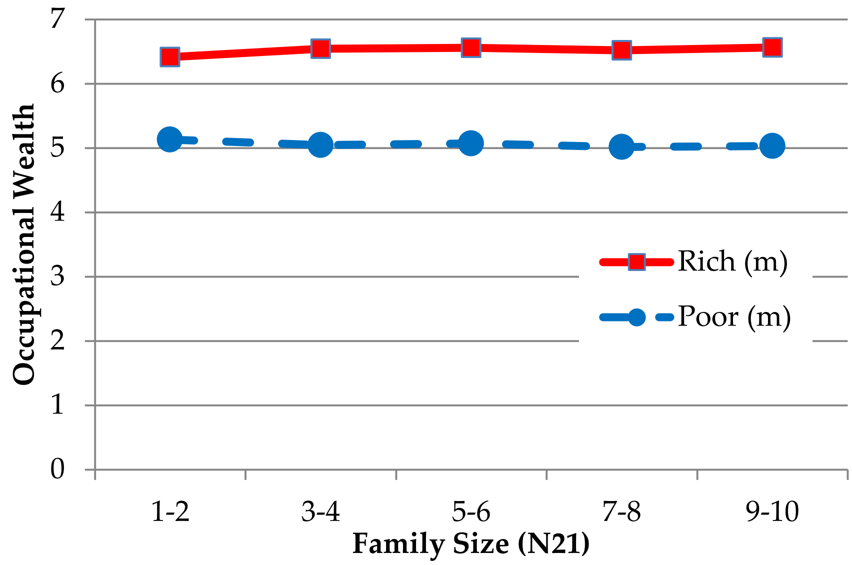
* $p<0.05$; ** $p<0.01$

Table 12: Family Size and Occupation Status, Poor Lineages, sons, marriages 1780-1879

	(1)	(2)	(3)	(4)
N21	-0.015	-0.003		
	(0.008)	(0.009)		
N0			-0.020**	-0.009
			(0.006)	(0.007)
Educated Father		0.015		0.013
		(0.257)		(0.256)
Ln(Wealth) of Father		0.085**		0.084**
		(0.015)		(0.015)
Occupational Status, Father		0.146**		0.145**
		(0.029)		(0.029)
Birth Order		-0.014*		-0.010
		(0.006)		(0.006)
Father dies when child<21		0.003		-0.006
		(0.047)		(0.047)
R^2	0.00	0.15	0.01	0.15
N	1,906	1,427	1,906	1,427

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

Figure 11: Son Occupational Status, rich and poor lineages, marriages 1780-1879



Family Size and Adult Longevity

As shown above adult longevity in this period is associated significantly with social status. If we look, for example, just at adult males, for those marrying before 1880, there is a significant association between occupational status and average life span, with those of the highest occupational status living on average 7 years longer than those of the lowest status. Men attaining some kind of higher education similarly live 2.3 years longer than those who do not.

This implies that the adult longevity of children can be used as a proxy for child quality. This proxy unlike the previous one, also applies for daughters as well as sons. Table 13 shows the results of 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 sample of 1,156,512 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. As table 13 shows 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. Surviving children (N21) does exhibit a raw and modest positive correlation with longevity – perhaps a result of health effects. Adding controls reduces the correlation to indistinguishable from zero at the standard levels. There is no association of births and longevity.

Estimating the effects of family size on child mortality rates is more complicated. Child mortality rates help determine both N0 and N21. 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 is potentially true for completed family size, N21. Better child survival rates potentially raise completed family size.

We can get round the endogeneity of family size (whether N0 or N21) and underlying family quality by moving to the next generation, the grandchildren. We saw above that there is no correlation in fertility between fathers marrying pre 1880, and their sons. But there is a significant correlation between fathers and sons in social status and in child and adult mortality. Thus any negative shock to child quality created by larger family size in the first generation should show up as an increase in child mortality at the grandchild generation. Table 14 shows for the two different measures of family size, births (N0) and N21, the effects on child survival rates for births 1877-1939. The average survival rate in the sample in this interval is 0.853, but for children descended from the poor surname lineages it was only 0.816 while from those descended from the rich lineages it was 0.886. Though the wealth and occupation of grandfathers predicts survival rates for their grandchildren, the numbers of children the grandfather had has no significant effect on grandchild survival rates once we control for family characteristics.

Table 13: Child Adult Lifespan and Family Size, Marriages 1780-1879

	(1)	(2)	(3)	(4)
N21	0.014**	0.012*		
	(0.004)	(0.005)		
N0			0.004	0.006
			(0.003)	(0.004)
Age of Parents at Death (Z)		0.193**		0.193**
		(0.026)		(0.026)
Birth Order		-0.014**		-0.011*
		(0.005)		(0.005)
Ln(Wealth) of Father		0.020**		0.021**
		(0.005)		(0.005)
Educated Father		0.013		0.013
		(0.032)		(0.032)
Occupational Status, Father		-0.001		0.001
		(0.012)		(0.012)
Female		0.267**		0.268**
		(0.024)		(0.024)
Father dies when child<21		-0.041		-0.046
		(0.036)		(0.036)
R^2	0.00	0.05	0.00	0.05
N	9,757	6,749	9,757	6,749

* p<0.05; ** p<0.01

Table 14: Family Size and Grandchild Survival Rates, Births 1880-1919

	(1)	(2)	(3)	(4)
N21, Grandfather	0.049**	0.022		
	(0.010)	(0.018)		
N0, Grandfather			0.001	0.007
			(0.008)	(0.014)
Female	-0.056	-0.046	-0.052	-0.044
	(0.055)	(0.075)	(0.055)	(0.075)
Educated Grandfather		-0.157		-0.159
		(0.141)		(0.140)
Ln(Wealth) of Grandfather		0.085**		0.087**
		(0.017)		(0.017)
Occupational Status, grandfather		0.089		0.094*
		(0.048)		(0.048)
Pseudo R^2	0.00	0.03	0.00	0.03
N	8,549	4,934	8,549	4,934

* p<0.05; ** p<0.01

Family Size and Child Wealth

We have estimates of wealth at death for all fathers 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 after 1858 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, 628). We thus 1858 and later took as the value of estate for those not probated as typically half the minimum requiring probate: £5 (1858-1900), £10 (1901-9), £15 (1910-9), £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.

In the years 1799-1857 there is more selective information on the value of personalty available for wills probated in the highest of the ecclesiastical probate courts, the Prerogative Courts of the Archbishop of Canterbury and of York. However, only about 5% of men were probated in these courts, 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.

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. Also since wealth at death has a very skewed distribution, we use the logarithm of normalized estimated wealth to produce a distribution closer to normal. We thus construct for each person i dying in year t a measure of normalized wealth at death which is

$$lnW_{it}^{*} = lnW_{it} - ln\bar{W}_{it}$$

where $ln\bar{W}_{it}$ is the estimated average wealth at death by decade.[15] For each decade lnW_{it}^{*} will thus have an average expected value for the population as a whole of close to 0

[15] This was estimated 1895 and later from aggregate probate values reported by Atkinson (2013). 1858-1894 this was estimated from a sample of probate values.

We can thus estimate the effect of family size on wealth through

$$lnW_c^* = b_0 + b_1 lnW_f^* + b_2 Dfalive + b_3 \ln(Age) + b_4 Dfem + b_5 Border + b_6 \ln(N21) \quad (4)$$

where:

lnW_c^*	=	ln normalized wealth each child of a given father
lnW_f^*	=	ln normalized wealth of the father
Dfalive	=	indicator for when the father is still alive at the time of the child's death
Ln(Age)	=	ln of age at death
Dfem	=	indicator of 1 for daughter
Border	=	birth order

Dfalive is a control for the effects of children who die before fathers, and thus likely receive smaller wealth transfers from fathers. Ln(Age) controls for the observed rise in wealth with age at death. With this formulation, b_6 is the elasticity of son's wealth as a function of the number of surviving children the father left. The coefficient b_1 shows the direct link between fathers' and sons' wealth, independent of the number of children.

Column (1) of table 15 shows the estimated coefficients from equation (4), for all children. The coefficient on Ln(N21), is negative and strongly statistically significant. Family size could have an influence on wealth for two reasons. First inherited wealth has to be divided across more recipients. But secondly the quality of children could decline with family size in terms of their ability to earn and accumulate wealth. We can check which of these forces is at work here by dividing the sample of fathers into two groups. First there are fathers from rich rare surname lineages where significant wealth passes between generations, and the issue is how much of this is dissipated by the receiving generation. But there are also poor rare surname lineages where wealth is absent or inconsequential. Here differences in child wealth the product of the earnings of children, and their saving behavior. In columns (2) and (4), we estimate the parameters of equation (4) separately for each of these groups. For the children of the wealthy lineages the effects of family size are very similar to those for children overall. However, when we look at children from the poorer lineages whose fathers were not probated we find that family size has no significant effect on wealth. Where inheritance of wealth matters, as in the rich lineages, the size effect is important. Where only human capital matters, size is not important. Thus the data is consistent with family size mattering in this case not because of effects on human capital, but because of the consequences for the amounts inherited.

Table 15: Child Wealth and Family Size, marriages 1780-1879

	All	Rich	Rich	Poor, no bequest
	(1)	(2)	(3)	(4)
Ln(N21), Father	-0.343**	-0.361**	0.011	-0.129
	(0.074)	(0.100)	(0.097)	(0.093)
Ln(Wealth) of Father	0.473**	0.372**	-	-
	(0.010)	(0.018)		
Bequest	-	-	0.372**	-
			(0.018)	
Ln(Age at Death), Child	1.575**	1.520**	1.520**	1.738**
	(0.130)	(0.166)	(0.166)	(0.215)
Female	-0.352**	-0.657**	-0.657**	0.055
	(0.068)	(0.087)	(0.087)	(0.091)
Birth Order	-0.024*	-0.039*	-0.039*	0.050**
	(0.012)	(0.017)	(0.017)	(0.013)
Father Alive	-0.700**	-1.086**	-1.086**	0.070
	(0.145)	(0.209)	(0.209)	(0.149)
R^2	0.41	0.22	0.22	0.13
N	7,397	4,821	4,821	2,143

* p<0.05; ** p<0.01

If we rewrite the relevant parts of equation (4) above as

$$lnW_c^* = b_0 + b_1 ln\left(\frac{W_f^*}{N21}\right) + b_6 \ln(N21) \qquad (4)$$

the $\frac{W_f^*}{N21}$ is an estimate of the amount of bequest a child received, so that then $b_1$is the estimate of the effect of bequest size on child wealth, while b_6 is the estimate of the residual effect of family size, through the human capital channel, on wealth retention or accumulation.

What we see from table 15, column 3 is that for rich lineages the residual effect of family size on wealth, net of inheritance, is close to 0. Thus family size for neither rich nor poor families has any effect on wealth accumulation, net of what is predicted by the expected bequest.

Table 16: Grandchild Wealth and Grandfather Family Size, marriages 1780-1879

	Grandfather -Son (all)	Grandfather -Son (rich)	Grandfather -Grandchild (all)	Grandfather -Grandchild (rich)
Ln(N21), Grandfather	0.649**	0.509**	0.382**	0.278**
	(0.020)	(0.048)	(0.013)	(0.026)
Ln(Wealth), Grandfather	-0.299	-0.365	-0.041	-0.061
	(0.159)	(0.200)	(0.097)	(0.121)
Ln(Age at Death), Grandfather	1.188**	0.866*		
	(0.293)	(0.426)		
Ln(Age at Death) of Son			1.955**	1.932**
			(0.129)	(0.167)
Female			-0.381**	-0.546**
			(0.088)	(0.108)
R^2	0.52	0.20	0.32	0.13
N	1,152	763	4,037	2,924

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

The multigenerational nature of our data allows us to address this issue further. In table 16 the third column shows estimates of the wealth of the grandchildren of men who first married before 1880, as a function of grandfather wealth, and family size, N21, in the grandfathers' generation, when family size was a random shock. The wealth of grandchildren is still strongly associated with the wealth of the grandfather. But the shock to wealth caused by the accident of family size becomes insignificantly different from zero, whether we look at the sample as a whole, or just the grandchildren from the rich surname lineages. 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.

Why is the Quality-Quantity Tradeoff so Weak?

For richer families the absence of any substantial quality-quantity tradeoff in human capital is not surprising. In nineteenth century England the children in such families were raised and educated at home with the aid of nursemaids and governesses. The annual salary of a governess at £35-50 was modest relative to the annual income of such families. For married men dying in the wealthier lineages before 1914, for example, assets at death averaged more than £55,000. When older, sons often went to private boarding schools such as Eton, Harrow, Rugby and Winchester. The annual fee for a private boarding school circa 1861 would be £120-£250 per year, and day schools would be considerably cheaper.[16] Tuition at Oxford in the 1840s was only £16-£25, though many students paid £40-£50 in addition for private tutoring, again modest relative to the resources of even middle class families.[17]

The absence of significant quality-quantity effects for the poor lineage families is more surprising. In larger families parents would have less time to interact with young children with more children to care for. More children also implied less ability of women to contribute through market work to family incomes, and less food consumption, space and clothing for other family members. The costs of formal schooling, even before the era of free provision of compulsory education after 1891, were mainly the foregone wages of children. In the mid nineteenth century the actual weekly costs of school attendance were typically 6d or 12d a week. By age 13 or 14 a son or daughter could expect to earn 36-72d a week at work, depending on the nature of the local industries.[18] Apprenticeships, typically entered into around age 14, would provide maintenance for children. But these usually required premiums, though in lieu of that payment the length of apprenticeship could be increased, and the earnings above maintenance in later years reduced. Why didn't these costs of schooling and training force families with larger numbers of children to set their children to unskilled labor at a young age, limiting their future occupational status and earnings?

We do see above in table 9 that the boys from such families were more likely to be observed at work aged 11-20 than in schooling or training the larger the family size. But in general quantity has weak detrimental effects on quality even for poorer families – measured as either education, occupation, longevity, or even wealth. We find, for example, families

[16] Turner, 2015, 249.
[17] Curthoys, 1997, 150-151.
[18] Humphries, 2010, 230-33, 316-7.

such as that of Alfred Albert and Eliza Wimbleton who produced 9 children between 1866 and 1888, where Alfred was a general laborer, and Eliza had no occupation. In 1881 when 6 of those children were at home with the parents, aged 15 to 1 the oldest four, respectively 15, 13, 11, and 10 were all still at school. Large families, even at the bottom of the earnings ladder, could afford to keep children in school. In contrast Charles William Wressell, son of an agricultural laborer, in 1861 was at work age 12 also as a laborer, despite his parents having only one other dependent. Thus in nineteenth century England the choice whether to educate children or not was driven by parental attitudes, and the abilities of children, rather than being dictated by any binding budget constraint.

One reason that there was no binding budget constraint on children's care, nutrition and education, even at family sizes larger than 10, was the typical spacing of surviving children at birth intervals of 2 or more years. The typical age of marriage was 25-27 in nineteenth century England. Before marriage older children would often contribute financially, and with child care, to their families. Thus the younger children in large families, those occurring at birth orders 7 and above, often got transfers of care and resources not just from their parents, but from siblings.

Implications

The results above are clear. In England 1780-1880 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 great 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, at their strongest, modest in terms of the human capital of the children. Sons in poorer lineages were more likely to be observed at work aged 11-20 if they came from a larger family. But this effect does not result in them having lower occupational status as adults, or lower lifespans, or less wealth at death. Otherwise the effects of family size on all human capital outcomes are marginal if any. Thus for the daughters of the poor, as well as all the children of the rich, family size has no effect on schooling 11-20. For all groups it had no affect on occupational status as an adult, on attaining higher education for sons, or on lifespan for anyone. Size was significantly associated with less wealth at death. But 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.

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 apparatus 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 there is no sign that larger pre-industrial families involved a sacrifice of child quality.

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