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

Gregory Clark, Department of Economics, University of California, Davis
(gclark@ucdavis.edu)
Neil Cummins, Department of Economic History, LSE
(N.J.Cummins@lse.ac.uk)

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A child quantity/quality tradeoff is central to economic theorizing about modern growth. Smaller families, it is argued, led to increased human capital and modern growth. Yet the 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 was no fertility control within marriage, huge natural variation in family sizes, and no association between completed family size and parent "quality." Yet family size has no effect on educational attainment, occupational status, or adult longevity. Larger family size does reduce child wealth: physical capital. But controlling for bequests received, children of larger families had more wealth at death than those of smaller ones. The quality-quantity tradeoff is a myth. The theory of growth 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 observation, 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, Lucas, 2002, Becker, Murphy, Tamura, 1990, Galor and Weil, 2000, Galor and Moav, 2002, Galor, 2011, Willis, 1973). But only when the 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, who 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 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.

In this paper we utilize a dataset containing the histories of a set of English families which had rare surnames 1770-2012. Using birth, death and marriage records, probate records, censuses, and other sources we reconstruct the histories of 56,000 individuals dying 1770 and later. In England for marriages commencing 1770-1800 there is no significant association between fertility and parent "quality". But more importantly most family size variation lies outside control of parents, so that the bias caused by correlations between family size and "quality" is minimized. We are thus able to get largely unbiased estimates of the correlation between size and education, longevity and wealth. The conclusion is that family size has no effect on education, longevity, or even on wealth, though in this case it is wealth relative to wealth inherited.

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.[1] 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 have to 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. As shown in figure 2, estimates $\hat{\beta}$ of β in the regression

$$q = \beta N + u, \tag{1}$$

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 first 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.

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[1] 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).

Parent influences on child quality – modern world

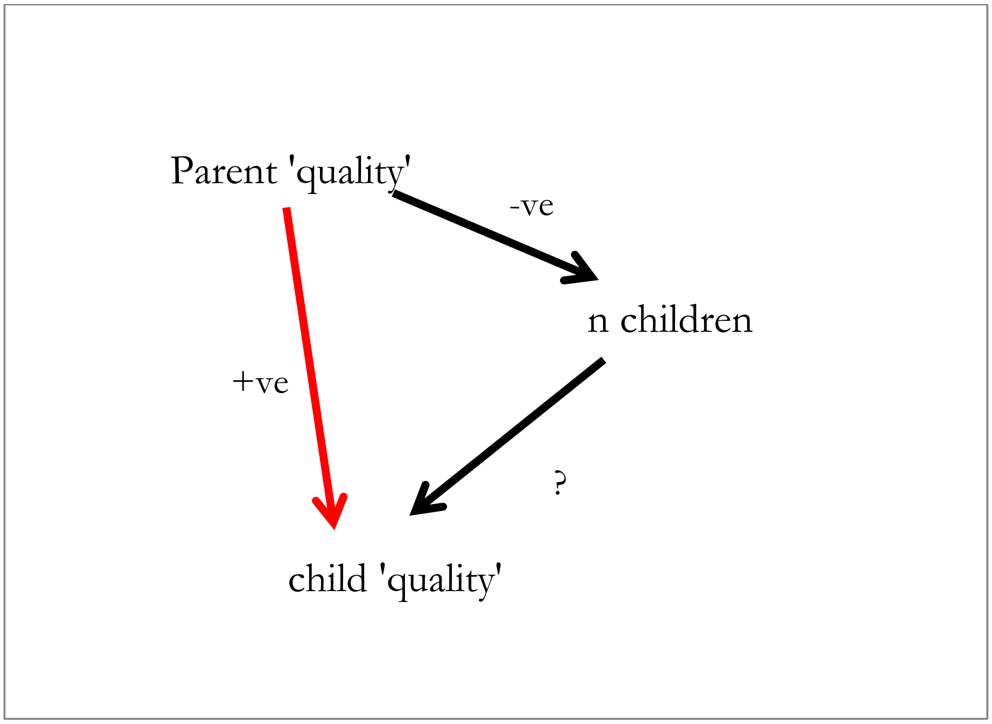
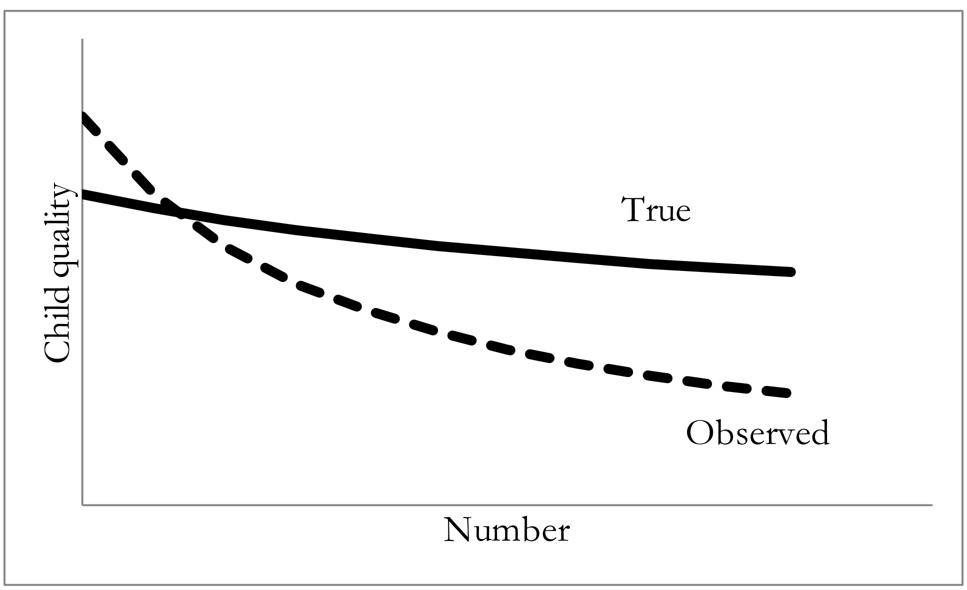


Figure 2: The True and Observed Quality-Quantity Tradeoff, Modern Economies



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, the quality-quantity relationship is unclear. The quality-quantity tradeoff so vital to most theoretical accounts of modern economic growth is, at best, unproven.

Measuring the Quality-Quantity Tradeoff in England, 1770-1879

We can measure the quality quantity tradeoff well for marriages in England 1770-1879 because there was no 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 only element in determining family size that parents chose was age at marriage of the parents. Here there is a very modest tendency for higher status men to marry slightly older women.[2] But that tendency explains less than 1% of the variance in the age of marriage of women.

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 the bias will be modest.

The Variation in Family Sizes. Figure 3 shows the distribution of children (21+) by family size for marriages in the rare surname sample 1770-1879.[3] 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 as can be seen 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 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.

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 4, for example, shows family size (21+) versus the ln 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 significantly different from 0.

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

[3] In this data, at least 13% of daughters are missing. Appendix 1 discusses the imperfections in the data, and how important these are.

Figure 3: Share of Children in each family size, 1770-1879, 1960-89

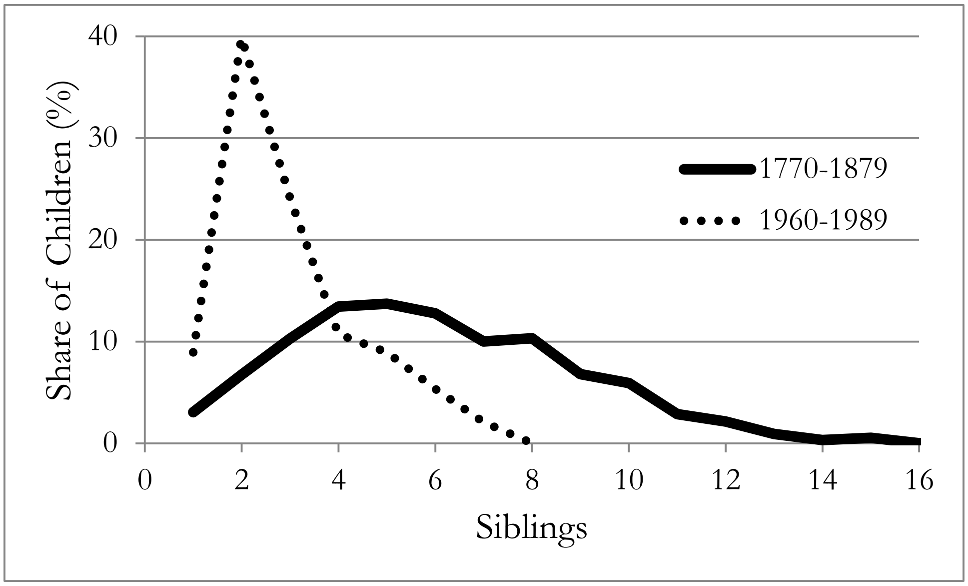


Figure 4: Family Size versus Father Wealth, England, marriages 1770-1879

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

If we measure family size as births, however, a significant negative association appears between family size and wealth. Here the coefficient on ln 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 have higher infant mortality rates, and this in turn induces higher levels of fertility. There is no evidence that the lower birth rate within higher status families is the product of any attempt to deliberately control fertility.

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 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, but 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 fathers, then brothers would share that characteristic to some degree (all other behaviors correlate across brothers), and their fertility would correlate. It does not. It cannot be the product of any systematic family characteristics.

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

Table 2: Brother Correlations, marriages before 1880

Characteristic	Correlation	Standard Error	Number of Pairs
Occupational Status	0.651**	0.029	207
Ln Wealth	0.570**	0.026	985
Oxbridge Matriculation	0.257**	0.029	1,139
Age at First Marriage	0.254**	0.031	992
Wife Age at First Marriage	0.131**	0.042	586
Child Mortality Rate	0.219**	0.037	771
Lifespan	0.114**	0.028	1,204
Ever married	0.071**	0.022	2,472
Children 21+	0.023	0.030	1,288
Births	0.022	0.030	1,288

The Quantity-Quality Tradeoff

We have four measures of child quality for children born from English men first married in the years before 1880.

- 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.[4] 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 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 3 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.

[4] 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 3: Survival Rates and Social Class, Births 1840-79

Group	Births 1860-79	Survival Rate 0-2	Survival Rate 3-21	e_{21}
Richest	1796	0.959	0.954	46.9
Rich	1726	0.938	0.935	45.5
Average	1090	0.886	0.922	43.4
Poor	2295	0.906	0.910	44.4

Given their educational status, longevity and wealth did parents with more children produce children who were of lower "quality" on the above four 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, per father 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 two measures of educational attainment: Oxbridge enrollment, and a more general measure of educational attainment. These 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. So in the estimations below we concentrate on the richer family lineages.

The basic regression we estimate for education attainment is

$$S_1 = b_0 + b_1 S_0 + b_2 N + b_3 BORDER \qquad (2)$$

where S is an indicator variable either for Oxbridge attendance, or for more general educational attainment, N is one of the three child measures, BORDER is son's birth order. S_0 is educational attainment of the father, S_1 attainment of the sons (and sons-in-law). The key parameter of interest here is b_2, but the value of b_3 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.

Table 4 reports the results of this estimation, using logit. 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 4 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 potentially be correlated with unmeasured aspects of family quality, there is no significant association between child numbers and educational outcomes.

Table 4: Family Size and Educational Attainment

Dependent	Pre1880 Doxb	Doxb	1880-1919 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)
N Child 21+	0.000 (0.022)		-0.037 (0.083)	
Child Years (0-14)		-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

$$OS_1 = b_0 + b_1 OS_0 + b_2 N \tag{3}$$

where OS_0 is educational attainment of the father, OS_1 attainment of the sons, and N is one of the three child quantity measures. The key parameter of interest here again is b_2. Table 5 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 5: 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.[5] 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 the results on this. Since average lifespan, and also the variance

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

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 7 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 6: Adult Longevity and Family Size

	Pre 1880	Pre 1880	1880-1919	1880-1919
Average Lifespan Parents	0.179**	0.182**	0.203**	0.204**
	(0.027)	(0.027)	(0.035)	(0.035)
N21	0.005		0.004	
	(0.006)		(0.010)	
N14		-0.000		0.002
		(0.005)		(0.009)
Ln(Wealth) of Father	0.016**	0.016**	-0.007	-0.007
	(0.004)	(0.004)	(0.009)	(0.008)
Educated Father	0.042	0.041	0.126	0.125
	(0.034)	(0.034)	(0.067)	(0.067)
Female	0.296**	0.296**	0.398**	0.398**
	(0.026)	(0.026)	(0.037)	(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 7: 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.[6] 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

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

[6] 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.

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

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 8 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 8 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 8: 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 9 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.

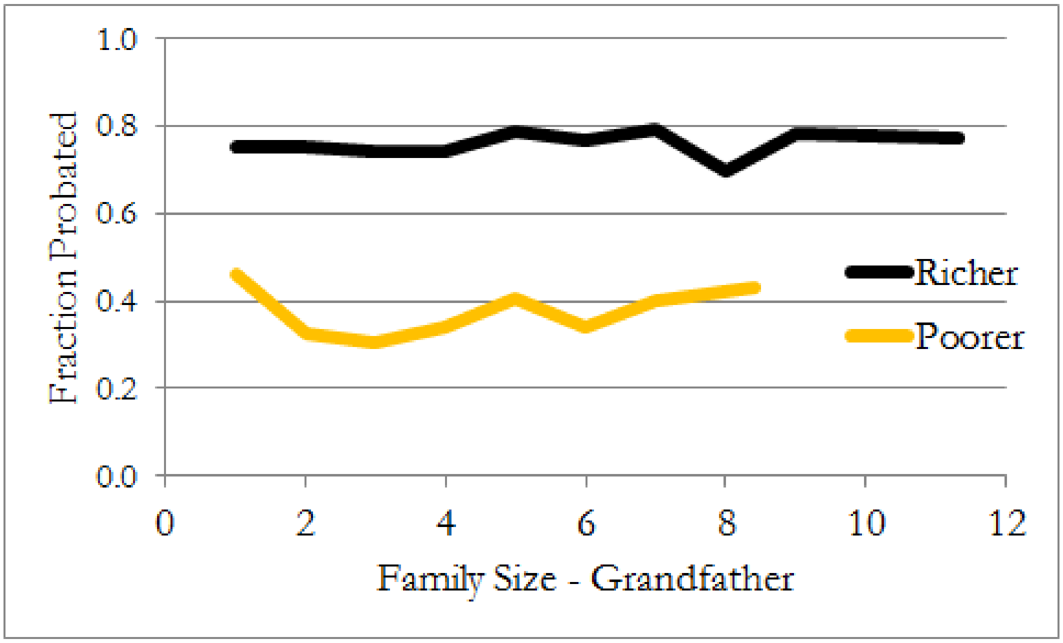
Table 9: Grandchild Wealth and Family Size

Dependent Variable	Ln Son Wealth	Ln Grandchild Wealth
Ln Wealth Grandfather	0.550**	0.325**
	(0.016)	(0.012)
lnN21	-0.236*	-0.042
	(0.112)	(0.083)
Dfalive	-0.852**	-0.128
	(0.272)	(0.225)
Years since bequest (son)	0.0092**	0.0170**
	(0.0035)	(0.0026)
Years since bequest (grandchild)	-	0.0247**
		(0.0018)
Dfem	-	-0.257**
		(0.073)
Observations	1,918	5,434
R-squared	0.450	0.297

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

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.

Figure 5: Probate Rates of Grandchildren as a Function of Grandfather Family Size, First Marriages before 1880



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. 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 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.

Implications

The results above are clear. In England before 1880 family size was from the perspective of the parents mainly 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: Missing Children

The data figure 3 is draw from suffers a disability, in that not all children reaching age 21 will be detected in our sample. The missing children will mainly be girls, since their name typically changes at marriage. Men in our sample will be identified as reaching age 21 from a variety of records: marriage, death, census, occupation listings. But for women who marry the only record that will show this is the marriage itself. Reflecting this there are more sons than daughters in our records. Thus for marriages pre-1880 we identify 5,558 sons aged 21 and above, but only 4,868 daughters. Assuming equal numbers of men and women reach age 21 we are missing at least 12% of girls (and 6% of children overall). We thus also estimate average family size for rich and poor using just sons, and assuming that the ration of sons to daughters at age 21 was 1:1. This is shown in figure 4. The rough equality in completed family sizes for rich and poor for marriages pre 1880 is still found.

The missing female children in our sample, however, will not bias the estimates of family size effects much. If only the girls are missing then the average family size is 6% larger than reported. However, many of the missing girls seem to be from daughter-only families, who then do not appear at all in our estimations. Table 1A shows the number of recorded families of each size, for marriages pre-1880. Also shown are the numbers of men and women in each reported family size. The share of women missing from smaller 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 large 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 1A: Missing Women by Family Size, pre-1880 marriages

Family Size	All	All Children	Male	Female	% missing females
1	330	330	221	109	51
2	359	718	403	315	22
3	359	1077	620	457	26
4-5	649	2,880	1,549	1,331	14
6-7	376	2,409	1,260	1,149	9
8+	322	3,012	1,505	1,507	0
All	2,395	10,426	5,558	4,868	12

References

Angrist, Joshua, Victor Lavy and Analia Schlosser. 2006. "Multiple experiments for the causal link between the quantity and quality of children." *Working Paper 06-26*, Massachusetts Institute of Technology.

Åslund, Olof and Hans Grönqvist. 2010. "Family size and child outcomes: Is there really no trade-off?" *Labour Economics*, *17(1)*: 130-39.

Becker, Gary S. 1988. "Family Economics and Macro Behavior." *American Economic Review, 78*: 1-13.

Becker, Gary S. 1960. "An Economic Analysis of Fertility." Pp. 135–87 in *Demographic and Economic Change in Developed Countries,* edited by G.S. Becker. Princeton, NJ: Princeton University Press.

Becker, Gary S. 1991. *A Treatise on the Family*. Cambridge, MA: Harvard University Press.

Becker, G.S. and H.G. Lewis. 1973. "On the Interaction Between the Quantity and Quality of Children." *Journal of Political Economy* 81(2):S279–S288.

Becker, G.S. and N. Tomes. 1976. "Child Endowments and the Quantity and Quality of Children." *Journal of Political Economy* 84(4):S143–S162.

Becker, Gary, Kevin Murphy, and Robert Tamura. 1990. "Human Capital, Fertility and Economic Growth." *Journal of Political Economy*, *98*: S12-37.

Black, Sandra., Paul J. Devereux and Kjell. G. Salvanes. 2005. "The More the Merrier? The Effect of Family Composition on Children's Education." *Quarterly Journal of Economics*, 120(2): 669-700.

Blake, Judith**.** 1981. "Family Size and the Quality of Children." *Demography*, 18(4): 421-442.

Clark, Gregory. 2007. *A Farewell to Alms: A Brief Economic History of the World.* Princeton: Princeton University Press

Clark, Gregory. 2005. "Human Capital, Fertility and the Industrial Revolution" *Journal of the European Economic Association, 3* (2-3): 505-515.

Clark, Gregory and Gillian Hamilton. 2006. "Survival of the Richest. The Malthusian Mechanism in Pre-Industrial England." ***Journal of Economic History, 66***(3) (September, 2006): 707-36.

Clark, Gregory. 2008. "In Defense of the Malthusian Interpretation of History," *European Review of Economic History, 12(2)* (August).

Clark, Gregory and Neil Cummins. 2009. "Urbanization, Mortality and Fertility in Malthusian England." (with Neil Cummins), *American Economic Review, 99(2)* (May 2009): ---.

Clark, Gregory and Neil Cummins. 2014a "Intergenerational Wealth Mobility in England, 1858-2012. Surnames and Social Mobility," *The Economic Journal* DOI: 10.1111/ecoj.12165

Clark, Gregory and Neil Cummins. 2014b. "Malthus to modernity: wealth, status, and fertility in England, 1500–1879," *Journal of Population Economics*: Jan-27 DOI: 10.1007/s00148-014-0509-9

Clement, Douglas. 2009. "Interview with Kevin Murphy." *The Region, Federal Reserve Bank of Minneapolis, 23(2)*: 14-23.

Desai, Sonalde**.** 1995. "When are Children from Large Families Disadvantaged? Evidence from Cross-National Analyses." *Population Studies , 49*(2):195-210.

Galor, Oded and Omer Moav. 2002. "Natural Selection and the Origin of Economic Growth." *Quarterly Journal of Economics*.

Galor, Oded and David N. Weil. 1996. "The Gender Gap, Fertility and Growth." *American Economic Review*, *86*: 374-387.

Galor, Oded and David N. Weil. 2000. "Population, Technology and Growth: From Malthusian Stagnation to the Demographic Transition and Beyond." *American Economic Review* 90: 806-828.

Galor, Oded. 2011. *Unified Growth Theory*. Princeton: Princeton University Press.

Goose, Nigel and Nesta Evans. 2000. "Wills as an Historical Source" in Tom Arkell, Nesta Evans and Nigel Goose (eds.), *When Death Do Us Part: Understanding and Interpreting the Probate Records of Early Modern England*. Oxford: Leopard's Head Press.

Gottfried, Robert S. 1982. *Bury St. Edmunds and the Urban Crisis, 1290-1539*. Princeton: Princeton University Press.

Grawe, Nathan D**.** 2009. Bequest receipt and family size effects. Economic Inquiry.

________ **.** 2008. "The Quality-Quantity Trade-Off in Fertility across Parent Earnings Levels: A Test for Credit Market Failure." *Review of Economics of the Household,* 6(1): 29-45.

________ **.** 2004. "Testing Alternative Models of the Quality-quantity Trade-off." Society of Labor Economists, San Antonio, TX.

Jensen, Robert**.** 2005. "Equal Treatment, unequal outcomes? Generating gender inequality through fertility behavior." *Working Paper,* J. F. Kennedy School of Government, Harvard University

Kaplan, Hillard S., Jane B. Lancaster, John A. Bock and Sara E. Johnson**.** 1995. "Does Observed Fertility Maximize Fitness Among New Mexican Men? A Test Of An Optimality Model and a New Theory of Parental Investment in the Embodied Capital of Offspring." *Human Nature* 6:325-360.

Lawson, David W. & Ruth Mace. 2009. "Optimizing modern family size: Trade-offs between fertility and the economic costs of reproduction." *Human Nature*

Lee, Jungmin. 2004. "Sibling Size and Investment in Children's Education: an Asian Instrument." *IZA Discussion Paper 1323*.

Li, Hongbin, Junsen Zhang, and Yi Zhu. 2008. "The Quantity-Quality Trade-off of Children in a Developing Country: Identification Using Chinese Twins." *Demography*, 45(1): 223-243.

Lucas, Robert E. 2002. "The Industrial Revolution: Past and Future." In Robert E. Lucas, *Lectures on Economic Growth*. Cambridge: Harvard University Press.

ONS (Office for National Statitics). 2010. Cohort Fertility, England and Wales, 2009 (Excel sheet 430Kb). [Digital Resource, accessed 05/09/2014]. Available at http://www.ons.gov.uk/ons/rel/fertility-analysis/cohort-fertility--england-and-wales/2009/cohort-fertility-2009.xls

Owens, A. Green, D.R., Bailey, C., and Kay, A.C. 2006. "A measure of worth: probate valuations, personal wealth and indebtedness in England, 1810-40" *Historical Research* 79 (205): 383–403.

Qian, Nancy. 2006. "Quantity-Quality: The Positive Effect of Family Size on School Enrollment in China." mimeo, Brown University.

Rosenzweig, Mark R. and Kenneth I Wolpin. 1980a. "Testing the Quantity-Quality Fertility Model: The Use of Twins as a Natural Experiment." *Econometrica*, 48(1): 227-240.

Rosenzweig, Mark R. and Kenneth. I. Wolpin. 1980b. "Life Cycle Labor Supply and Fertility: Causal Inferences from Household Models", *Journal of Political Economy*, 88(2): 328-348.

Rubenstein, W.D. 1977. "Wealth, Elites and the Class Structure of Modern Britain." *Past and Present.*

Schultz, T. Paul. 2007. "Population Policies, Fertility, Women's Human Capital, and Child Quality," Economic Growth Center Yale University, Discussion Paper No. 954.

Van Bavel, Jan. 2005. "The Effect Of Fertility Limitation On Intergenerational Social Mobility: The Quality–Quantity Trade-Off During The Demographic Transition." *Journal of Bio-Social Science*

Van Zanden, Jan Luiten. 2004. "The European Skill Premium in International Comparative Perspective, 1200-1950" Working Paper, University of Utrecht.

Willis, R. 1973. "A New Approach to the Economic Theory of Fertility Behavior." *Journal of Political Economy* 81(2):S14–S64.

Wrigley, E. A. and R. S. Schofield. 1981. *The population history of England, 1541-1871 : a reconstruction*. Cambridge: Cambridge University Press.

Wrigley, E. A., R.S. Davies, J.E. Oeppen, and Roger Schofield. 1997. *English Population History from Family Reconstitution, 1580-1837*. Cambridge: Cambridge University Press.