The Child Quality-Quantity Tradeoff, England, 1750-1879: Is a Fundamental Component of the Economic Theory of Growth 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)

April, 2015

A child quantity/quality tradeoff has been central to economic theorizing about modern growth. Yet the evidence for this tradeoff is surprisingly limited. Measuring the tradeoff in the modern era is difficult because family size is chosen endogenously, and family size is negatively associated with unmeasured aspects of family "quality." England 1770-1880 offers an opportunity to measure this tradeoff in the first modern economy. In this period there was little association between family sizes and family "quality", and if anything this association was positive. Also completed family size was largely randomly determined, varying in our sample from 1 to 18. We find no effect of family size on educational attainment, longevity, or child mortality. Child wealth at death declines with family size, but this effect disappears with grandchildren. The switch in England in the Industrial Revolution to faster growth rates thus seems to owe nothing to declining family size.

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 basic fact, and made it the center of 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). But only when the circumstances arose in which parents chose to have smaller family sizes was it possible to increase levels of human capital. Parents have a limited budget of time and money. The more children parents choose to raise, the less input each child receives, and the less effective they will be when grown as an economic agent. Economic growth did not come to the world until the last 250 years because before then the typical women gave birth to many children, and these children received little in the way of nurture or education to make them effective economic agents.

Yet this crucial underlying assumption - that the more children a given set of parents have, the less successful as economic agents the children will be - has never been empirically demonstrated. The problem with determining the quality-quantity tradeoff is that the number of children parents have in the modern world is largely determined by conscious fertility choices. These choices correlate with other unobservable features of parents which influence child quality.

In this paper we reconstruct the entire histories of a set of English families which had rare surnames 1799-2014. Using birth, death and marriage records, probate records, censuses, and other sources we reconstruct the histories of 23,000 individuals dying 1799 and later. In England for marriages commencing before 1880 the association between fertility and parent "quality" is either absent, or positive. But more importantly family size seems largely to be random, 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 generally based on negative correlations between family size and the measurable 'quality' of offspring (for instance educational attainment or health). Most studies of the uncontrolled link in modern populations show a negative correlation between child numbers, and educational and economic achievement. See, for example, Grawe (2004) and Lawson and Mace (2009) for Britain, Rosenzweig and Wolpin (1980b) and Kaplan et al. (1995) for the US, Rosenzweig and Wolpin (1980a) and 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). These studies have also recently highlighted varying trade-offs within groups at different socioeconomic levels. For example, Grawe (2009) for the US finds a stronger quality-quantity tradeoff for richer families, a similar result to Lawson and Mace (2009) for Britain.

Schultz comments, however, that the literature's "empirical regularity" of an inverse relationship between family size and measurable child quality is a "poor test of the quality-quantity tradeoff hypothesis" because the statistical correlations "are not based on exogenous variation in fertility that is independent of heterogeneous parent preferences or unobserved economic constraints" (Schultz, 2007, 19). In capturing the true quality-quantity trade-off, researchers have had to control for the inherent endogeneity between family size and child quality. In particular in the modern world if higher quality parents tend to choose fewer children (which has until recently been true in the aggregate data), then the raw quality-quantity tradeoff may have nothing to do with the numbers of children in a family.

We can portray parent influences on child "quality" as following two potential routes, as in figure 1. Since in the modern world high 'quality' parents also tend to 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 figure 2 shows the estimate of the tradeoff between quantity and quality will be too steep using just the observed relationship. Estimates $\hat{\beta}$ of β in the regression

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

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

Parent influences on child quality – modern world

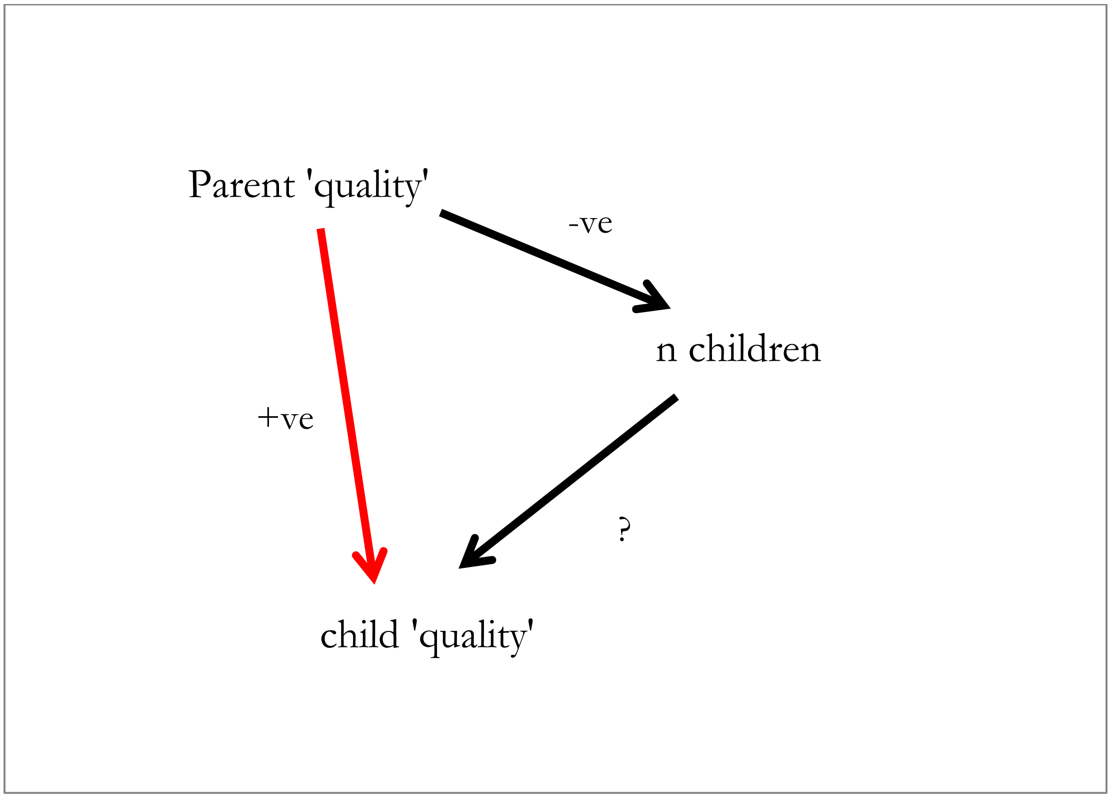
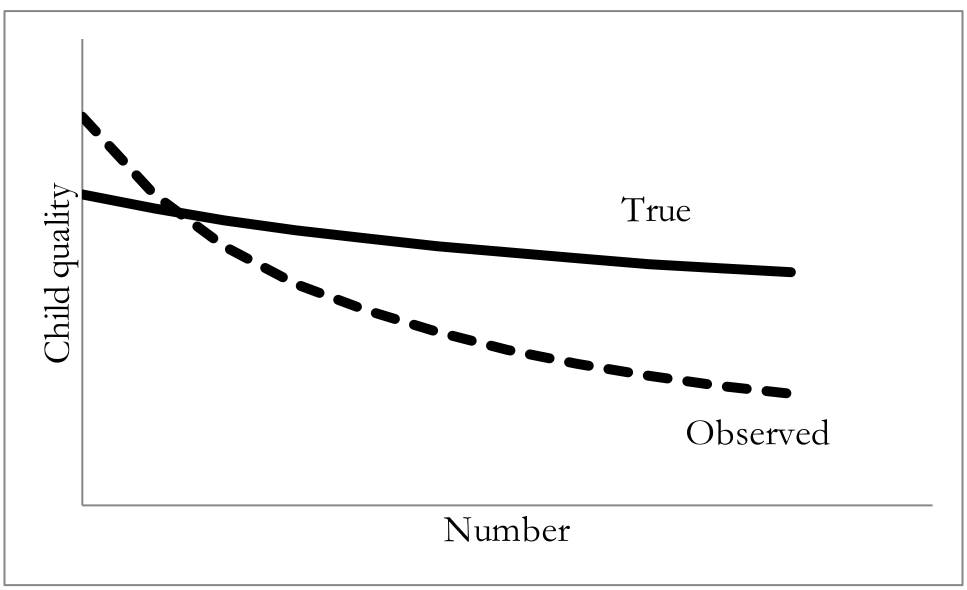


Figure 2: The True and Observed Quality-Quantity Tradeoff



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 of twins. What happens to the quality of these children compared to the quality of the children of such families compared to those of two child families?

Recent studies using the random incidence of twin births as an instrument for child quantity, find the uncontrolled relationship between quantity and quality decreases. Indeed it is often insignificant and sometimes positive (Schultz, 2007, 20). For instance; Angrist, et al. (2006) find "no evidence of a quality-quantity trade-off" for Israel using census data. Qian (2006) similarly rejects any simple quality-quantity tradeoff in China (using school enrolment as a measure of quality). 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 instruments and other controls to deal with the endogeneity of child quality and quantity are included, the quality-quantity relationship becomes unclear. The quality-quantity tradeoff so vital to most theoretical accounts of modern economic growth is, at best, unproven.

A second issue that we face is why fertility declined after the Industrial Revolution? One possibility is that with the changes in technology and social organization, education became much more important in determining income, but formal education was expensive so that the quality-quantity tradeoff in children became more adverse. This greater cost of more children led to the decline in fertility characteristic of the modern world.

Here we use two features of fertility in England for marriages 1750-1879 to attempt to uncover the true relationship between quantity and quality, and its change over time. The first is that the connection between observed family quality (wealth, social status, literacy) and completed family size was very different in preindustrial England than in the modern world.

Figure 3 shows, for example, the net fertility, defined here as numbers of children surviving to age 21 and above, for two groups of people with rare surnames, rich and poor, defined by their average wealth at death in 1858-1887, by decade of first marriage by men from 1820 to 1929. For marriages pre-1880 there is little difference in average net fertility for rich and poor. There is thus an interval in England where there is no correlation between "quality" and child quantity.[1] For marriages 1790-1879 parent quality and numbers of children are uncorrelated, so that $\hat{\beta}$ will be unbiased. But after 1880, when a generalized decline in net fertility appears, a clear difference emerges with substantially greater net fertility among poor families.

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 3,641 sons aged 21 and above, but only 3,144 daughters. Assuming equal numbers of men and women reach age 21 we are missing at least 13.7% of girls. 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.

---

[1] The era seems to have stretched from marriages 1790 to 1879. Before then, high status families produced more surviving children, so that $\hat{\beta}$ will be biased towards 0 in this era.

Figure 3: Net Fertility of Rich Versus Poor, marriages 1820-1929

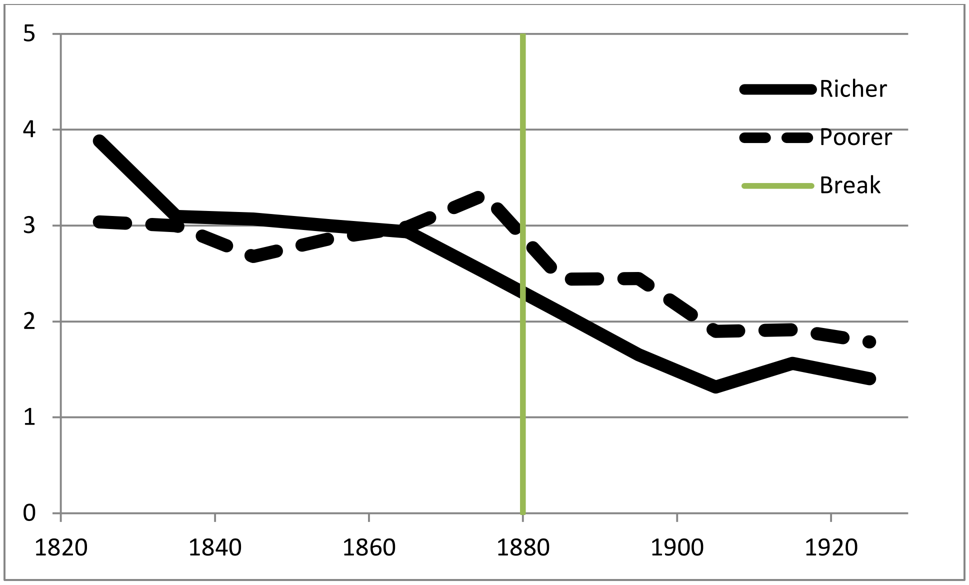
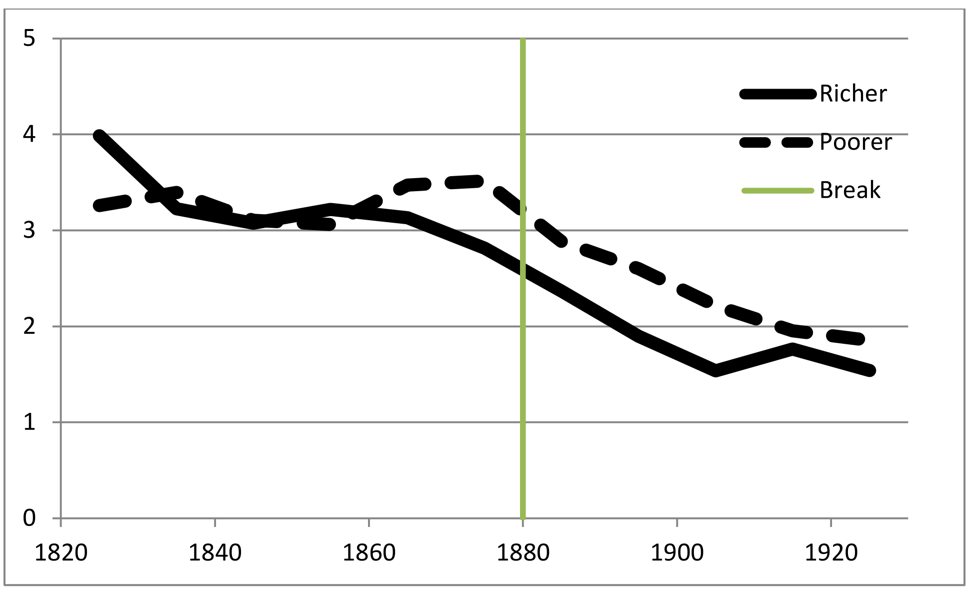


Figure 4: Net Fertility of Rich Versus Poor, based on sons only, marriages 1820-1929



The missing female children in our sample will not bias the estimates of family size effects much. If only the girls are missing then the average family size is 7% 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 1 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 small 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 below.

Table 1: Missing Women by Family Size, pre-1880 marriages

Family Size	All	All Children	Male	Female	% missing females
1	221	221	139	82	41
2	251	523	314	209	33
3	259	777	449	328	27
4-5	218	1,797	960	837	13
6-7	185	1,611	847	764	10
8+	153	1,871	947	924	2
All	2,082	6,785	3,641	3,144	13

The second advantage of the pre-industrial data from England for observing the quality quantity tradeoff is the much greater variation in family sizes before 1880 than in the modern world, and the evidence that this variance was largely the product of chance, like modern twin births. Figure 5 shows the distribution of the number of adult children per father (21+) for the sample of families used in this paper where the marriage was between 1790 and 1879. Numbers of surviving children ranged from 0 to 18. This number will include children from more than one wife, if a first wife died and the husband remarried. For comparison, for English women born in 1964, 70% have a family size in the 1-3 range (ONS 2010, Table 3). The standard deviation of family size (families 1+) in our sample is thus 2.7. By the time of marriages 1910-29 this standard deviation had fallen to 1.7.

In the years before 1880 extensive demographic research has failed to uncover any sign of conscious fertility control within marriage. The main element controlling gross fertility for married couples that was under control was thus just the age of the bride at marriage. On average brides of the wealthier rare surname lineages tended to get married slightly older, as shown in table 2. But these age differences of brides turn out to explain very little of fertility differences across men. Table 3 shows the results of a negative binomial estimation of gross and net fertility per man where the independent variables are the log wealth of the father, the educational status of the father, the number of wives (under age 40), the age of the father at first marriage, and the age of the first wife at first marriage. In general both gross and net fertility is largely unpredictable from these factors. The pseudo-R^2 of these regressions is less than 0.02. The only statistically significant variable is first wife's age at marriage. But even here a wife one year older reduces predicted fertility by only 1.3%.

When the coefficient β in the equation

$$q = \beta N + u$$

is estimated by OLS, the estimate of β will be

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

But in pre-industrial England the degree of bias this will impart will be small because N was largely a random variable, so the bias in estimating β will be correspondingly very slight.

Figure 5: The Distribution of Family Size in the Rare Surnames Sample, pre-1880

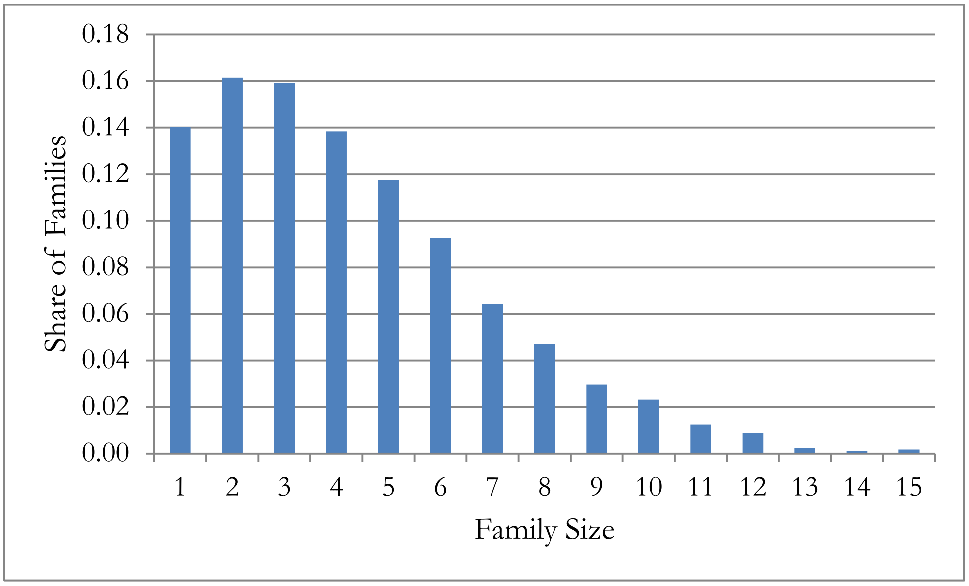


Figure 6: Share of Children in each family size, pre-1880

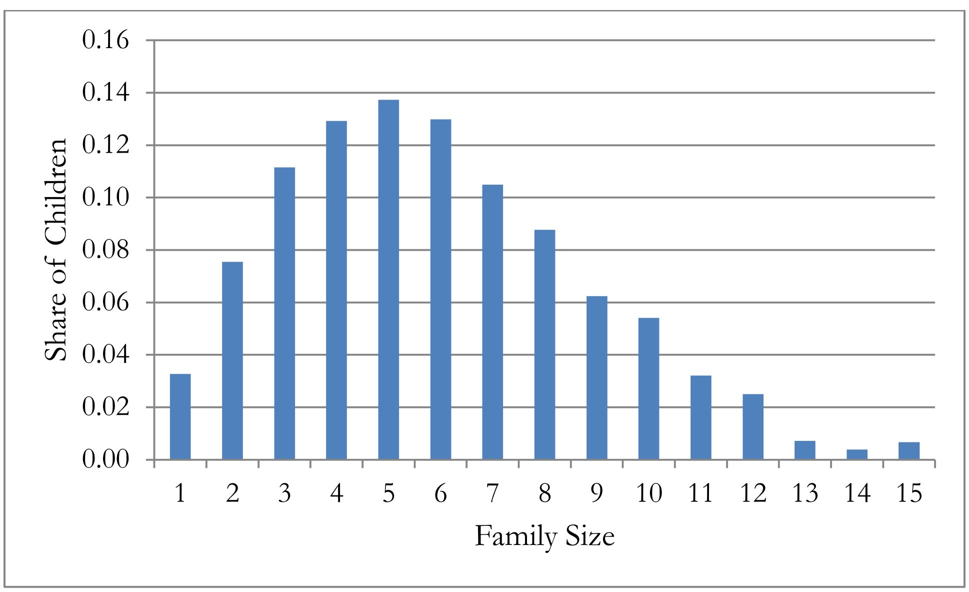


Table 2: Female Age at First Marriage versus Husband Wealth Group

Wealth group	Marriages 1790-1879	Standard Error	Marriages 1880-1929	Standard Error
Richest	25.3	0.19	26.7	0.19
Rich	25.1	0.21	26.5	0.19
Poor	23.7	0.23	24.6	0.16

Notes: Average of wives aged 44 and less at first marriage.

Table 3: Determinants of Children per father, marriage pre-1880

	(1)	(2)	(3)	(4)
	Gross	Lnalpha	Net	lnalpha
Ln Wealth Father	0.015		0.018	
	(0.013)		(0.013)	
Number of wives (under 40)	-0.018		-0.011	
	(0.133)		(0.139)	
Oxbridge Enrollment Father	0.003		0.011	
	(0.099)		(0.103)	
Father age at marriage	-0.010		-0.011	
	(0.008)		(0.009)	
Wife Age at First Marriage	-0.013**		-0.015**	
	(0.006)		(0.006)	
Constant	0.82	-53.59	0.76	-51.58
	(0.32)	(0.00)	(0.34)	(0.00)
Pseudo R2	0.0146		0.0165	
Observations	398	398	395	395

Standard errors in parentheses, ** $p<0.05$.

Decade of Marriage Dummies included.

Thus suppose $N = \theta u + e$. Then

$$\frac{cov(N,u)}{var(N)} = \frac{\theta var(u)}{\theta^2 var(u) + var(e)}$$

The greater is *var(e)*, the random component in *N*, then the less the bias in the estimate of β from any unobserved covariance of *N* and parent quality. We show above that for marriages formed before 1879 *var(e)* was enormous relative to $\theta^2 var(u)$. We can thus use the observed correlation between quality and quantity in this period as a measure of the true underlying causal connection between quantity and quality in Industrial Revolution England.

The Quantity-Quality Tradeoff

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

(1) 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.[2] 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.

(2) 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

[2] The data for Cambridge is comprehensive for the years 1900 and before, and thereafter has omissions. For Oxford the data is comprehensive 1886 and earlier, with more significant omissions later.

there was still a positive association. Table 4 shows child survival rates and adult life expectancy by rare surname groups. Survival rate 0-5 is the fraction of those born who live to age 5 or greater. Survival rate 5-21 is the fraction of those at age 5 who live to at least age 21. e_{21} is expected further years of life at age 21.

Table 4: Survival Rates and Social Class, Births 1860-79

Group	Births 1860-79	Survival Rate 0-5	Survival Rate 5-21	e_{21}
Richest	1,562	0.933	0.973	48.5
Rich	1,414	0.890	0.971	48.1
Average	975	0.783	0.945	44.9
Poor	2,094	0.746	0.925	45.9

(3) For all children we have whether they were probated or not, and estimated wealth at death for the probated and non-probated.

(4) For sons there are measures of occupational status from the censuses of 1841-1911, and from probate records 1800-1891.

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 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

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

where S is an indicator variable either for Oxbridge attendance, or for more general educational attainment, N is number of children reaching age 21, DOLDEST is an indicator for the son being the oldest surviving son. 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 5 reports the results of this estimation, using logit. Father's attending Oxbridge are strong indicators of any son's attendance. Also father's wealth in addition is a strong predictor of attendance. But the number of children in the family is not associated with any son's chance of attending Oxbridge. However, if we add an indicator for the oldest son (DELDEST), then this is also strongly associated with a higher chance of attending Oxbridge. Once such an indicator is added to the regression, however, the effect of size becomes positive and statistically significant. The larger the family size the greater the chance of each son attending Oxbridge. This is consistent with the idea that the number of children did not affect the chances of any son attending Oxbridge, but within sons the oldest was more likely to be chosen for this career path than later children.

Table 5: Family Size and Educational Attainment

VARIABLES	All Men	Sons Only	All Men	Sons Only
DOXB father	0.899***	0.996***	1.014***	1.105***
	(0.108)	(0.113)	(0.115)	(0.121)
Ln(Wealth father)	0.108***	0.121***	0.100***	0.110***
	(0.019)	(0.020)	(0.020)	(0.021)
N	**-0.005**	**-0.010**	**0.039****	**0.037***
	(0.018)	**(0.019)**	**(0.019)**	**(0.021)**
Deldest			1.163***	1.188***
			(0.103)	(0.107)
Age father at Birth			0.002	0.001
			(0.005)	(0.006)
Prop. Sons			0.431*	0.381
			(0.248)	(0.267)
Son Death Year			-0.009***	-0.009***
			(0.002)	(0.002)
Son-in-Law			-0.128	
			(0.181)	
Constant	-3.039	-3.080	14.261	12.866
Observations	5,017	4,255	4,451	3,847

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.[3] 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. Table 6 shows the results on this. Since there is a biological inheritance of longevity also we control for the age of death of the parents. There is always a modest, 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.[4]

However, when we add to the regression the number of children living to adulthood, there is never any quantitative association with longevity. An increase of family size from 1 to 10 children would lead in fact to an increase in longevity on these estimates of 0.2-0.3 years, though the effect has no statistical significance. Even at the 5% lower confidence interval an additional child would impose a cost in longevity of just -0.19 years across all children. The switch in average completed family size of upper class families from 4 to 2 or less children would thus increase their adult longevity advantage over poor families by less than 0.36 years, compared to the base level of 4.4 years.

In we consider child survival rates then there at first blush appears to be a quality-quantity tradeoff. Table 7 shows estimated average survival rates for children to age 21 as a function of family size (measured now by births). Survival rates are positively associated with wealth and education, but decline with the number of births per father. However, this association may be mechanical. Most child deaths occur in the first year of life. Such deaths will be associated with an increased chance of pregnancy by mothers in the subsequent period, because of the termination of

---

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

[4] Interestingly the separate effect of fathers' and mothers' longevity on child longevity is not significantly different

Table 6: Longevity and Family Size, First Marriages pre 1880

	(1)	(2)	(3)
Average parent longevity	0.178***	0.156***	
	(0.032)	(0.034)	
Father longevity			0.087***
			(0.027)
Mother longevity			0.072***
			(0.023)
N	**0.035**	**0.024**	**0.019**
	(0.113)	**(0.122)**	**(0.124)**
Ln(Wealth) father		-0.007	-0.006
		(0.096)	(0.096)
DEducated father		0.671	0.671
		(0.757)	(0.758)
Dfem	6.28***	6.22***	6.21***
	(0.617)	(0.649)	(0.650)
Age of father at birth		0.002	-0.001
		(0.055)	(0.055)
Age of mother at birth		-0.022	-0.019
		(0.069)	(0.069)
Constant	50.6	52.8	52.7
Observations	3,873	3,561	3,561
R-squared	0.036	0.033	0.034

Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$
Clustered SEs on father.

Table 7: Survival Rates 0-21 and 5-21 as a function of family size

Survivorship	Marriages Pre 1880	All	All Survivorship 5-21
Births per father	-0.005***	-0.008***	0.025***
	(0.002)	(0.001)	(0.005)
Ln(wealth father)	0.007***	0.005***	-0.008**
	(0.001)	(0.001)	(0.004)
DOXB father	0.014	0.014	-0.059
	(0.010)	(0.007)	(0.032)
Constant	-0.045	-0.014	-0.002
	(0.147)	(0.128)	(0.530)
Observations	992	2,164	1,786
R-squared	0.093	0.121	0.353

Notes: OLS estimate. Standard errors in parentheses, *** $p<0.01$, ** $p<0.05$. Decade of marriage dummy included. Weighted by number of births per father.

breast feeding. Thus a family with low child survival rates will, all else equal, have a higher number of births. We can get away from this mechanical association by looking at survival rates 5-21. These we saw in table 4 were also associated strongly with social class. Here the negative effect of family size (births) on survivorship disappears and is replaced by a strong positive effect. Children in larger families, measured by births, are more robust than those in smaller ones.

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.[5] 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

[5] 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.

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

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

Where:

N = number of surviving children

lnW_c = log wealth each children of a given father

DFALIVE = indicator for when the father is still alive at the time of the son's death

CONTROLS = indicators for period, age of father etc.

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.

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.

Table 8 shows the estimated coefficients from equation (4). For wealth the coefficient on numbers of children is negative and strongly statistically significant, whether we control using just father's wealth, or the average of parent's wealth. However, wealth is n 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?

Table 8: Child Wealth and Family Size

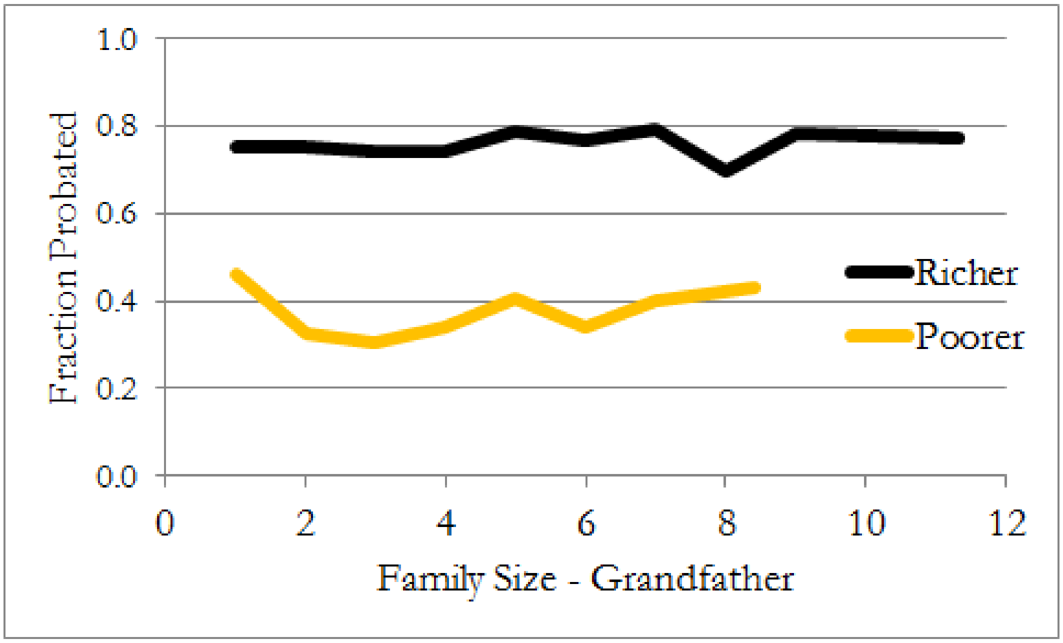
Ln Wealth Child	Fathers' Wealth	Grand Father
Ln Wealth Father	0.334***	
	(0.020)	
lnN	-0.404***	
	(0.107)	
Ln(Gfather wealth)		0.210***
		(0.027)
lnN(Gfather)		-0.052
		(0.142)
Observations	4,732	2,824
R-squared	0.120	0.046

Notes: Robust standard errors in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Clustered SEs on father.

The multigenerational nature of our data allows us to address this issue. The last column of table 8 estimates the effects of a grandfather's wealth and family size on grandchildren's wealth at death. If larger family size at the grandfather level reduces 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.

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

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



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.

Another way of seeing that the wealth evidence is consistent with human capital being unaffected by family size is to consider child wealth as a function of inherited wealth. We can estimate the inherited wealth of each person as the wealth of the father divided by the number of children. Table 9 shows the results of estimating wealth at death controlling for amounts inherited, the time since the inheritance and other child demographics. Inherited wealth is a significant predictor of child wealth. But if we additionally include in this regression family size as an indicator of likely

Table 9: Family Size and Wealth Accumulation

VARIABLES	$Ln(Wealth_c)$	$Ln(Wealth_c)$
Ln(Inherited Wealth)	0.341***	0.341***
	(0.018)	(0.018)
Years since	0.020***	0.020***
inheritance	(0.003)	(0.003)
lnN		**0.022**
		(0.096)
Observations	5,286	5,286
R-squared	0.173	0.173

child human capital we see that it has no effect on child wealth, once we control for inheritance. Relative to the amounts they inherit children in larger families do as well as those in smaller families in terms of wealth accumulation. So while family size does negatively influence child wealth, the channel for this seems to be entirely through smaller inheritances. Given what they inherit the children of larger families do as wealth in terms of wealth at death as those in smaller families. And as we saw above by the time we look at wealth at death of grandchildren, there is no effect of family size.

Implications

The results above are clear. In England before 1880 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. Children in general of larger families did not have lower longevity. They survived in the interval 5-21 as well as children in smaller families. 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 seems to be 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. Modern growth 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. But as is shown above, even though before 1880 observational data will give an unbiased estimate of the effects of child quantity on quality, the observational data shows no reduction in quality as completed family size increases. To explain modern growth we must turn to other mechanisms.

References

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

Atkinson, ----------

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.

———.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.

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 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.