The Origins of Modern Growth: Fertility and Human Capital in England, 1500-1914

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Abstract

Recent theories of the origins of modern growth stress an improvement in human capital through reduced fertility and more intensive investment in the nurturing and education of children. But it is hard to directly test the proposition that reducing family sizes improves the "quality" of children in the modern world. What tests have been done have produced few positive signs of an association. Using the information from the wills of a large collection of fathers and sons in England 1500-1914, and the unusual nature of the demographic regime in place for most of this period, we are able to measure directly the connection between numbers of surviving children and the economic fortunes of children. There is a tradeoff between quality and quantity, but only before the Industrial Revolution. After 1800 larger family sizes have little influence on the fortunes of sons. Fertility declines cannot explain the emergence of modern growth.

Introduction

Modern high income societies have a combination of low fertility levels and high levels of nurture and education for children. In economics terminology, 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.

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.

Schematically 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 $q = \beta n + u$, 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 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,

Figure 1: Parent influences on child quality

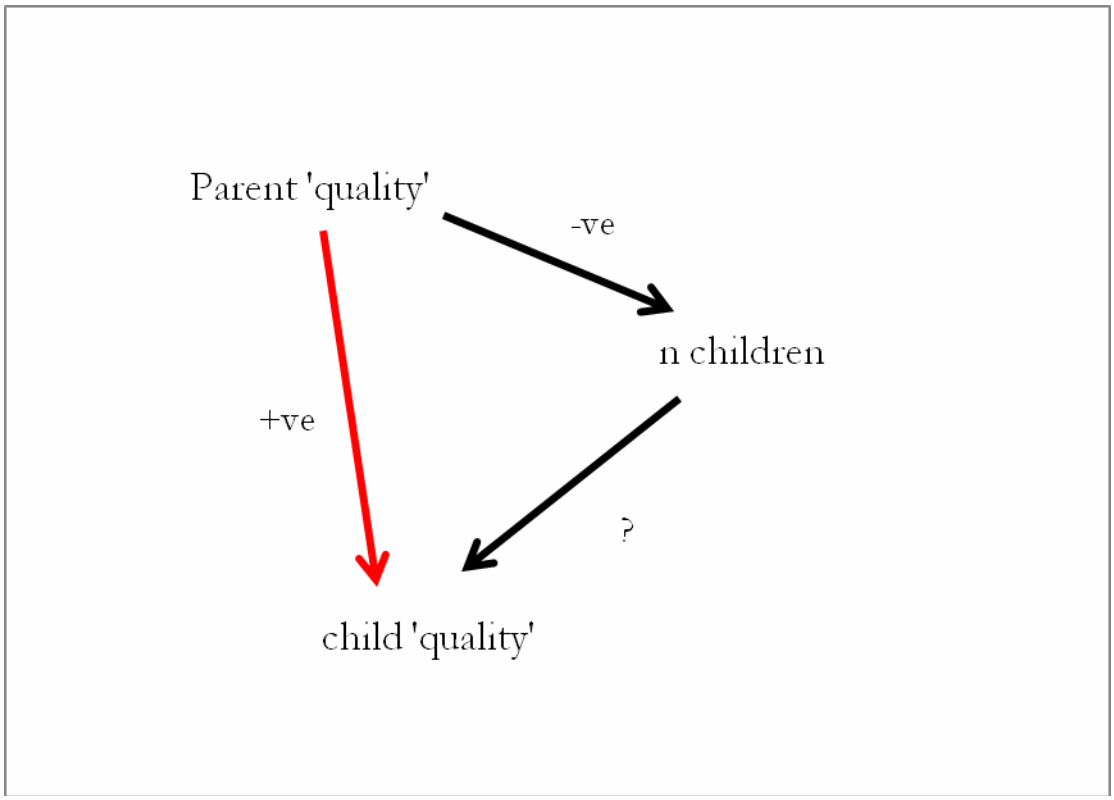
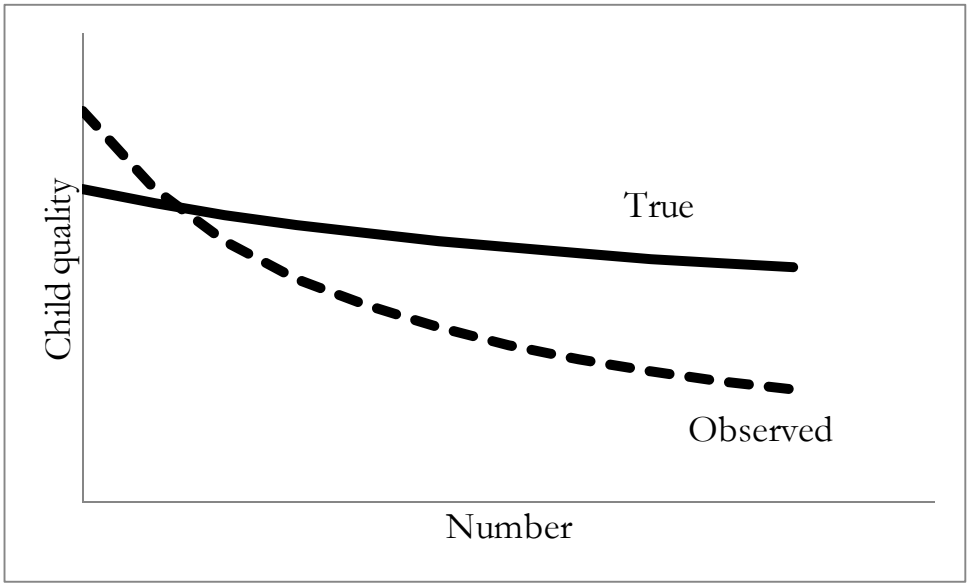


Figure 2: The True and Observed Quality-Quantity Tradeoff



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.

Demography in Pre-Industrial England

Here we use two features of the demography of England in the years 1500-1870 to attempt to uncover the true relationship between quantity and quality. The first is that the connection between observed family quality (wealth, social status, literacy) and both births and completed family size was very different in preindustrial England than in the modern world. For marriages before 1800 the correlation between child numbers and parent quality was positive, the opposite of the modern world, so that $\hat{\beta}$ will be biased towards 0. Figure 3 shows the numbers of surviving children male testators in England had as a function of their estimated asset incomes at death, for men born before 1770. There is a strong positive relationship all across the asset range. The figure also shows this relationship for men born 1770-1840. Now the relationship changes and becomes flat with asset incomes. For marriages 1800-1870 parent quality and numbers of children are uncorrelated, so that $\hat{\beta}$ will be unbiased. Figure 4 shows this effect. Any negative effects of quantity on quality found will be underestimated, as opposed to the bias in estimating β in modern studies. The positive connection between parent quality and numbers of children before 1800 continues all the way across the spectrum of wealth, though it flattens out as we get to very high levels of wealth, as figure 5 shows.

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 1870 than in the modern world, and the evidence that this variance was largely the product of chance, like the modern twin births. Figure 6 shows the distribution of the number of surviving children per father, at the time of the father's will, for fathers marrying 1500-1800, and 1800-1870. This number may include children from more than one wife, if a first wife died and the husband remarried.

Figure 3: Asset Class and Children at Death, men born 1500-1840

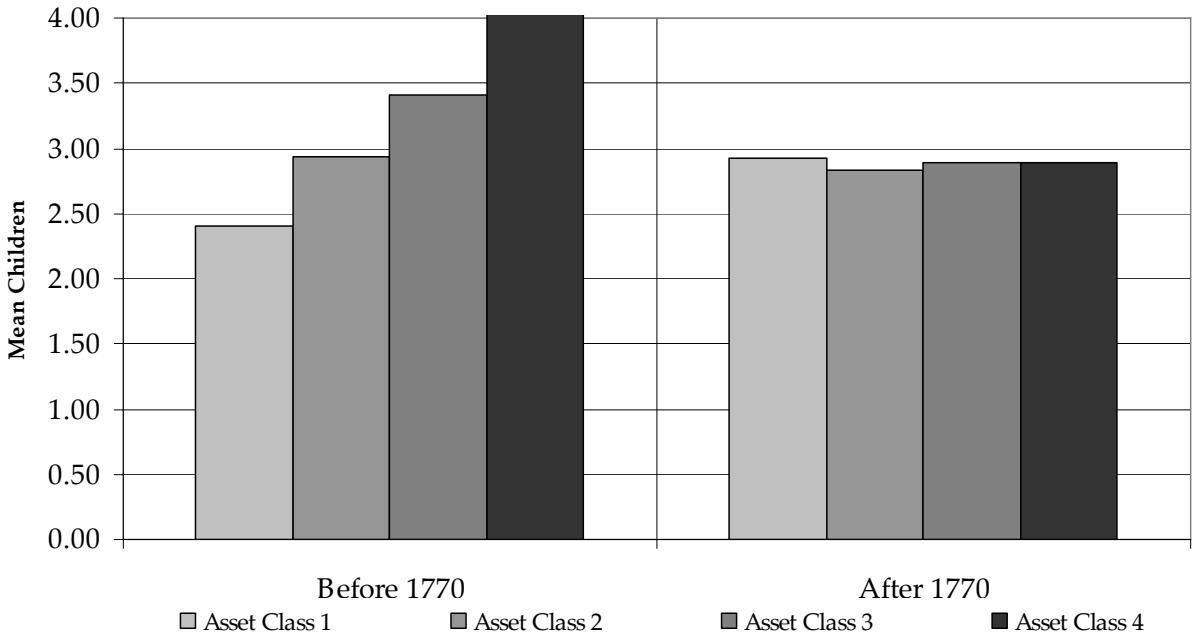


Figure 4: The True and Observed Quality-Quantity Tradeoff, pre 1800

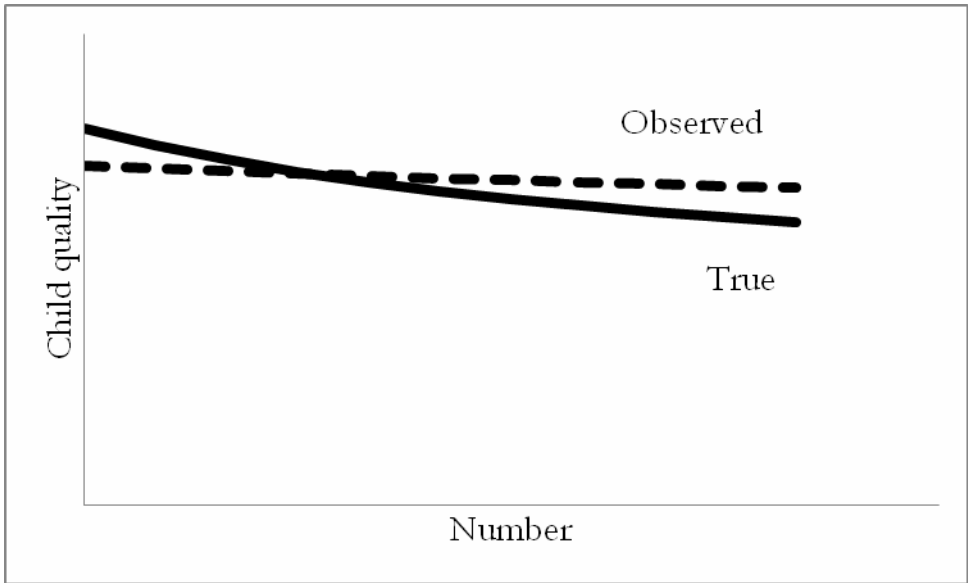


Figure 5: Asset Income and Net Fertility before 1800

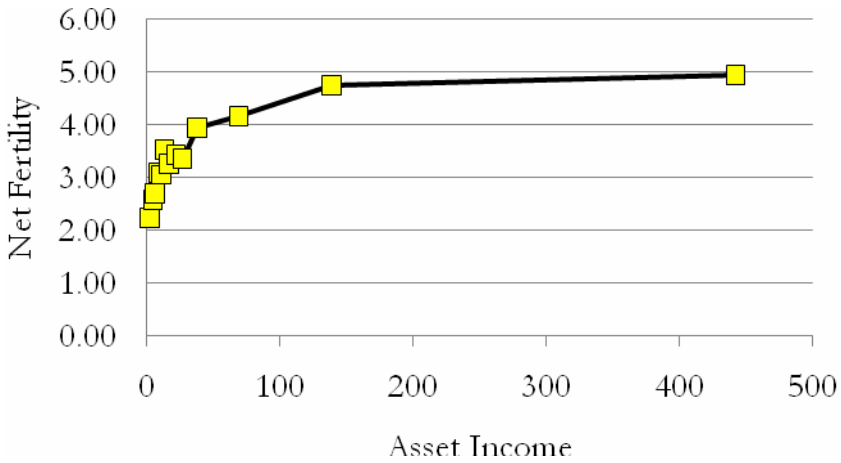
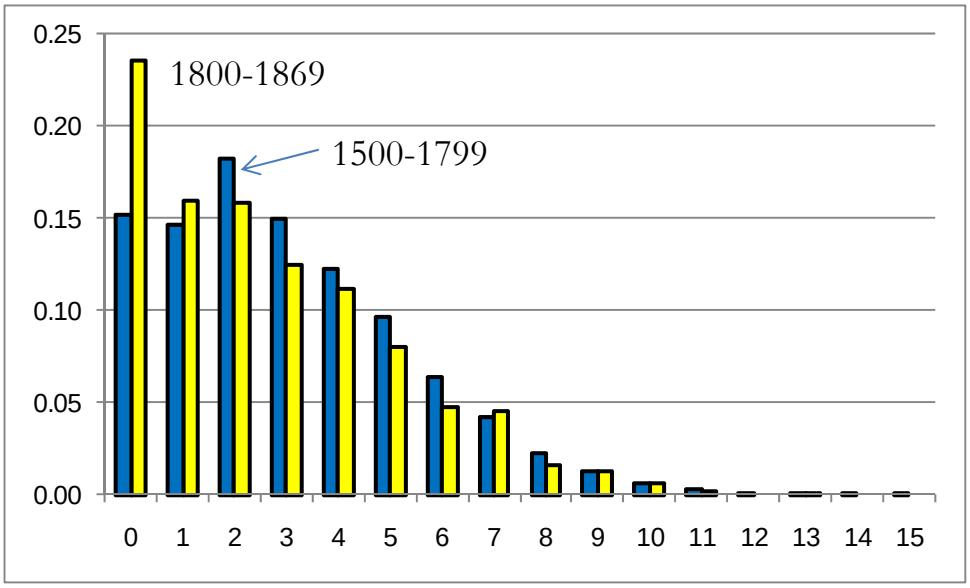


Figure 6: The distribution of net family sizes in pre-industrial England

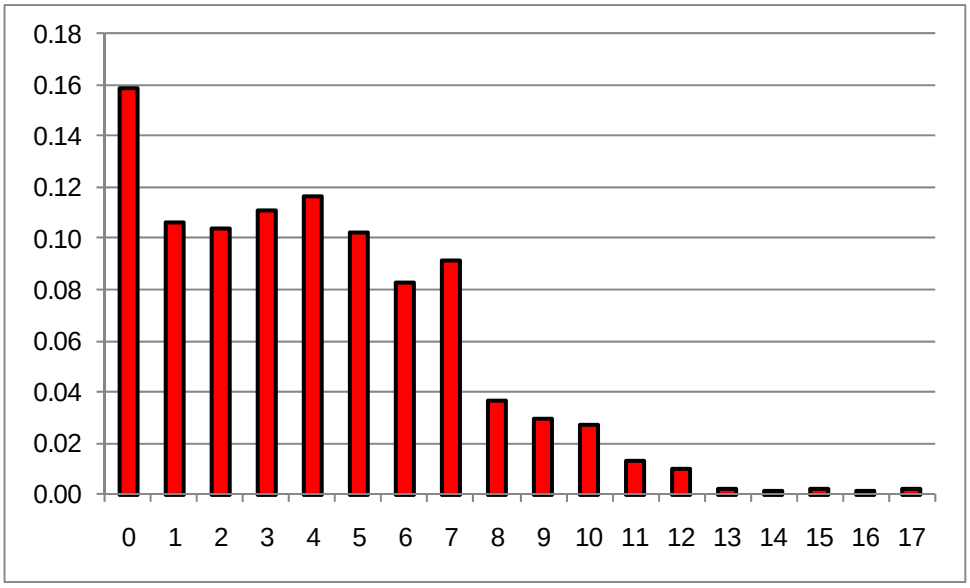


Note: Number of observations before 1800, 6,940, after 1800, 1,418.

We can measure family size in two ways. A second is the number of births per family, gross fertility. This is shown in figure 7, giving the distribution of births per mother for the wives of men marrying in England 1500-1799, where the husband had only one wife. Thus despite the average of 5 births per wife, in 10% of all marriages there was only one child born, in about 20% only two. The number of baptisms is the overwhelming explanator of the number of surviving children per man. The R^2 of the regression predicting numbers of surviving children from the number baptized is 0.73. On average 0.62 of each child born would be alive at the time of the will. If we include in this regression indicators for location, social status, wealth, and time period then the R^2 increases only marginally to 0.75. At the individual family level both gross fertility, births, and net fertility, the number of surviving children, were largely random variables. Only a tiny fraction of the variation in each is explained by correlates such as wealth, occupation, literacy and location.

In the years before 1890 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. But even this tended to be independent or even *negatively* correlated with measures of parent quality such as wealth, occupational status or literacy. Table 1 shows the connection between wife's age at marriage and wealth and husbands literacy for deaths before and after 1800. The wealth quartiles are arranged in ascending order. But even in the years before 1800 the positive correlation between fertility and parent quality induced by the conscious decision of earlier marriage for the wives of richer men would be very small.

Figure 7: The Distribution of number of baptisms per wife, 1500-1799



Note: Number of observations before 1800, 818.

Table 1: Wife's First Marriage Age and Wealth of Husband at Death

Wealth	Deaths before 1800	Average age	Deaths 1800-1914	Average Age
Quartile 1	31	24.6	43	24.5
Quartile 2	37	25.0	60	23.7
Quartile 3	42	23.6	102	23.1
Quartile 4	46	23.7	108	24.7
Illiterate	42	24.8	31	23.1
Literate	86	23.5	249	24.2

This is illustrated in the following regression results. Table 2 shows the coefficient estimates for a negative binomial regression of the numbers of surviving children at time of father's death as a function of location, wealth, and literacy with controls also for occupational status. Even though there is a strong positive association between wealth and numbers of surviving children before 1800, and strong effects of location, the Pseudo R^2 of the regression is always very small, 2 percent or less. For men dying 1820-1914 the ability to predict completed family size is even lower, with the Pseudo R^2 now only 0.6%. Table 2 also shows the same regression estimates for a smaller sample where we observe the numbers of births to the father (for those with one wife only in the course of their life). Here location no longer matters, but wealth is still positively associated with births before 1800. Again after 1820 wealth effects disappear. The Pseudo R^2 is again extremely low. Nor is occupational status significantly linked to status. The share of variance in child numbers thus explained by unmeasured variation in parent quality is thus likely to be extremely small, given that observable measures of parent quality explain so little directly.

When the coefficient β in the equation

$$q = \beta n + u$$

the OLS estimate of β will be

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

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.

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

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

Table 2: Predicting Gross and Net Fertility before the Demographic Transition

Variable	Net Fertility Deaths pre 1800	Net Fertility Deaths 1820-1914	Gross Fertility Deaths pre 1800	Gross Fertility Deaths 1820-1914
Located in London	-0.429**	0.039	0.000	0.090
	(0.051)	(0.086)	(0.099)	(0.148)
Located in any town	-0.157**	-0.171**	-0.063	-0.005
	(0.035)	(0.051)	(0.072)	(0.081)
Living on farm	0.226**	0.002	0.077	0.167
	(0.035)	(0.085)	(0.096)	(0.155)
Wealth class 2	0.141**	-0.065	0.109	-0.063
	(0.039)	(0.074)	(0.087)	(0.118)
Wealth class 3	0.238**	-0.001	0.178	-0.012
	(0.043)	(0.072)	(0.093)	(0.121)
Wealth class 4	0.400**	0.134	0.360**	0.149
	(0.046)	(0.069)	(0.099)	(0.121)
Literacy Unknown	-0.046	0.065	-0.163	-0.042
	(0.036)	(0.096)	(0.081)	(0.132)
Literate	-0.054	-0.027	-0.041	-0.147
	(0.036)	(0.088)	(0.070)	(0.115)
Controls	Occupation	Occupation	Occupation	Occupation
Pseudo R^2	0.022	0.006	0.018	0.019
N	3,622	1,946	500	371

Note: ** = significantly different from zero at 1% level, * = significant at 5% level. Standard errors in parentheses.

The greater is var(e), the random component in n, then the less the bias in the estimate of β. We show below that for marriages formed before 1870 var(e) was enormous relative to θ^2var(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 the years before and during the Industrial Revolution.

Data

The data used to examine this question are summaries of the wills of male testators from England in 1500-1914. These wills contain some or all of the following information: occupation of testator, marital status (married, widowed, single), place of residence, number of children of each gender,[1] birth order, literacy of testator (measured by whether the will was signed), money bequeathed, and to whom (spouse, children, etc.), number of houses bequeathed and to whom whether land was bequeathed (generally the amount is not specified), other goods bequeathed, and for the years after 1785 the total value of the bequest except for real estate. These sources are described in Clark and Hamilton (2006), Clark (2007), and Clark and Cummins (2009).

The wills before 1858 come mainly from local Ecclesiastical courts in Essex, Suffolk and Surrey (before 1858 church courts handled all matters of wills and testaments). Some also come from the Prerogative Court of Canterbury, which handled estates of higher value with assets distributed across a wider area. After 1858 the wills come from the records of the Principal Probate Registry in London which has preserved all probated wills in the south of England after 1858. For wills after 1841 we are also able to link many testators to individual census records giving the age of the

[1] If a child was dead at the time of the will, but had left grandchildren then this child was counted as a survivor.

testator at death. For the earlier wills we can get the age at death for a subset of the testators from parish records giving baptisms and marriages.

For those testators where we do not have a direct estimate of age at death we can infer this from the observed features of the testator such as their marital status, numbers of children reported in the will, numbers of grandchildren, whether one of their parents is alive, and whether they have a child aged 21 or above.

The assets of testators were estimated in two ways. For many wills probated in 1786 and later we get an estimate of the "personalty" – assets other than real estate – from estate tax declarations. We add these to estimates of real estate from houses and land mentioned in the will to get a total value of the bequest. In only about 20% of cases where land was bequeathed was the area of the land indicated. But we are able to approximate the area from other details of the will such as the testators occupation and cash bequests.

The major flaws with using probate valuations as true measures of wealth other than real estate are the omissions of settled property and debts and credits (Owens et al 2006, 384). Before 1898, the reported probate valuations are estimates of "the gross value of an individual's unsettled personal property", and were estimated for tax purposes (Owens, Green, Bailey and Kay 2006, 383). After 1898, settled property was included (Rubinstein 1977, 100). The executors or administrators of the wills submitted estimates, and because of a fine for undervaluation "the gross valuation was always likely to be an upper estimate of an individuals worth" (Owens et al. 2006, 386).

This "gross" estimate omitted any debts or credits due by or to the deceased individual. For the period after 1881, Rubenstein estimates that the difference between the gross and net value of an estate, was on average 5 to 15% (Owens et al 2006, 387). Before 1881, effects are reported as an approximation, under a certain set threshold level (e.g. under £50, under £100). As Owens et al.

noted, the effect of these tax bandings is to inflate the already rough estimates of wealth (Owens et al. 2006, 387).

For earlier years the estimated assets of testators were constructed from the information in wills by adding together the cash payments directed by the testator, with the estimated value of houses, land, animals, grain bequeathed by the testator. For a subset of 506 wills we have both estimates. In these overlapping cases the bequests estimated in the second fashion are 0.66 of the bequests estimated in the first way. For consistency the first set of estimates was thus multiplied by 0.66. All values were deflated to a common price level of the 1630s to get a unified measure of the real bequest over the entire period. In the course of the years 1500-1914 the real rate of return on assets in England declined significantly. The annual real purchasing power associated with a £1 of assets thus declined significantly over time as interest rates fell. We thus calculated an expected "bequest income stream" for each testator over time as a better way of quantifying the average value of the bequest. Table 3 summarizes by period the numbers of men for which we have information on assets at death and numbers of surviving children by half century birth cohorts. We have 6,714 wills coded so far, with about 200 per decade for men born between 1700 and 1850.

We also coded the occupations of the testators into 7 socio-economic status categories. These differ from the more modern socio-economic status classification because of the prevalence in status descriptions on wills even as late as the late nineteenth century of such terms as "yeoman," "husbandman" and "gentleman." But they do seem to capture socio-economic differences. Table 4 shows for men born before 1770 by socio-economic status average assets, the percent literate (as revealed by a signed will), and average age at death. Average assets and literacy were strongly correlated with the assigned socio-economic status. And there was also some correlation of the estimated age of death, with gentry testators on average dying 5 years later than laborers.

Table 3: Summary of the Wills Data

Period	N	Ave Assets (£)	Ave Asset Income (£)	Ave Age at Death
1450-99	200	246	17.0	53
1500-49	589	440	31.5	56
1550-99	1,967	357	25.9	54
1600-49	236	514	36.2	52
1650-99	307	537	33.5	61
1700-49	1,083	451	25.2	62
1750-99	1,139	970	48.7	64
1800-49	1,140	2,808	138.7	65
1850-79	53	2,065	106.7	-*

Note: *The 1850-79 cohort has a censored age distribution.

Table 4: Social Status, Assets and Literacy, pre 1770 births

Social group	N	Average assets (£)	% literate	Ave Age at Death
Gentry	229	2,030	90	59
Merchants/ professionals	189	922	96	55
Farmers	1,551	516	61	59
Traders	437	360	74	56
Craftsmen	791	239	64	57
Husbandmen	609	148	36	55
Laborers /Servants	207	104	23	54

Table 5 shows similar correlates of socio-economic status with assets and average age at death for men born after 1770. Again socio-economic status correlates strongly with average assets, and is also correlated with average age at death. Now the average for the gentry is 70, as opposed to 64 for laborers.

The numbers of surviving children for each testator were estimated from the wills in three ways. First there are wills where all the children were recorded. Here we counted dead children who had produced children of their own as "surviving" children also. Next there were earlier wills where girls tended to be omitted. In wills written before 1550 substantial numbers of daughters are omitted where there is a male heir. Thus the average family which reported one male heir after 1550 reported 1.55 daughters, but before 1550 only 0.89 daughters. We thus have to infer the number of daughters for wills before this date. We do so by multiplying each reported daughter in a will by 1.49, to get an estimated total number of daughters. Finally there are wills where besides the children specified there were also indications of an unspecified number of additional. Where we could determine in a will that the number of children was "$\geq$ n" we estimated the expected number of children from the average of wills in this category (see the appendix).

Estimating net fertility from wills will always tend to produce a lower bound estimate, since the errors will typically be the omission of some children from the will. But the wills will show relative net fertility levels by asset wealth, by socio-economic status, and over time. For birth cohorts earlier than the 1770s, and thus typically for marriages formed before the 1800s, there is a strong positive association in all periods between wealth at death and net fertility. But with surprising rapidity this association disappears for the generations of men born in the 1770s and later. That disappearance involves both a substantial decline in the net fertility of the richer testators after 1770, but also a modest but quite significant increase in the fertility of the poorest testators.

Table 5: Social Status, Assets and Average Age, post 1770 births

Social group	N	Average assets (£)	Ave Age at Death
Gentry/Independent	176	5,612	70
Merchants/ professionals	317	3,855	67
Farmers	355	1,692	65
Traders	446	1,816	64
Craftsmen	341	842	63
Husbandmen	99	438	65
Laborers/Servants	61	259	64

To demonstrate this we divide testators into rough quartiles, based on the implied income stream from the assets of the sample of testators as a whole. Thus in each period the poorest group are those with an implied asset income below £6 per year (in 1630s prices), the richest are those with implied asset incomes above £31. We then estimate for ever married men the coefficients of the regression

$$N = a + \sum b_j DINCQ_j + \sum c_j D1770 \cdot DINCQ_j + h_1 DLON + h_2 DTOWN + h_3 DFARM + e$$

where N is the number of surviving children, $DINCQ_j$ an indictor for each of the four asset groups, D1770 an indicator for a testator born after 1770, and DLON, DTOWN and FDARM indicators for testators living in London, some other town, or on a farm (with these effects being estimated separately for cohorts born before 1760, 1760-1809, and 1810 or later). Table 6 shows by twenty year periods around 1770 the net fertilities of the richest and poorest testators. The drop in net

Table 6: Net Fertility by Birth Cohorts

Birth Cohort	Obs	N poor	N Rich
1690-1709	179	2.54	3.78
1710-29	315	2.32	3.79
1730-49	499	2.41	4.20
1750-69	350	2.37	4.29
1770-89	384	**3.17**	**3.06**
1790-1809	459	**2.39**	**2.37**
1810-29	508	**3.05**	**2.97**
1830-49	302	**2.68**	**3.06**
1850-69	46	**2.90**	**2.88**

fertility for the rich is immediate after the 1770 birth cohort. The rise in fertility by the poorest group is potentially a little more protracted. While measured net fertility rose for the 1770-89 cohort, it was not any higher for the 1790-1809 cohort, so that the true date of transition could be anywhere between the 1770 and 1810 cohort.

The change is indeed even slightly more abrupt statistically if instead we organize testators by the estimated date of their first marriage. In this case it is marriages formed in 1800 or later which first show the absence of a wealth gradient to net fertility. Table 7 shows the transition measured in terms of first marriage cohorts.

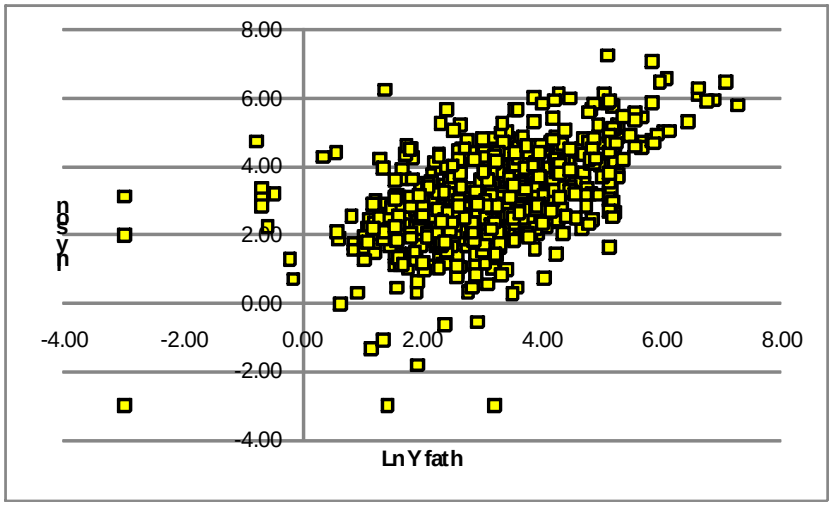
Table 7: Net Fertility by First Marriage Cohorts

Marriage Cohort	Obs	N poor	N Rich
1720-39	176	2.52	3.89
1740-59	345	2.27	3.74
1760-79	502	2.37	4.42
1780-99	330	2.50	4.15
1800-19	397	**2.98**	**2.97**
1820-39	458	**2.67**	**2.41**
1840-59	528	**2.90**	**2.88**
1860-79	255	**2.83**	**3.17**

To look at the costs of higher fertility we have matched fathers and sons in the will database. For father's wills in the years 1504-1898, we have already 718 pairs of fathers and sons with evidence on the wealth of each in the pair. Figure 8 shows the basic data for the existing sample, where wealth is measured as the logarithm of the values, revealing the link between sons' wealth at death and that of their fathers. To control for changes in interest rates over time, the wealth measure is the estimated annual income from assets per year. Measuring wealth in logs creates a problem for a few observations at the bottom of the wealth distribution where the estimated wealth is 0 or negative. For all cases where the estimated annual income from assets was less than £0.1 (implying a wealth of about £2) the wealth income was taken as £0.1 (which has a log value of -3). There were only 3 observations of both fathers and sons estimated incomes that had to be so adjusted.

The father can be conceived of influencing the wealth of the son through two channels. The first is through mechanisms such as genes, culture, and social position that are independent of the number of children. The expected wealth of the child through this channel will be some function of

Figure 8: Wealth at death of fathers and sons



the wealth of the father, Y_f. The second mechanism is through the transfer of wealth and resources such as training time and formal education from father to son. The influence here will depend on the numbers of children sharing the resources of the father. The wealth of children will be a function of Y_f/N, where N is the number of children. The relative magnitude of effects through this channel compared with the unlimited transfer will dictate how strong the quality-quantity tradeoff is.

The basic estimating equation will be a variant of

$$ln(Y_s) = b_0 + b_1 D1780 + b_2 ln(Y_f) + b_3 ln\left(\frac{Y_f}{N}\right) + b_4 DFALIVE + b_5 DOLDEST$$

Where:

D1780 = father's will 1780 or later

N = number of surviving children

DFALIVE = father alive at the time of son's will

DOLDEST = indicator if son oldest child

D1780 is included since the wealth of testators in general increased substantially after 1780 (with more data more elaborate controls will be included for time trends in average wealth). DFALIVE is another control for the effects of sons not having yet inherited anything from their father's. Such sons will also tend to be younger. DOLDEST is an indicator to control for any tendencies towards primogenitor in inheritance practices.

With this formulation, the estimated coefficient $-b_3$ is the elasticity of son's asset income as a function of the number of surviving children the father left. N varies in the sub-sample of fathers and sons from 1 to 13. The coefficient b_2 shows the direct link between fathers' and sons' wealth, independent of the size of the fathers' family. The sum of the coefficients, $b_2 + b_3$, is the total elasticity of sons' wealth with respect to fathers.

Column 2 of table 8 shows this basic estimation for all the data. The control variables enter as expected. In later years sons expected wealth is higher. Sons dying before fathers are poorer. The estimation also suggests that globally there was a quantity/quality tradeoff. Sons from larger families bequeath less wealth. The effect is both quantitatively and statistically significant. The effect, however, is not particularly strong. A son from a family with 5 surviving children as opposed to 4 will have a wealth at death that is on average 4 percent less. Going from 2 to 3 children would reduce sons' wealth by 7 percent.

The traditional view has been that not all sons would be treated equally. We are able to roughly estimate the birth order from many wills. The third column of table 8 thus shows the same estimation but with a dummy variable included for the case where the son appears to be the oldest

Table 8: All Data (718 observations)

Variable	Basic	Oldest	W_f/N post 1780
Intercept	1.553	1.442	1.337
D1780	0.206* (.088)	0.205* (.088)	0.491** (.140)
$Ln(Y_f)$	0.370** (.080)	0.401** (.083)	0.393* (.082)
$Ln(Y_f/N)$	0.169* (.078)	0.139 (.081)	0.217* (.086)
Dfalive	-0.300 (.233)	-0.300 (.233)	-0.281 (.232)
Doldest	-	0.122 (.087)	0.119 (.087)
$Ln(Y_f/N)$ – post 1780	-	-	-0.167** (.064)

Note: ** = significantly different from zero at 1% level, * = significant at 5% level. Standard errors in parentheses.

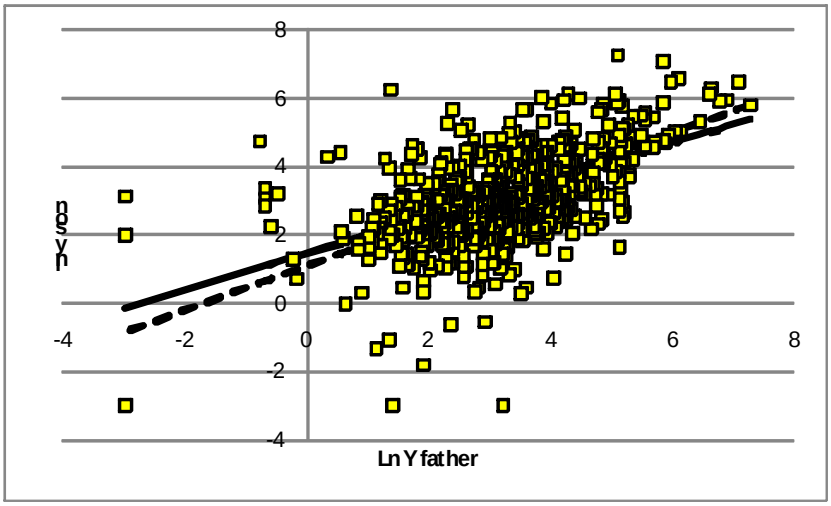
son. The data suggest that on average this son would be 12 percent richer than his brothers, though this effect is not statistically significant. Even at 12 percent this is, however, a modest birth order premium. Inclusion of birth order also has the effect of reducing the magnitude and statistical significance of family size.

With the much larger data set of fathers and sons that this project will create, it will be possible to include complete controls for sons' birth order. It will also be possible to include controls for the gender composition of siblings. Girls did receive substantial inheritances throughout this period, but typically the amounts they received were less than for their brothers – typically 30-50% less. It will also be possible to include controls for married sisters, who would get their inheritance as a dowry at the time of marriage.

The final estimation in table 8 also includes "$\ln(Y_f/N)$ – post 1780" which is the family size effect separately entered for father-son pairs where the father left a will 1780 and later. 241 of 718 pairs are post 1780. This estimation suggests that there was a significantly greater elasticity of son wealth with respect to numbers of children for fathers making wills before 1780 than for those later. Indeed for those after 1780 there is almost no effect of family size on the wealth of sons.

The probability of leaving a will, however, was higher the greater the wealth of the table. Thus in figure 1 there are many missing observations, which come mainly from the lower left hand quadrant: poorer fathers leaving poorer sons. These missing observations will bias the coefficients b_2 and b_3 downwards towards 0. Figure 9 shows the estimated connection between the wealth of fathers and sons using the observed data, and the likely true relationship if all father son pairs were observed (dashed line).

Figure 9: The Estimated Connection between Fathers' and Sons' Wealth



A simple way to correct for the bias induced in the estimation by these missing father-son will pairs is just to drop all the pairs where the wealth of the father is smaller, and estimate the relationship only from the cases of richer fathers and their sons. The cutoff point for this estimation takes only the top half of the wealth distribution of fathers. This has a second advantage in that it concentrates on what happens before and after 1780 for the wealthier group. This was a group whose net fertility relative to the poorer testators fell in the years after 1800.

Table 9 shows the results of the various estimations using this smaller group of 645 wealthier fathers. In the first two estimations the combined coefficient on the log of fathers' wealth rises from 0.54 to 0.65, as predicted from the nature of the missing observations. Fathers' wealth thus becomes more strongly predictive of sons'.

Table 9: Wealthier fathers (645 observations)

Variable	Basic	Oldest	W_f/N post 1780
Intercept	1.227	1.072	1.053
D1780	0.084 (.088)	0.082 (.088)	0.130 (.174)
$Ln(Y_f)$	0.457** (.083)	0.498** (.085)	0.498** (.085)
$Ln(Y_f/N)$	0.194* (.080)	0.153 (.082)	0.163 (.089)
Dfalive	-0.253 (.225)	-0.257 (.224)	-0.254 (.224)
Doldest	-	0.179* (.086)	0.178* (.086)
$Ln(Y_f/N)$ – post 1780	-	-	-0.024 (.077)

Note: ** = significantly different from zero at 1% level, * = significant at 5% level. Standard errors in parentheses.

But the effect of family size on sons' wealth, the quantity-quality tradeoff, is still very modest. And now when we split this coefficient around 1780 there is no sign of any change in the relationship. Size still matters very modestly in predicting sons' wealth. And there is still no sign that the relationship is shifting to becoming more negative.

Socio-Economic Status

Since the wills frequently reveal information also on the socio-economic status of the testator, we can also examine the effects of family size on social mobility. In larger sized families are children more likely to decline in occupational status? For this purpose we use a seven point occupational division that is tailored to the pre-industrial era where most of the data comes from. The occupations are assigned a status from 1 (laborer) to 7 (gentleman). This is thus just a crude cardinalization of occupational rank. But this is good enough for our purposes, and should serve to detect the effects of family size on social mobility. The basic estimating equation is now

$$STAT_s = b_0 + b_1 D1780 + b_2 STAT_f + b_3 N + b_4 DFALIVE + b_5 DOLDEST$$

If larger family size depresses the socio-economic status of sons, then b_3 should be significant and negative. Table 9 shows the results of these estimations, using the same format as with wealth. There are 605 pairs of father-son wills where both are ascribed a socio-economic status.

There is a strong connection between the status of fathers and sons. However adding another child has no effect on the socio-economic status of sons. Interestingly while oldest sons were significantly wealthier than younger brothers, they have no gain in the status ascribed in the will. Post 1780 family size gets closer to having a significant negative effect on the socio-economic status of sons. But the overall effect even post 1780 is still quantitatively very minor.

Table 5: Status and Family Size, 1470-1898

Variable	Basic	Oldest	W_f/N post 1780
Intercept	2.28	2.26	2.11
D1780	0.068 (.105)	0.068 (.105)	0.453 (.232)
$STAT_f$	0.546** (.039)	0.546** (.039)	0.542** (.039)
N	-0.022 (.022)	-0.021 (.023)	0.017 (.031)
Dfalive	-0.113 (.282)	-0.115 (.283)	-0.110 (.282)
Doldest	-	0.016 (.105)	0.016 (.105)
N – post 1780	-	-	-0.083 (.044)

Note: ** = significantly different from zero at 1% level, * = significant at 5% level. Standard errors in parentheses.

Implications

The preliminary results above, if supported with the much larger body of data it will be possible to assemble, have profound implications for the major current theories of economic

growth. Consider first the effect of child numbers on the wealth at death of sons. In the years before 1780 there was a modest but significant negative relationship between family size and the wealth of sons. Yet this was a period with no sign of any limitation of family sizes. In the years 1780-1890 the tradeoff between quality and quantity, instead of becoming steeper, got if anything less adverse. So in the approach to the Demographic Transition of 1890 the costs of larger numbers of children became smaller for families. This would imply that the fundamental cause of the Demographic Transition cannot have been a more adverse quality-quantity tradeoff. In complete opposition to Becker, Murphy and Tamura (1990), there is no sign of a switch from a world where there was little quantity-quality tradeoff in children. Instead the initial results suggest the opposite path. A move towards a world where the quantity-quality tradeoff became less adverse than before – accompanied, of course, by a decline in average family sizes. If sufficient data can be constructed to pin down these relationships over time, and show that the quality-quantity tradeoff did indeed become less negative as the English economy moved through the Industrial Revolution, then this would force a revision in most theoretical accounts of the Industrial Revolution, such as those of Lucas (2002), Galor and Weil (2000), and Galor and Moav (2002). The Demographic Transition, instead of being the result of the changing relative costs of quantity versus quality, would have to have had some very different explanation.

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