The Child Quantity-Quality Trade-Off:
Evidence from England during the Industrial Revolution[1]

VERY PRELIMINARY

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Abstract

An extensive theoretical literature postulates a negative trade-off between family size and children's education. But causal evidence is mixed, and existent means of exogenous variation in family size are highly disputed. We take the theory to the historical record, investigating the causal link from family size to children's literacy using Anglican parish registers (English church book records). Historical family planning and a lack of access to modern contraceptives enable us to explore a novel source of exogenous variation in family size: marital fecundity as measured by the interval from marriage to first birth. We find that an extra child significantly reduced the chances of literacy, even when controlling for various family characteristics including parental literacy, social class, and birth-order effects.

JEL Codes: J13, N3, O10

Keywords: Child Quantity-Quality Trade-Off, Demographic Transition, Household Economics, Instrumental Variable Analysis, Human Capital Accumulation

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Introduction

One of the main goals of policy makers in developing countries is to design programs to reduce family size. That goal is influenced by a hypothesis proposed by Gary Becker and co-authors which implies that fewer children frees up resources that can then be invested in the human capital of remaining offspring (Becker 1960, Becker and Lewis 1973, Becker and Tomes 1976). While the theoretic foundation for Becker's hypothesis is firmly in place, the empirical literature is sending mixed signals. Some find that family size and children's schooling are negatively related (Rosenzweig and Wolpin, 1980a; Hanushek, 1992, Rosenzweig and Zhang 2009). Others find little or no effect (Caceres 2004; Black *et al*. 2005a; Angrist *et al*. 2010; Qian 2006; Li, Zhang and Zhu 2008). A key issue is the need for exogenous variation in fertility, and a big debate evolves around the current use of twin births (called *twinning*) as an instrument for family size (see Rosenzweig and Zhang 2009).

The current work escapes the debate and criticized instruments by taking Becker's hypothesis to the historical record, exploring variation across 1.294 individuals from 589 families who lived in England in the 'long' eighteenth century, c. 1700-1830. Historical family planning, as well as the lack of access to modern birth control, provide a unique opportunity to test the Becker's child quantity-quality trade-off hypothesis using a novel source of exogenous variation in family size, but a conventional measure of marital fecundity in societies where marriage marks the onset of unprotected sex. Namely the time interval from a couple's marriage to their first birth. Using this interval as an instrumental variable, we investigate the causal link from family sibship size to the chances of finding literacy among the family's offspring. The analysis makes use of data from Anglican parish registers (English church book records), collected over the past forty years by the Cambridge Group and documented in Wrigley *et al*. (1997). The data enable us to control for a variety of family characteristics, including parental literacy, family social class (based on the husband's occupation), location, birth order and sex of offspring. We find that an extra child decreased the chances of finding literacy among all family siblings by nine percent, thus strongly supporting Becker's theory.

While this is not the first attempt to analyse the child quantity-quality trade-off based on historical data – Becker et al. (2010) recently did it for nineteenth-century Prussia – we push the research frontier further along three dimensions. Firstly, we explore an outstanding source of information in the context of child quantity-quality trade-off analysis: the so-called *Population History of England from Family Reconstitution* (Wrigley *et al*. 1997). Exceptional for historical demographic statistics, this data allow us to analyse the within-family linkage from sibship size to the literacy status of offspring. Secondly, we are the first to analyse the child quantity-quality trade-off for historical England, the world's leading economy of the eighteenth century, during one of its greatest growth experiences ever, the industrial revolution. Last but not least, the use of marital fecundity as a source of exogenous variation in family size offers an novel instrument for testing the child quantity-quality trade-off among societies where marriage marks the onset of unprotected sex.

England during the industrial revolution provides an ideal place to test the quantity-quality trade-off. Recent research shows that British parents invested heavily in the quality of their offspring even back into the seventeenth century (Leunig *et al.* 2010). England's growth experience has also inspired a big and growing theoretical literature, known as *Unified Growth Theory* (Galor 2005). Building on seminal work by Galor and Weil (2000) and Hansen and Prescott (2002) several attempts have been made to try to pinpoint the factors that ultimately triggered the escape from pre-industrial *Malthusian* stagnation (low and stationary income *per capita*) into a subsequent regime of sustained economic growth. A key mechanism to drive this transition to riches, inspired by Becker's child quantity-quality trade-off, is that parents in response to economic incentives start to invest in the human capita of their offspring – an investment made possible by a reduction in number of births. Among the most recent contributions in this area are De La Croix and Licandro (2009) and O'Rourke *et al*. (2010). Despite numerous attempts to model the shift to sustained growth theoretically, the empirical record has remained remarkably silent as to whether the historical child quantity-quality trade-off hypothesis holds water. With the exception of Becker *et al*. (2010)'s inquiry into historical Prussia, the present article is the first to explore historical data in an attempt to justify this key mechanisms of Unified Growth Theory.

Data Description

The data used for the analysis, collected since the 1960's by the Cambridge Group from Anglican church book registers, offers an extraordinary insight into the demographic life-history of individuals and families, built up from records of their birth (baptism), marriage, and death (burial). The full data covers 26 parishes scattered across England in a way that makes them representative of the entire country. While the full data spans the period 1541-1871, the information permitting us to conduct the quantity-quality trade-off analysis below mainly fall within the period 1700-1830, and includes a total of 15 parishes.

In addition to collecting and digitalizing the church book data, the Cambridge Group has used the data to reconstructed families based on observations of the birth, death and marriages of family members. This *family reconstitution* project, described in detail in Wrigley *et al*. (1997), is particularly interesting from the viewpoint of testing the child quantity-quality trade-off. At first glance, data on someone's birth, marriage and death dates does not seem to carry much information. But in addition to the dates of these events, the registers occasionally also specify the individual's occupation at the time of marriage and death. Furthermore, and to be used as a 'quality' measure, an individual's literacy status can be inferred from that person's signature, or the lack hereof, on the wedding certificate: if the individual was illiterate, then he or she would simply leave a mark instead of a signature (Schofield 1973). Literacy was by no means free of charge. Sunday schools and most other teaching institutional demanded a fee, and only a very limited number of genuinely free places were available (*ibid*.). Surveys done for the early nineteenth century show that, even in the case of free schools, attendance dropped when employment was available. The capacity to be able to read and write was, therefore, in direct competition with other goods for cash expenditure.

The birth (baptism) record also detail the names of parents of the child baptised. By putting all of this information together – and this is what family reconstitution is all about – it is possibly, for each married couple, to count their number of offspring and to explore the offspring's literacy status. The purpose of the analysis conducted below is thus to investigate if sibship size (number of family offspring) has any explanatory power over the chances of finding literacy among the offspring, controlling for a number of family background characteristics as detailed below. Note that the family-level statistics allow us to use the variation, not just across the different parish locations in the sample, but between more than a thousand individuals whose family size and literacy status we can infer from the records.

Table 1 offers a more exact account of the statistics attainable from the church book registers, as well as information that can reasonably be inferred from the records, such as individual longevity, social status, and an account of surviving offspring (surpassing the age of five years). Asterisks in the Table signify variables that were deduced, either by us or by the Cambridge Group. Every record in the *family reconstitution* is build up around a marriage. The Table contains an example of the demographic, educational (with regards to literacy) and occupational information of the marriage between Joseph Chester and Mary Smalley. This marriage is representative of the families in the sample used in the analysis below, in terms of family size, literacy, longevity and occupational information.

The marriage between Joseph and Mary took place on 16 May 1811 in Shepshed, Leicestershire. Shepshed was characterized by Schofield (2005) as an 'industrial' location. The label 'industrial' is given to parishes where 30 percent or more of males over 25 years observed in the church book of Shepshed are recorded as being engaged in occupations that were categorized as industrial (such as smiths, brick makers, and tailors). By similar reasoning, other parishes have been labelled 'agricultural', 'retail and handicraft' and 'other', the latter referring to a mix of the three others.

Table 1:

Family-Level Data: Marriage Number 599 in Shepshed (Observed and Inferred)

MARRIAGE NO	DATE	PARISH NAME	PARISH TYPE *	IV: TTFB *	IV: AGE-ADJ *	FERTILITY *	> AGE 5 *
559	16 MAY 1811	SHEPSHED	"INDUSTRIAL"	10.38	-3.456	8	8
SPOUSE NAME	**BIRTH**	**DEATH**	**AGE ***	**MAR-AGE ***	**LITERACY**	**OCCUPATION**	**SOCIAL CLASS ***
JOSEPH CHESTER	16 APR 1785	16 OCT 1844	60	26	LITERATE	FARMER	MANUAL
MARY SMALLEY	3 JUN 1787	25 SEP 1846	59	24	LITERATE	-	-
CHILD'S NAME	**BIRTH**	**DEATH**	**AGE ***	**MARRIAGE NO**	**LITERACY**	**ORDER**	**SEX**
MARY	27 MAR 1812	-	> 5	1789	ILLITERATE	1	F
SARAH	24 DEC 1813	-	> 5	1661	LITERATE	2	F
CATHERINE	22 MAR 1815	28 SEP 1826	12	-	-	3	F
MARIA	16 AUG 1817	-	> 5	2165	LITERATE	4	F
JOSEPH	23 OCT 1819	-	> 5	-	-	5	M
WILLIAM	2 APR 1823	-	> 5	-	-	6	M
FANNY	27 JUL 1826	24 JAN 1844	18	-	-	7	F
CATHERINE	11 APR 1828	-	> 5	-	-	8	F

Source: Wrigley *et al*. (1997).

The record also states that husband Joseph was born (baptised) on 16 April 1785, and that he died (was buried) on 16 October 1844. As was common practise at the time (as in the case of Joseph), the church typically took down baptism and burial dates rather than birth and death dates. Birth and death dates, when available, are always the default options. In almost all cases in our sample, however, only baptism and burial dates are available. The fact that the records report burial dates rather than death dates is not a serious problem for the analysis conducted below. For obvious reasons people were rarely buried shortly after death, in most cases often within three days (Schofield 1970). [Footnote: The proportion of burials in Hawkshed, Lancashire, in the late eighteenth century at different intervals after death were as follows: same day, 1%; 1st day, 21%; 2nd day, 50%; 3rd day, 25%; 4th day, 2%; 5th to 7th day, 1% (*ibid*.).] Similarly, it is only rarely the case that the baptismal registers also give dates of birth. Towards the end of the eighteen century most children were baptised within a month of birth; this is slightly more than was observed in previous centuries (Schofield 1971). However, since 99 percent of the individuals in our sample were baptised during the eighteenth century or later, this should have no bearings on the instrumental variable analysis below.

Getting back to Table 1, the information about Joseph's baptism and burial dates allow us to approximate his age at death, which was 60 years. The knowledge of his marriage date furthermore permits us to estimate his age at marriage, which was 26 years. The church book record also reveals that Joseph's marriage certificate had his signature on it, from which can be infer that he was literate. Moreover, at the time of his marriage Joseph's was noted in the church register to be a farmer. This information is used to approximate the family's social status, and thus implicitly its income potential, as will be explain in detail below. The records sometimes offer occupational status at the time of the death in addition to that of marriage (though not in the case of Joseph). In that event, occupation at marriage is the default variable on the assumption that this give a clearer picture of the families' income potential than occupation at death. In cases were the data only reports occupation at death we use this as a proxy for occupation at marriage. By using the so-called *History of Work Information System* (*HISCO*) we are able to map all the different occupational titles in the data into one of two social groups: *manual* and *non-manual* labourer. [Footnote: See van Leuwen (2007)] [Footnote: We can observe from cases where we have occupation (and thus social class) at time of death as well as at time of marriage that the two are positively correlated.] Clark and Cummins (2010) have used wills information to map English historical occupations in into wealth, and we know from their study that the wealth of manual labourers was lower than that of their non-manual counterparts. Thus, by dividing occupations into manual and non-manual labour we this way get a crude proxy for wealth (and hence income) status of those households in the sample who has occupation available. Husband Joseph's occupation (farmer) places him in the group of manual workers.

The records also show that Joseph's wife Mary was born (baptised) on 3 June 1787 and died (was buried) on 25 September 1846. She thus lived to reach age 59, and the record reveals that she married at age 24. Mary, like her husband, was literate. The record offers no account of her occupation. This is typical of the wives in the sample, reflecting the fact that labour force participation among married women of the eighteenth century was rather low (Horrell and Humphries 1995). Mary gave birth to a total of eight children, two of which were boys: Joseph and William (birth orders five and six). Three of Mary's children were reported to have married in their parish of birth: Mary, Sarah, and Maria (birth orders one, two, and four). None of their remaining siblings were registered as being married in their parish of birth; this, however, does not imply that they did not go on to marry in a parish not observed by the Cambridge Group (see below).

By visiting the marriage records of each of the three females who married in their parish of origin (family reconstitution numbers 1789, 1661, and 2165 of Shepshed), the records show that daughter Mary (birth order one) was illiterate, while her two sisters Sarah (birth order two) and Maria (birth order four) were both literate. Note that in the cases of Catherine and Fanny (birth orders three and seven) it is obvious that death emerged before either of them became married. Catherine was buried at age 12, and Fanny at age 18. Despite their early deaths, we proceed to include them in the family's sibship size since both of them lived long enough that they consumed a fair fraction of the family's resources. Meanwhile, as is standard among demographers [REF?], children, who pass away before reaching the age of five, are not counted as sibship in the analysis below, due to their limited influence on the family budget.

Somewhat unusual for the families in the sample, none of the children of the Chester family described in Table 1 suffered mortality before reaching age five. [Footnote: Other research conducted using the same data shows that families lose on average one child this way (Boberg-Fazlig et al. (2011)]

The record implicitly states that all siblings of the Chester family, with the exception of Catherine and Fanny, eventually moved out of their parish of birth. We know this because of their missing death dates (Souden 1984). The high migration rate is consistent with the substantial relocation from rural to urban areas which took place over eighteenth century England (Allen 2000). [FN Between 1700 and 1800 the share of England's population living in urban areas doubled (*ibid*., Table 2)]. The average migration rate by sample family offspring, however, is 52 percent. The church book registers offer no information on the date of migration, or whether marriage of the unmarried eventually took place in their destination parish. From the record of people who migrated *into* the parishes included in the data we are able to observe that five percent got married, and we know the literacy status of 69 percent of these. But since in those cases we have no information on family background - sibship size in particular - this information is useless in the present context. Taken together, this means that all individual with missing birth (baptism) dates need to be excluded from the sample. By similar reasoning, children who have missing death dates, and who do not marry in their parish of origin before migrating, also have to be eliminated from the sample.

Historical Family Planning

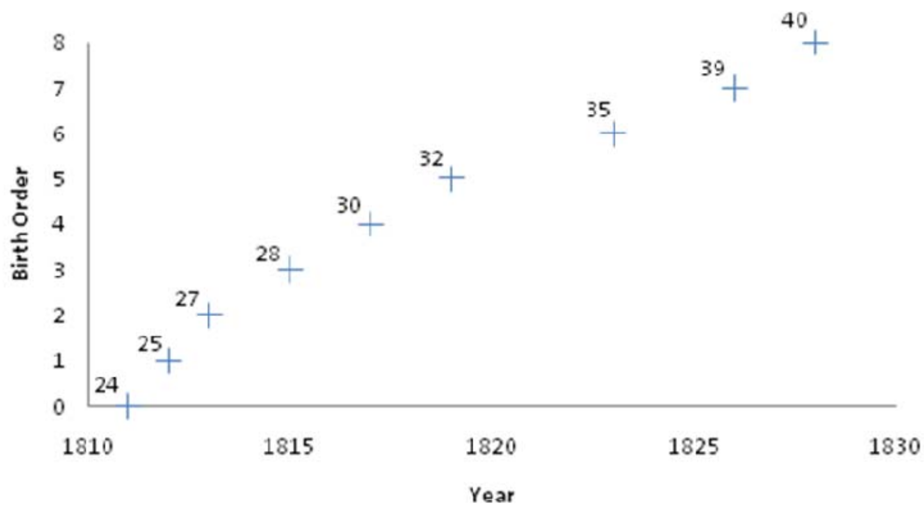
The argument forwarded in the analysis below requires a certain level of knowledge about family planning in historical England. A key feature to this is that the production of children born outside of marriage (so-called *bastards*) were a highly immoral act in the eyes of the Church. Indeed, this was an act whose resulting social illegitimacy eventually had a strong influence on the social status and mortality of these children, as documented by Stone (1977). While *pre-nuptially conceived* births, i.e. children conceived *before* marriage, but born *in* marriage, was a rather common feature of English population history, the desire to avoid pre-marriage deliveries effectively meant that births in the majority of cases came after marriage. (Footnote: It has been estimated that in the late eighteenth and early nineteenth century roughly six percent of all births were illegitimate (Wrigley *et* al. 1997, p. 471)] Furthermore, the absence of modern contraceptives meant that within-marriage births were subject to limited control. Abstinence from intercourse, *coitus interuptus*, and extended breast feeding were the main means of controlling fertility after the onset of marriage.

Limited access to birth control effectively meant that within-marriage births continued up until the wife reached the end of her reproductive age, typically between ages 40 and 50 (*ibid*.). Figure 1 offers an example from the sample used in the analysis below, illustrating the birth history of wife Mary from the Chester family described in Table 1 above. Born in 1787 and married at age 24, Mary gave birth to her first child at age 25 and made her last delivery at age 40. In total she gave birth to eight children. The average fertility rate in the sample is 6.9, with a standard deviation of 2.9, so Mary's reproduction rate of eight children was by no means unusual. Women in the data sample analyzed below married on average at age 24.9, with a standard deviation of 4.5, and Marys' age at marriage is thus very close to the norm. On average the last delivery of women of the sample happened at age 39.6, with a standard variation of 5.9, and here, too, Mary's age at last birth is almost identical to the average age.

Figure 1

Mary Chester's Reproduction History

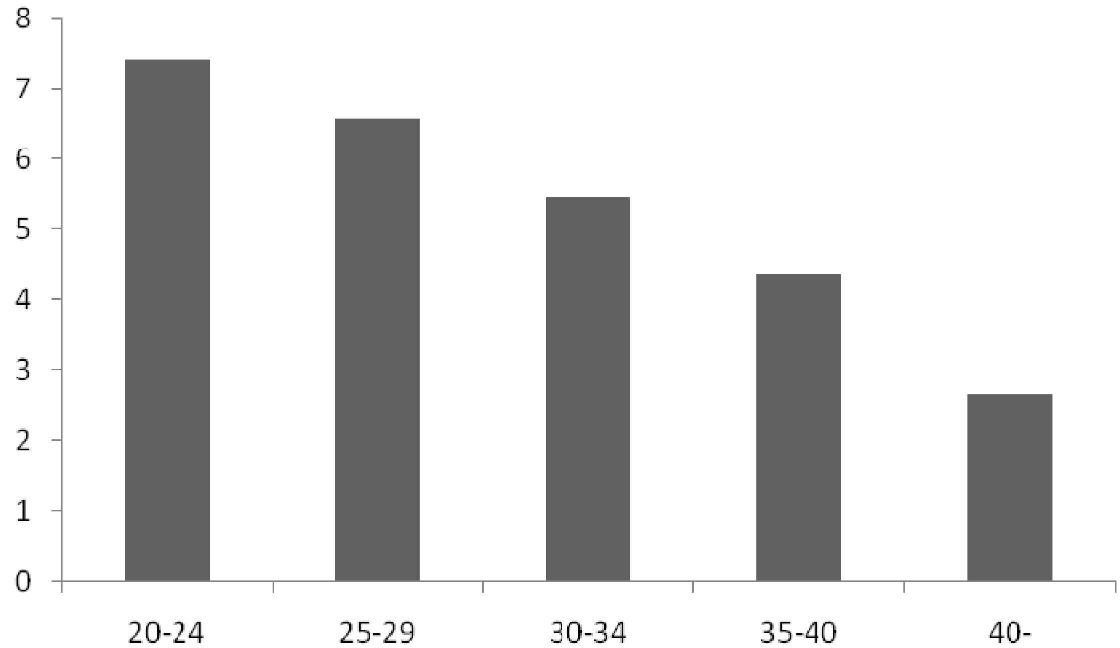
(numbers: Mary's age at the time of the birth)



In the absence of modern contraceptives, and with limited means of birth control, the timing of the marriage was the chief means of family birth control. The older a women was when she married the shorter was her time spend in the reproductive period, and hence the fewer children she would have time to give birth to. This fact is well-captured by Figure 2, which shows from the sample the average number of births by wife's age at marriage. Recent research based on the same data supports the notion that wife's age as marriage was the main means of birth control, showing that middle-class families (gentry, merchants or other professionals) had more children than their poorer counterparts (husbandmen, labourers, and servants) precisely because more well-off husbands had younger brides (Boberg-Fazlig *et al*. 2011).

Figure 2

Average Births my Wife's Age at Marriage



The fact that couples were able through timing of the marriage to target family size did not necessarily mean that they would eventually meet their goal in terms of number of offspring. Not only would child mortality influence on a target number of surviving offspring. The death of a spouse before the wife completed her reproductive age was quite normal at the time, and it is clear that this would bring family births to a halt before the target was reached. The way in which to treat the issue of pre-mature death among spouses is by excluding families where spouses died before the wife completed her reproductive age (50 years). This means that only so-called *completed* marriages are included in the sample below (Wrigley *et al*. (1997, p. 357).

Even in the absence of incomplete marriages, yet another factor is bound to influence family fertility, namely marital fecundity. it is obvious that couples of relatively low fecundity are subject to a relatively lower reproductive rate (defined as number of birth per year within the wife's reproductive age). And vice versa for couples of relatively high fecundity. In a world of perfect birth control, and that was hardly the case of historical England, couples of relatively high fecundity would able to limit their births, so as to meet a target number of offspring. But for couples with relatively low fecundity little can be done to catch up. Since historical couples, moreover, had little control over within-marriage births (as discussed above), both high and low fecundity couples were exposed to the risk an off-target family size. [Footnote (move this!): The correlation coefficient between the mean spacing of the children in the families of our sample in years and the sibship size (>5 years) is -0.356 with a *p*-value of less than .0000, meaning that fecundity and spacing is significantly negatively related.]

It is precisely these differences in marital fecundity that we attempt to use below as a means of exogenous variation in family size to test Becker's hypothesis. This brings us straight to the matter of how to measure marital fecundity among couples in the sample. The first thing to note is that the concept of fecundability refers to the probability of conceiving in the course of a single monthly cycle on the part of a woman who is capable of conceiving. Based on this definition, demographers have argued that among societies where marriage marks the onset of unprotected sex marital fecundity can be estimated simply by the time interval from the marriage of a couple to their first birth (Wrigley *et al*. 1997, pp. 465). The reason why fecundability cannot be measured based on the time interval between subsequent births is that women, who are pregnant or breastfeeding, fail to meet the condition of being capable of conceiving.

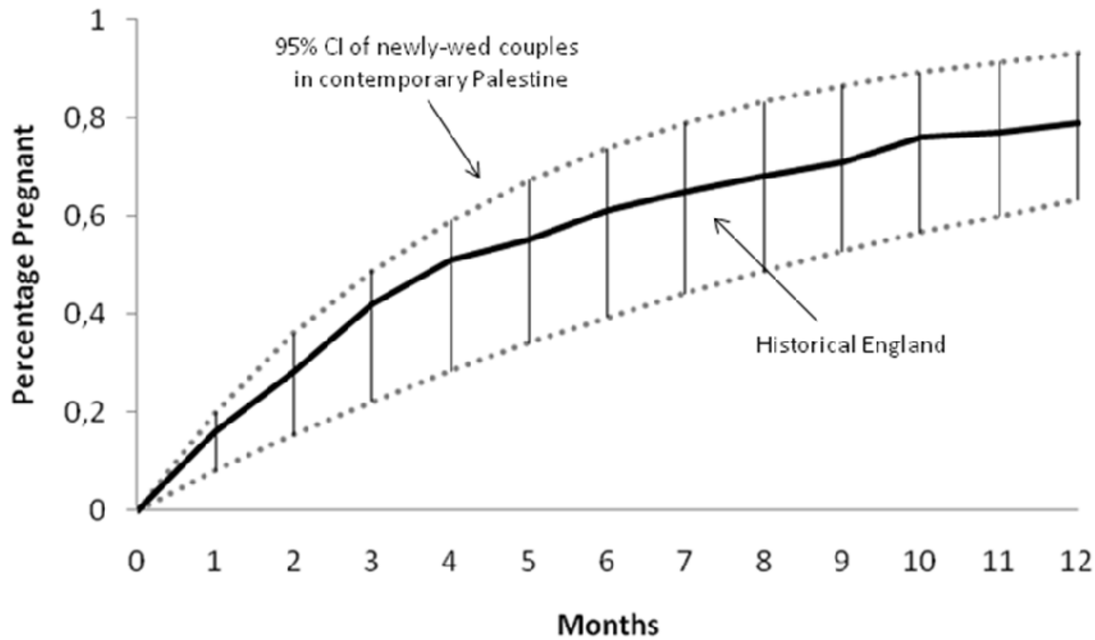
Did marriage among families in the sample below mark the onset of unprotected sex? We attempt to answer that question by comparing marital fecundability among sample couples with couples we know practises this tradition. The dashed lines of Figure 3 envelopes the 95-percent confidence interval of cumulative fecundability among newly-wed couples in agricultural villages in Palestine studied by Issa *et al*. (2010). The lines are based on measures of average fecundability among Palestinian wives whose educational attainments was less than 10 years of schooling (*ibid*., Table 1). Their average fecundability was 0.13, with 0.08 and 0.20 marking the lower and upper bounds of the 95-percent confidence interval. An average fecundability of 0.13 percent means that a wife on average had a 13 percent change of conceiving during one menstrual cycle (roughly one month). There are three reasons why the study of Palestinian couples is particularly well-suited for comparison with the church book data of historical England. First, pre-marital sex is a cultural taboo in the contemporary Palestinian community, and the authors of the study found no evidence of pre-marital pregnancies or even co-habitation among the couples. Second, the Palestine couples allegedly started unprotected sexual intercourse at the date of marriage in order to conceive their first child. The couples observed were recorded to have frequent intercourse until pregnancy was achieved, with 16 percent having intercourse between one and six times per week, while 74 percent were having intercourse more than seven times weakly (11 percent refused to answer). Finally, by contrast to other studies of Western societies the Palestine study includes information on unprotected intercourse *not* leading to pregnancy, just as we will have it in the current sample.

The solid line illustrates the cumulative fecundability of the couples of historical England. Five things should be noted. First, we have excluded families whose children were born within nine months of marriage, i.e. so-called pre-nuptually conceived births families are not included. Second, since the Cambridge records measures the interval from marriage to first birth (and not to first pregnancy) we have subtracted from each observation nine months (the time difference between the time of conceiving and birth). Third, we compare with observations among Palestinian wives whose educational attainment compares with that the wives of our sample, meaning less than 10 years of schooling. Palestinian wives with more years of schooling had slightly higher fecundabililty. Fourth, the average age of marriage among the Palestinian wives was 21.7 years; this is considerably lower than the average age of marriage of our sample, which is 24.9 years. Since fecundability is likely to fall with women's age (see further below) this means that we could be underestimating fecundability among historical wives relative to their Palestine counterparts. Finally, we have not adjusted for the time lag between birth and baptism. Adjusting for this time lag will increase the reproductive success of the historical couples relative to that of the Palestinians.

To sum up, Figure 3 shows that the fecundability among the English couples fits well within the boundaries of the Palestinian couples' fecundability. Taken together, the evidence in Figure 3 is not only supportive of the case that marriage marks the onset of unprotected sex among the sample families. Since we know that the Palestinians did not postpone their pregnancies after marriage, it also demonstrates, importantly, that our historical couples do not display any deliberate delaying behaviour.

Figure 3

Cumulative Fecundability: Contempory Palestine and Historical England



Solid line: Cambridge data. Space between dashed lines: 95% confidence interval of Palestinian couples. *Source*: Cambridge Data (Wrigley and Schofield (1997) and Issa *et al*. (2010).

Data Limitation

The Cambridge data contains a total of 10,442 individuals with literacy status known and for whom we have birth information available; these individuals come from a total of 6.045 families. However, there are two reasons why some of these families need to be removed from the sample. The first has to do with early death of a spouse, and the second with the incidence of pre-nuptially conceived births. Starting with the former, if a couple's fecundity (as measured by the interval between marriage and first birth) is going to operate as a proxy for family size, then we need to know what the family size was when sterility set in, and not a reduced family size caused by pre-mature death of a spouse. We thus follow the guidelines described in Wrigley *et al.* (1997, pp. 357) and restrict the set of marriages in the sample to only include *completed* marriages. A marriage is said to be completed when the wife survives in marriage to age 50, meaning that the timing of her last birth is unaffected by the risk of pre-mature death. By including only completed marriages in the sample, the total number of individuals drops to 2.172, coming from a total of 955 families.

Turning to the issue of pre-nuptially conceived birth, this was, as mentioned earlier, a rather common feature of English population history. In roughly 40 percent of all families in the sample children were born *before* the ninth month into the marriage. [Footnote: Note that families characterized by pre-nuptially conceived births were excluded from Figure 3 above.] It is questionable whether the time from marriage to first birth offers any insight into the fecundability among couples who gave birth to children conceived *before* the marriage (Wrigely *et al*. 1997, p. XX), and for that reason we exclude these families from the benchmark analysis below. We will later proceed to re-include these families for robustness purposes. In the meantime, excluding them from the sample leaves us with 1.294 individuals from a total of 589 families.

Last but not least, the underlying notion of Becker's child quantity-quality trade-off is that fewer children frees up resources that can be invested in the human capital of remaining offspring. Since children who suffered child mortality (death before age five) arguable did not consume of a big fraction of the family's resources, family size in the analysis below includes only children surpassing age five. [Footnote: Results are robust to this restriction.] Returning to the Chester family described in Table 1, we can see that all of Joseph's and Mary's children presumably made it to age five. The reason we can be sure of this, despite their missing death dates, is due to the unlikelihood that they moved away from their family before reaching age five (Wrigley *et al*. 1997, p. XX, App. 6).

Table 2

Summary Statistics

Variable	Obs (1)	Mean (2)	Sd. (3)	Min (4)	Max (5)
Literate	1294	0.58	0.49	0	1
Sibship size	1294	6.96	2.94	1	21
Sibship size (> 5 years)	1294	5.99	2.54	1	16
Time from marriage to first birth	1294	1.51	1.14	0.75	9.92
Male sex	1294	0.41	0.49	0	1
Husband's longevity	1294	72.34	9.68	40.41	96.61
Wife literate	892	0.35	0.48	0	1
Husband literate	921	0.62	0.49	0	1
Husband manual work	845	0.24	0.43	0	1
Agricultural parish	1294	0.30	0.46	0	1
Retail parish	1294	0.11	0.31	0	1
Industrial parish	1294	0.31	0.46	0	1
Other parish	1294	0.28	0.45	0	1

Sources: Cambridge data (Wrigley *et al*. 1997).

Table 2 reports the summary statistics. Around 58 percent of all individuals in the sample where literate. The average birth rate was seven children, out of which six made it to age five. The average time from marriage to first birth was little more than one and a half years. There were 41 percent males among the surviving offspring. That reflects the fact that the child mortality of females were lower than that of males. Parental literacy is not known for all 1,294 observations; we have literacy information of 892 wives, out of which 35 percent where literate. Likewise, literacy status is available for 921 husbands, out of which 62 percent were able to read and write. In 845 of the 1,294 cases we know the occupation of husbands, and roughly one quarter of these are classified, according to the HISCO classification system, as manual workers. [Footnote: See van Leuwen (2007)] Around 30 percent of the individuals in the sample lived in parishes dominated by agricultural activities, and slightly more (31 percent) in parishes dominated by industrial activities; 11 percent were living in parishes characterised by retail and handicraft, while the rest (28 percent) lived in parishes where economic activities were mixed.

The Instrument

Is the interval from marriage to first pregnancy a valid instrument for family size? The question of whether the *exclusion restriction* is satisfied in this case translates into a question of whether the time from marriage to first pregnancy is exogenous to the couples in the sample, and whether it is correlated with anything that affects literacy of the offspring. We have already seen that marital fecundity of the families in the sample squares nicely with those among contemporary people where marriage marks the onset of unprotected sexual intercourse, supporting the notion that the time interval from marriage to first birth is indeed a proper measure of marital fecundity.

Yet, since it was possibly to delay the first pregnancy after marriage, by means of abstaining from sexual intercourse or use of *coitus interuptus*, an interesting question is whether there are any signs in the data of such a delay behaviour. More specifically, we would like to know if couples, or certain groups of couples, are systematically postponing the time span to first pregnancy, in order, for example, to reduce number of offspring so as to be able to afford more child quality.

Two main points can be made with regards to this concern. The first thing to note is that historical England was renowned for its *preventive checks*. Preventive checks capture a mechanism, first described by Malthus (1789), by which couples engaged to be married respond to economic conditions by regulating their marriage dates. Malthus' argument was that, if price of provisions rises, then it becomes harder to support a family. This, he said, would result in fewer marriages, leading ultimately to fewer births, and hence to smaller families. By looking at the impact of real wages on marriage rates, scholars have repeatedly documented, using church book data documented in Wrigley and Schofield (1989), that English couples did in fact respond to economic hardship by delaying marriage (Nicolini 2007; Møller and Sharp 2009). So if a couples wanted to reduce its births, then why not just delay marriage rather than postpone pregnancy after marriage?

Even so, it is still possible to envision that, say, couples who are literate themselves would wish to have literate children, and that they would thus act to postpone first pregnancy after marriage to be able to afford that. It is equally possible to imagine that *illiterate* couples were induced to try to upgrade their offspring's status to literate, and hence would postpone *their* pregnancy to afford that. It is easy to shed light on these conjectures by regressing the time interval from marriage to first birth on a number of social variables, including parental literacy and the family's social class (manual or non-manual labour). We can do this using a larger sample than the one used for the analysis below, where we do not require the literacy status of offspring to be known. The results are reported in Table 3. It shows no evidence, however, of any systematic delay-behaviour among any of the social groups identified in the data.

Table 3

Factors Potentially influencing Time to First Birth

Dependent: Time to First Birth	
Wife's marriage age	-0.0039
	(0.0053)
Male sex	-0.0098
	(0.0232)
Wife literate	0.0922
	(0.1022)
Husband literate	-0.0645
	(0.0953)
Wife manual work	-0.0625
	(0.1709)
Husband manual work	-0.0344
	(0.0729)
Husband longevity	0.0003
	(0.0025)
Retail and handicraft	-0.1526
	(0.0930)
Industrial	-0.0871
	(0.0794)
Other	-0.0169
	(0.0860)
Years since 1580	0.0002
	(0.0002)
Constant	0.0641
	(0.3088)
Observations	9,465
Observations, clustered	1,771
R^2 (adjusted)	0.0074

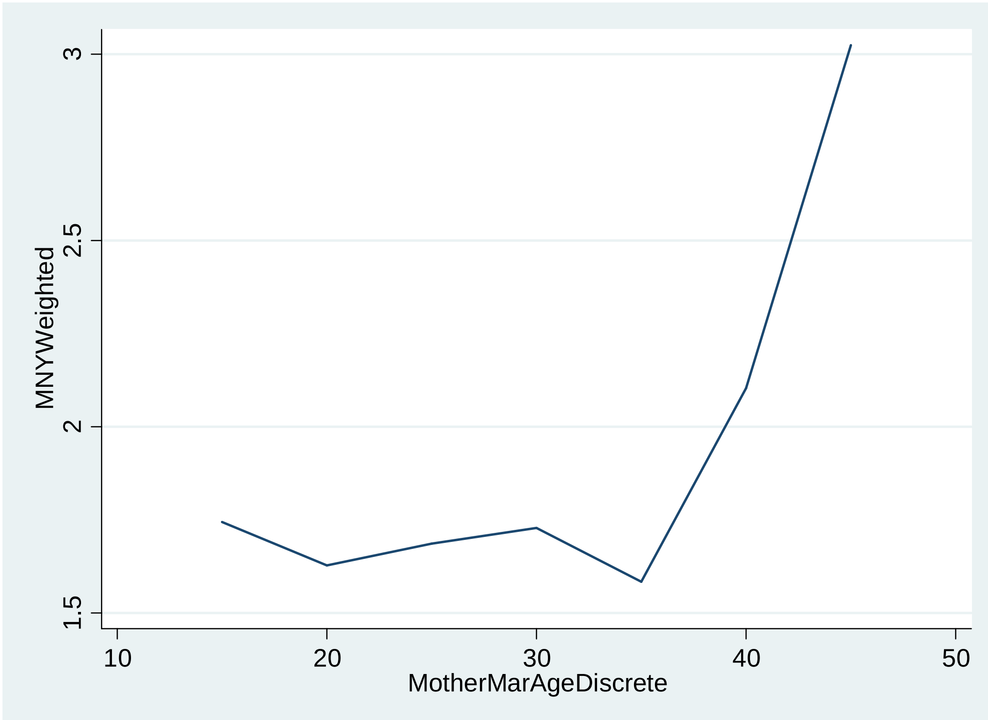
Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Sources: Cambridge data (Wrigley *et al*. 1997).

In light of what we know from human biology about women's fertility declining with age, it is noteworthy that wife's age at marriage has no significant influence on the time from marriage to first birth (Table 3). Figure 4 sheds further light on this matter, showing the time interval from marriage to first birth by wife's age at marriage. From the illustration it becomes immediately clear that fertility decline among the women of the sample does not set in before after age 35. Given that no more than a few percent of these women married after age 35, it is perhaps not surprising that there is no significant effect of the wife's marriage age on the time to her first delivery.

Figure 4

Average Time from Marriage to First Birth by Wife's Age at Marriage



Sources: Cambridge data (Wrigley *et al*. 1997).

In order to be absolutely certain that we are indeed accounting for any decline in fertility with age of women, we proceed to compute an individual, age-adjusted measure of time from marriage to first birth. To illustrate this for the case of the Chester family described in Table 1, their time span from marriage to first birth was 0.87 years (or 10.5 months). From this number we subtract the age-specific mean of women grouped into five-year interval marriage cohorts. Since Mary was married at age 24, she belongs to the cohort of women marrying between ages 20 and 25. The average time to first-born of this marriage cohort was 1.42 years, and since Mary's time-span was 0.87 years, her age-adjusted time from marriage to first birth was -0.55 years. This number indicates that the marital fecundability of Mary and Joseph was relatively high.

Analysis and Results

We now advance to estimate the effect of sibship size on individual literacy using OLS and 2SLS (instrumental variable) regression analyses. The OLS model is given by the following equation:

$$literacy = \alpha_0 + \alpha_1 sibshipsize + \alpha_2' X + \varepsilon,$$

where X is a vector of covariates, and ε is an error term. Covariates comprise sex of offspring, parental literacy, occupational status of the husband, as well as dummies for time (centuries since 1580), birth order, parish location type, and missing information regarding parental literacy and occupation of the husband. Birth orders include orders from one up to nine and then 10+. We use the same covariates in both the OLS and the 2SLS regression analysis.

We know from previous literature that the OLS estimate may be biased, and that an observed negative association between sibship size and literacy may not have a causal interpretation (e.g., Angrist et al. 2010). In case of simultaneity, if literacy depends negatively on fertility, and fertility depends negatively on literacy, then the OLS estimate of α_1 will be downward biased. On the other hand, if literacy and fertility are both positively correlated with an omitted variable, then the estimate of α_1 will be upward biased. As in the existing literature we attempt to tackle the potential problem of endogeneity by use of 2SLS analysis. Specifically, the first step predicts family sibship size using our instrumental variable (age-adjusted time interval from marriage to first birth) as well as covariates. The second step then predicts literacy using the equation above. The first-stage regression equation of the 2SLS analysis hence reads

$$\textit{sibshipsize} = \beta_0 + \beta_1 IV + \beta_2' X + \nu,$$

where IV is our instrumental variable, X the covariates, and ν is an error term.

The estimation results of the OLS, as well as the 2SLS analyses, are reported in Table 4. Dummy-estimates for birth order, pre-nuptially conceived births, as well as missing observations, are all excluded from the table [but are reported in an appendix not intended for publication]. Observations are clustered by family.

Table 4

Regression Results

Dependent: Literacy	(1) OLS	(2) IV: 1st Stage	(3) IV: 2nd Stage
Sibship size (> 5 years)	-0.012 (0.007)		-0.086*** (0.027)
Male sex	0.100*** (0.026)	0.015 (0.121)	0.099*** (0.028)
Wife literate	0.247*** (0.045)	-0.186 (0.298)	0.228*** (0.050)
Husband literate	0.221*** (0.046)	0.530* (0.278)	0.262*** (0.052)
Husband manual job	0.127*** (0.045)	-0.587** (0.275)	0.087 (0.053)
Years since 1580	0.000 (0.000)	0.003** (0.001)	0.000 (0.000)
IV		-0.482*** (0.058)	
Constant	0.675*** (0.176)	7.193*** (1.005)	1.201*** (0.262)
Observations	1294	1294	1294
Observations clustered	589	589	589
R^2 (adjusted)	0.168	0.325	0.062
Weak instrument test			67.926

Beginning with the OLS results (Column 1), the conditional correlation between sibship size and literacy is negative. Each additional sibling reduces the chances of literacy among all family siblings by 1.2 percentage points. This is a fairly modest effect, but we know it may be biased. It is also not statistically significant. Turning to the estimates of the covariates, these are all fully in line with the a priori: Males are more likely to be literate than females (10 percentage points). Children of literate parents are more likely to be literate themselves (25 percentage points in case of literate mothers/wives; 22 percentage points in case of literate fathers/husbands). If both parents are literate, therefore, then that raises the chances of literacy among their offspring by nearly fifty percentage points. It is perhaps somewhat unexpected, but not entirely unintuitive, that children of fathers who do manual work are more likely to be literate (13 percent points) than those whose fathers are non-manual workers. Time is a crucial factor.

Using marital fecundity of couples as an instrument for sibship size (Column 2), it follows from the estimate that two additional years above the age-specific mean birth-period means a decrease of roughly one surviving offspring. This effect is significant at the one-percent level. The second-stage estimate (Column 3) supports the finding of a trade-off from the OLS analysis. But not only is the numerical effect statistically significant at the one-percent level; it is more than seven times bigger. That is, each additional sibling reduces the chances of literacy among all family siblings by 8.6 percentage points. Note that the Wald *F*-statistic value - based on the Kleibergen-Paap *rk*-statistic (Kleibergen and Paap 2006) - are well above the critical value of 10, suggesting no signs that the instrumental variable used is weak (Baum and Schaffer 2007).

Sample Selection Bias [INCOMPLETE]

As was explained above, our sample of 1,294 individuals comes from a larger sample of 10,442 individuals. These, in turn, come from a set of 11,638 observations of individuals with known literacy information, but not necessarily known birth date. These again form of a subset of the complete dataset consisting of 306,277 observations. Many of these observations contain only parental information meaning that they are related to parents that had no children with any registered event in the given parish. Among these, 269,939 observations contain a birth date, meaning that they are related to children born in their given parish. For an observation to contain information about literacy, the individual had to marry in his parish of origin. As a general characteristic, any observation with available literacy information will be a subset of those individuals who got married in their home parish. That subset, in turn, will be a subset of those individuals who survived until the day of marriage. Some of those with known marriage information will also have information on the marriage date while some will not.

Out of the 306,277 observations, 36,313 has no known birth or baptism date recorded, meaning that they are only related to a pair of (potential) parents of which we can observe no children. There are 265,127 observations with unknown marriage date. The most likely reason for this is that these individuals died or moved before marriage, or that the observations are concerning potential parents only. Furthermore, 7,948 observations has no marriage date reported, although the marriage FRF number is know (meaning that we known the individual was indeed married). 294,639 individuals has no literacy information; 28,218 of these have a known marriage FRF number. There is no known marriage FRF number for 266,421 individuals, and the death and burial date is missing for 200,529 observations.

Since we only observe literacy status for individuals who got married, our analysis may potentially suffer from sample selection bias. This problem could be strengthened by the fact that we only observe marriage information for individuals who survived until the day of their marriage and did not move before that day. To investigate this potential bias we employ the so-called *Heckit* model. [Footnote: Since we are already using instrumental variables analysis, we use Procedure 17.2 of Wooldridge (2001, p. 568).] In order to predict if the literacy information is unobserved we use the explanatory variables of the 2SLS analysis in addition to the following extra dummy variables: a dummy indicating if the marriage date is known and a dummy indicating if the death date is known. The Heckit is estimated for the 9,547 observations for which we have all the explanatory variables and for which we have required that marriages are *completed*, that parental marriage date is known, that the birth date of the husband is known, and that the first-born was not pre-nuptially conceived. The dependent variable is a dummy that is equal to one if literacy information is unknown, and zero otherwise.

The dummy variables "MissingMarDate" and "MissingDiedDate" are highly significant, meaning that they have explanatory power over whether or not the literacy information is available. In the second step, the inverse Mills ratio can be seen to be close to zero and highly insignificant. Hence, the Heckit model does not indicate a problem with sample selection.

Figure 5

Heckman Test

	(1) est1	(2) est2
main		
SurvivingSibshipSize	0.004	-0.086***
	(0.018)	(0.027)
Male	0.138**	0.098***
	(0.057)	(0.028)
MotherLitDummy	0.015	0.227***
	(0.126)	(0.050)
FatherLitDummy	-0.133	0.263***
	(0.119)	(0.051)
FatherManualDummy	0.184	0.085
	(0.137)	(0.053)
FatherClassUnknownDummy	0.271***	-0.207***
	(0.105)	(0.053)
CentSince1580	-0.004***	0.000
	(0.000)	(0.000)
FatherLongevity	-0.005	-0.002
	(0.004)	(0.002)
Retail	0.560***	-0.037
	(0.139)	(0.067)
Industrial	0.309***	-0.042
	(0.113)	(0.052)
MissingMarDate	4.089***	
	(0.160)	
MissingDiedDate	0.657***	
	(0.075)	
InvMills		-0.010
		(0.047)
_cons	-4.333***	1.232***
	(0.444)	(0.290)
N	9547	1294
N_clust	1787	589
r2_a		0.062
widstat		67.867

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Concluding Remarks

We have used data collected from Anglican parish registers to test the Beckerian theory of a child quantity-quality trade-off. The data covers a substantial time-period, spanning more than 130 years including the time of England's industrial revolution. The nature of the historical family planning – that marriages seems to mark the onset of unprotected sex, and that within-family birth control is limited – permits us the use of a novel instrumental variable in the context of child quanity-quality trade-off analysis. Namely the exogenous variation in family size that stems from differences in marital fecundity as measured by the time interval from marriage to first family birth.

We find a negative and strongly significant causal effect from within family sibship size to individual literacy. The magnitude of the trade-off – a nearly nine percentage-points cut in the chances of finding literacy among a family's offspring for each additional surviving child - implies a substantial decrease in offspring quality among large families, and hence a strong support to Becker's trade-off hypothesis.

Our findings also lends strong support to Unified Growth Theory, which builds on the notion that parental preferences entail a quantity-quality trade-off of children - a mechanism conducive to the demographic transition (fertility decline) and the escape from Malthusian stagnation to sustained growth (Galor and Weil 2000). Our findings are also supportive of theoretical work proposed by (Galor and Moav 2002), who were the first to argue that the trade-off was decisive to economic advancement, not just from the onset of the demographic transition, but throughout human evolution.

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