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HUMAN CAPITAL AND FERTILITY IN CHINESE CLANS BEFORE MODERN GROWTH

Carol H. Shiue

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ABSTRACT

This paper studies the pre-industrial origins of modern-day fertility decline. The setting is in Anhwei Province, China over the 13th to 19th centuries, a period well before the onset of China's demographic transition and industrialization. There are four main results. First, we observe non-Malthusian effects in which high income households had relatively fewer children. Second, higher income households had relatively more educated sons, consistent with their greater ability to support major educational investments. Third, those households that invested in education had fewer children, suggesting that households producing educated children were reallocating resources away from child quantity and towards child quality. Fourth, over time, demand for human capital fell significantly. The most plausible reason is the declining returns to educational investments. The findings point to a role for demography in explaining China's failure to industrialize early on.

Carol H. Shiue
University of Colorado-Boulder
Department of Economics
Boulder, CO 80309
and
Stanford University
Hoover Institution
434 Galvez Mall
Stanford, CA 94305-6010
and also NBER
carol.shiue@colorado.edu

1. Introduction

It has often been observed that population dynamics and development are closely related. Most studies on patterns of fertility rates, however, focus on the period since industrialization, that is, the 19th - 20th centuries, when declines in average family size first occurred in Europe and other Western countries.[1] Less is known about fertility and income around the world prior to industrialization, and there is still no consensus on why pre-industrial economies in which birth rates tend to rise with income started to make the switch into a setting where a negative correlation between fertility and income is considered the norm.

Starting with the work of Gary Becker (Becker, 1960; Becker and Lewis, 1973), economists have pursued the idea that fertility is based on rational choice. The quantity-quality tradeoff, where parents limit the number of their children in order to increase the "quality" of each of them, is the cornerstone in much of our thinking of what explains modern growth (Lucas 2002, Ch. 5, Acemoglu, 2009, Ch. 21). These ideas are influential because it can be shown that fertility choice determines whether or not sustained per-capita growth will materialize (Barro and Becker, 1988; Becker, Murphy, and Tamura, 1990). More recent work has also demonstrated that the transition from the Malthusian regime to the era of modern growth can be explained in a unified framework (Galor, 2011). Different mechanisms underlying the quantity-quality tradeoff have been proposed, including income-elastic preferences and the demand for human capital.[2] It has become clear that understanding growth requires us to also understand not only why Malthusian dynamics no longer hold in most societies today, but when they ceased to hold, and among whom.

This paper investigates fertility control behavior and its relationship to human capital demand in China from the 13th to the 19th centuries. Due to a lack of data on learning and educational attainment for periods prior to modern growth it has been difficult to study parental choice over child quality versus quantity on the empirical front. In particular, there has been little micro evidence supporting this tradeoff (Acemoglu, 2009). In addition, other social scientists have suggested that social norms or cultural forces, rather than economic factors

[1] For a recent survey on the demographic transition see Guinnane (2011).
[2] Galor and Weil (2000) explain the reduction in fertility as a response to technological progress; Doepke (2004) examines government policies on child labor; and Galor (2012) discusses preference-based theory vs. human capital demand as causes for the demographic transition.

explain fertility.[3] The data used in this paper is from genealogies of individuals and households who lived in Tongcheng County of Anhwei Province. Chinese genealogies are considered to be particularly good records of vital statistics, especially of the paternal line. This feature makes the genre an untapped resource for testing theories on incentives that govern fertility and human capital choices.

The Chinese context is particularly well-suited to examining these issues for several reasons. First, there was a tradition of education in China that began during the Tang Dynasty (670-906 AD), when hereditary aristocracies were largely eliminated.[4] Beginning in the Song dynasty (960-1127 AD), officials of the state were selected on the basis of performance in formal examinations. By the 14th to 19th centuries, high level degrees were awarded upon success in exams administered by the government.[5] The central element of this system was its apparent meritocracy, in which commoners could not be barred from taking part.

Second, the state did not interfere with decisions on household investment activities or the number of children families should have. Mandatory public education did not exist at any level through the period under study. While the government closely monitored exams and relied on the talent pool of those families and individuals who willingly competed to enter official service, the main role of the state was as gatekeeper of the coveted degrees and official titles. Economic investments into education were borne privately by the families of potential candidates.

Third, education was costly but rewarding. The returns to the investments were not due to an increasing rate of technological progress, but rather through employment in the state sector. Both the investment in that education, as well as the private returns to successful degree holders were high, at least for much of the Qing Dynasty (1644-1911). Although children could not

[3] According to Wrigley (1978, 148), there was always some form of fertility control in almost all societies of the past. "The key change of the demographic transition was from a system of control through social institution and custom to one in which the private choice of individual couples played a major part in governing the fertility rate."
[4] For further discussions on social mobility in China during the late imperial era, see Ho (1964) and Greenhalgh (1988). The use of a civil service examination for government service was also used in Western countries, but only much later. England adopted a government service examination in 1870, and the U.S. in 1883 (Miyazaki 1976, 124).
[5] By about 1650, the only types of hereditary privileges and automatic status that remained belonged to the imperial lineage—where the throne was passed from the emperor to one of his sons—and the families of the Eight-Banner system. The latter was an exclusive hereditary institution that dominated military and command functions, and men born into banner families held a caste-like elite position. Elliot (2001) estimates the total banner population in the early 18th century was 3% of the population of China, most of whom resided in Beijing and Manchuria.

directly inherit official positions and titles, earned income could be passed on to descendants because of an economic environment of generally secure property rights combined with low taxation during the period under study.

In this paper, I first examine how family size changes as we move across the socioeconomic distribution of households in society. Pooling all households leads to the well-known Malthusian result that richer households produce more children.[6] I then use the bios of individuals in the genealogies to pin down the status of each household head. Once I condition on the ages of parents and the number of marriages, there is evidence for fertility control in the relatively high income households. These households had the resources to support the largest families, yet were choosing not to do so. This is the basic quantity-quality finding that holds true for families in China as early as the 1600s.

Next, I investigate whether human capital investment was a driving factor in fertility decisions. The history of education in China suggests that all civil service candidates faced schooling fees and opportunity costs, but the effective cost of getting a degree was lower for some than for others. In the quantity-quality framework, if there is heterogeneity in the cost of education, one expects that households that have lower costs tend to increase child quality relatively more. I compare family size for households that have educated sons and those that do not, finding two empirical regularities. First, the fraction of households that invest in education is higher as we move across the distribution of status. Second, educational attainment is heterogeneous even for individuals who are similar in terms of status or income. Some families had considerably higher proportions of degree-earning men compared to others. In addition, not all higher status families produced highly educated children who could pass the official examinations. Notably, men who possessed higher human capital not only came from higher status households, but they also tended to have fewer siblings.

I further investigate why some high income households are more likely to invest in education. A key idea that I examine is whether households with older generations who are themselves educated are more likely to produce younger educated members. This would happen because costs are likely to be lower for these families since men with educated backgrounds have better access to knowledge resources. I find that men who are educated are more likely to have

[6] See Harrell (1985) for evidence that rich households tended to have relatively more children.

fathers, grandfathers, and more educated family clan members in the father's generation. This is a finding that is consistent with costs of education being important to family size. These results are robust to controlling for birth order, which is well-known to affect human capital investments.

Over time, the government did not expand the number of high-ranked official positions in proportion to population growth. This meant that as population increased it became increasingly more difficult to obtain a degree by studying for the imperial examinations, implying that in China the net return to human capital investments may have fallen. Consistent with the historical evidence, I find that the fraction of highly educated individuals in my sample declined across all status categories over this time period.

The return to education is a factor that has thus far been largely overlooked in empirical studies of fertility change, but it is the major source of the quality-quantity tradeoff that is believed to be responsible for the origin of demographic transitions. The evidence presented in this paper is consistent with the view that households that invested in education had smaller families. Costs of education mattered to family planning calculation in the pre-industrial era, and for households that could make those investments it gives rise to patterns that we have so far associated with post-industrial populations.

These results contribute to the existing literature in several ways. Key questions that have been debated in the literature on the fertility decline in Europe concern the timing of fertility decline across countries, and its relation to incomes and rates of growth of those countries. The lack of general consensus on these issues is in part related to the fact that fertility measures computed at the country-level tend to confound differences in underlying reasons for fertility change within countries.[7] Indeed, taken as a whole, what recent studies have demonstrated is that there is much more variation in fertility rates at the disaggregated level, which makes the question of timing fertility decline more complex.[8] Another reason why correlations between income and fertility changes have ambiguous interpretations for Europe is

[7] See Coale and Treadway (1986) for a summary of the Princeton Project's study of fertility, which dated fertility decline in many European countries to the late 19th century; and methodological critiques of these findings in Guinnane, Okun, and Trussell (1994) and Guinanne and Brown (2007).

[8] Related to these questions are studies on Western countries that identify when signs of fertility decline can first be detected. For example, Haines and Hacker (2011) find fertility declines in the U.S. by the 1800s; Weir (1994) identifies the 1790s as the start of French declines. Knodel (1988) presents evidence of marital control among German couples for 1800-1824. For studies on family size and income in England: see Clark and Hamilton (2006) on the 16th and 17th centuries; Garrett et al. (2001) on the 19th century; also Wilson (1984).

that the source of income changes likely happened quite a bit earlier than when increases in per-capita income appear in national incomes statistics.[9] Given the likelihood that the social changes and productivity increases that have been the basis of Western industrialization go back to the 17th century or even earlier, it is difficult to rule out the possibility that demographic change occurred after, or, at least at the same time as the onset of modern growth.[10]

Unlike Western Europe, by all accounts China was not on the verge of industrialization in the 18th century. There were many structural shifts associated with incipient growth—due for example, to new technology, women's work, old age security, or public schooling—that had taken place in parts of Europe, but had not yet occurred in China. This should reduce concerns that changes in human capital investments are simply the mirror image of changes in the growth rate, as can happen if technological innovations or institutional changes were to affect both.

A separate literature has debated the extent of fertility control among the Chinese population, especially in comparison to European populations as of the 18th century (Coale1985; Lavely and Wong 1998; Lavely 2007; Lee and Wang 2001; Wolf 2001). Some of these studies have attempted to establish that marital fertility rates in China were low compared to European couples, and have looked at how this lowered fertility was achieved in the absence of modern contraception. This paper contributes to the literature on fertility control in China by assessing *why* some households had the incentives to reduce fertility.

Further, there is considerable debate on whether the quantity-quality tradeoff exists in developed countries that are no longer in the midst of a demographic transition. It is difficult to establish a causal relationship between education and fertility because family size may be related to other characteristics that affect child education. Previous papers have used exogenous sources of variation associated with twins (Rosenzweig and Wolpin 1980; Black et al. 2005; Angrist et al. 2005), or policy (Qian 2009), to determine if increases in family size decrease schooling. My sample precludes using twins and gender composition as instruments for family size, and the information I have on Chinese clans does not allow a fully-convincing causal effects analysis.

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[9] For example, after Newcomen and Watt pioneered the steam engine in 18th century Britain, by the 1830's the first railway lines were being constructed in Germany as well as the United States. Between 1825-1850, markets in Europe were much more integrated than they were just 50 years earlier, suggesting that the roots of modernization had taken hold (Shiue and Keller 2007; Keller and Shiue 2013).

[10] See Mokyr (2012) on the social origins of European industrialization in the Enlightenment, which dates to the 17th century. Allen (1992) documents changes in wages and agricultural productivity in England between the late medieval period and the 19th century.

While below I control for some first-order endogeneity concerns, the results reported in this paper should not be seen as "treatment" effects. The main contribution of the paper lies elsewhere. It paints a detailed picture of how the institutional environment of the Qing state with its tournament-style examinations in the absence of public education shaped the human capital investment and fertility decisions in China over several centuries. It is the only paper I am aware of that establishes that differentials in educational costs matter to family size in a pre-industrial economy.

The organization of the paper is as follows: Section 2 provides historical background on socioeconomic status, education, and human capital investment decisions in China during the Ming (1368-1644) and Qing Dynasties (1644-1911). Section 3 introduces a theoretical framework that guides the empirical analysis. Section 4 discusses the data and descriptive statistics on Tongcheng, Anhwei Province. The main empirical results are in section 5. I first examine the relationship between status and family size, finding both Malthusian and non-Malthusian elements as far back as the 1600s. Section 5.2 provides evidence on the quantity-quality trade-off that households faced, while in section 5.3 I explore the role of the costs of education as affecting the demand for human capital, as well as other factors in explaining these patterns. Section 6 concludes with a discussion of the implications of these findings.

2. The Ming-Qing educational system and state-examinations

Anecdotal accounts suggest the costs of schooling to attain basic literacy during the Qing period were modest. It is estimated that around 30-45 percent of males and 2 percent of females were literate in the late Qing (Rawski 1979, 23). Young boys might begin their education anywhere between the ages of seven to eleven. Over three or four years, children could learn approximately 1,000 characters, which was a sufficient number of characters to be able to read business contracts and vernacular text (Leung 1994, 393; Ebrey 1993, 348).

Parents of even moderate means could pool together tuition fees to hire a local schoolmaster—drawn from the pool of men who tried but were unsuccessful in the imperial exams—to teach village youngsters basic literacy in return for room and board, meals, and a small allowance (Ebrey 1993, 72); other types of support might be had from the lineage. Other teachers may have been elites who held degrees and were retired from their civil service career.

Much more time and effort than for basic literacy was required to prepare for the imperial examinations. Evidence of the costs of higher education can be seen in the private academies established in the 18th century, which allowed teaching and classical research to be alternative careers to government appointment. The cost of taking the metropolitan examinations during the 16th century is estimated to be around 833 silver dollars, a large amount. (Miyazaki 1976, 118). For comparison, it is estimated that the literati (those who were literate in the classics and therefore could enter teaching careers) had food, shelter, and an average income of 778 silver dollars in the 19th century (Elman 2002, 403).

While the state established the content and curriculum for the official examinations, the initial preparation for civil service was a private investment decision. Because schooling was neither mandatory nor regulated, a wide variety of schools could be found, with some kind of school present in most villages and urban centers (Rawski 1979,17; Leung 1994). Specialized schools, and officially subsidized schools, such as the schools specializing in military education of medicine, or national schools that were open to students preparing for state exams, could also be found. Private institutions also flourished—academies such as those established by salt merchants of Guangzhou, for example, may have allowed their sons to receive the best schooling of the empire (Elman 2002, 403-06).

By the 18th century, China was characterized by a market economy that in many ways functioned as well as the leading economies of Western Europe at the time (Shiue and Keller 2007). It was also, at least in principle, a meritocracy where non-elites could not be barred from gaining entry into wealth, high status, and political power upon passing the state administered written examinations. Especially gifted boys could rise in a rags-to-riches way through the ranks and there were men of legendary brilliance who did so (Elman 2000, 263). Generally, however, the sons of the upper class families had much better opportunities and much greater resources to receive the schooling and tutoring that was required for exam preparation. Although women were barred from state service, upper class girls also received lessons and were literate. For gentry boys, schooling likely began earlier than for most, at the age of 5, perhaps first with their mother and then with hired tutors (Elman 1991, 16-17).

The state examinations took place in stages, much like a tournament. Literate men were nominated at the county level for candidacy to the first level examinations. From the Ming to the

Qing, around 1-2 million candidates sat for the examinations, which were held every other year. Those who succeeded in this initial degree were licentiates (*sheng-yuan*), and were enrolled in the prefectural or county school to prepare for the next stage. To do this, these men were allowed a monthly rice stipend, free room and board, and exemption from corvée duty for themselves and two other adult males in their family (Ho 1964, 172-3). Candidates known to pass these licensing examinations were as young as 15 years, but most were in their twenties (Elman 2000, 263). Even passing the licensing examinations at the county level conferred a significant measure of status. Estimates place the number of licentiates in the nation in 1700 at 500,000 (perhaps 0.3% of the population).

Every three years, provincial exams were given in the provincial capital, taking place over a period of nine days.[11] Students wrote their exams in secluded cubicles and soldiers monitored the room to prevent cheating. Names were removed from exam papers and given anonymous codes. Those who passed these exams were Provincial graduates, who were already eligible for official appointments, but they could also choose to take the next level examinations, the metropolitan examinations, which took place in several rounds. A few thousand examiners were involved in this process, and at the conclusion of those exams a list of the successful candidates was produced, in rank order. Graduates of these exams enjoyed an extremely high reputation.

Exam questions were based on the moral and political thinking of classicism, and required candidates to compose poems and essays. The exams were not exclusively humanist, however, and included also policy questions on statecraft, fiscal policy, as well as military and political institutions at the time.[12] For example, in the first metropolitan exam of the Qing dynasty in 1646, the regent asked how the government could bring Manchu and Han officials and people together for a common purpose. This was an important question for the Qing Manchu government that sought to rule over a Han Chinese population. The question of the usefulness of the knowledge that was tested at the official exams is a subject worthy of study in its own right. For the purposes of this paper the content of the exams is not directly relevant. What is critical is that there was a considerable private return for investments in education, and that these investments were not small.

[11] Upwards of 4000 persons appeared for provincial exams at the capital (Twitchett and Mote 1998, p. 36)
[12] See Twitchett and Mote (1998), Ch 7, p. 361.

For those who received official degrees, their subsequent position as an official of the Qing state enabled them to amass a relatively high income (Chang, 1962, 3). This income, derived from both formal and informal sources, enabled the government official to have a relatively high living standard, contribute to local community projects, and make investments in landed property. It has been noted that an official position in the government offered some of the most financially rewarding careers available, and that the prestige and power that came with such positions was unmatched (Elman, 2000, 292). Merchants who had accumulated fortunes could on occasion purchase minor titles and thus buy into some part of the governing elite, but participation in the state exams was the direct route, and the only way to acquire higher level positions.

Over the Ming and Qing Dynasties, the return to education in the form of lifetime income from official salaries and bonuses remained significant and such individuals continued to enjoy prestige and high status. The annual salary of the head of the province (the governor-general) in the 18th century, plus the expected official bonuses, informal gifts, and grain easily surpassed the value of 250,000 silver dollars. For the head administrator of the county (the district magistrate), the sum of informal bonuses and gifts alone would have amounted to about 45,500 silver dollars per year (Wakeman, 1975, 26-27).

There were multiple levels of degrees that could be earned. The lowest level degree, the licentiate status (*sheng-yuan*) was given to men who passed the initial exam that licensed them to enter further examinations at the provincial level, which could eventually lead to the *jin-shi* degree, one of the highest awards that could be earned through the civil service examination system. The government controlled annual maximal quotas for the *sheng-yuan* degree.[13] The early Qing government based their land tax, head tax, and *sheng-yuan* quotas from the beginning of the Wan Li period (1573-1619) of the Ming Dynasty (1368-1643). From then on, fluctuations in the total cumulative number of *sheng-yuan* degrees during the first two centuries of the Qing period were not large (Ho, 1962, 179).

The regional distribution of academic success across provinces was unequal. For example, Zhejiang had the highest number of *jin-shi* degrees (3,280) during the Ming Dynasty. Anhwei

[13] In 1536, a statue allowed even candidates that had failed the exams many times to retain the student's privilege of tax exemptions. In 1661 maximal quotas for the numbers of eligible candidates per year were 20 for a large prefectural city, 15 for a large and "cultured" county, and 4-5 for a small and "backward" county (Ho, 1962, 179).

Province, which had about 87% of the population of Zhejiang at the time, had 1,036 *jin-shi* degrees—ranking right in the middle out of the empire's 18 provinces. More isolated provinces, such as Guizhou in the west and Liaoning in the north, produced only 85 and 57 *jin-shi*, respectively, during the entire 273 years of the Ming Dynasty. To the extent that there are no strong differences in the distribution of talent across provinces, these regional inequalities suggest that there were important differences with respect to demand or access to education across China.

Anecdotal accounts point to the Chinese culture holding education in high regard. For instance, merchants that became wealthy used that wealth to invest in the education of their sons for civil service careers. This can be interpreted in at least two ways. One is that as households become richer, they begin to prefer more educated children, and poor households rather preferred more children to help with the agricultural work at home. An alternative interpretation is that all households prefer to have educated children, but education was affordable only for the wealthier households. The next section introduces a framework for capturing these ideas.

3. Framework and testable implications

This section introduces two main reasons that may be behind a child quantity-quality tradeoff, before turning to the empirical implications of each. Consider the standard household utility maximization framework (Houthakker 1952, Becker 1960). To examine how income changes and changing costs impact on fertility choice, let utility of the households be given by:

$$U = U(n, h, c) \qquad (1)$$

where utility, U, is a function of *n*, the number of children, *h*, child quality or human capital of each child, and *c*, consumption of other goods by the household. Let *y* be the exogenously given household income, and suppose that all income is spent on either consumption (*c*) or on quality-adjusted number of children, (*nh*):

$$y = \pi nh + c, \qquad (2)$$

where π is the relative price of quality-adjusted children. The first order conditions of the utility maximization problem give the marginal utilities for the number and the quality of children: $MU_n = \lambda h\pi$ and $MU_h = \lambda n\pi$. These relationships show that the marginal costs of children with respect to the number (quality) is positively related to quality (number of children). This corresponds to the idea that increasing quantity is more expensive if the education level of each child is higher.

Consider the argument that increases in income generate declines in fertility. Becker and Lewis (1973) assume that the income elasticity with respect to quality, η_h is substantially larger than that for quantity, η_n (see also Becker 1960). The assumption is one way of generating the trade-off between child quantity and quality. Assume for simplicity that $\eta_n = 0$ and $\eta_h > 0$. Then, if income increases while prices are constant, the direct effect is that human capital will increase while *n* stays the same.[14] The increase in *h* means that its price will tend to fall, and parents will substitute child quality for child quantity. The number of children (n) will decline, reinforcing the direct effect of an increase in human capital per child.

Alternatively, a decline in the cost of education can also produce a quantity-quality tradeoff through its impact on the demand for human capital. Consider the following log-linear household utility function as a special case of equation (1):

$$U = (1-\gamma) \ln c + \gamma [\ln n + \beta \ln h(e)] \quad (3)$$

where the parameters are $0 < \gamma < 1$ and $0 < \beta < 1$. Human capital is a function of the education level, *e*: $h = h(e)$. Assume that *h* is an increasing, strictly concave function of the parental time investments in the level of education of each child, *e*. Each household is endowed with one unit of time which, if supplied to the labor market, gives income *y*. Also let π^n be the fraction of the household's unit-time endowment that is required for raising a child, and π^e the fraction of the household's time-endowment that is required for increasing one child's education by one unit.

From this, the total time cost for raising a child of education level *e* is given by $\pi^n + \pi^e e$. The household budget constraint is that spending on consumption and raising children cannot exceed income:

$$ny(\pi^n + \pi^e e) + c \leq y \quad (4)$$

where $y(\pi^n + \pi^e e)$ is the price of a child with education *e*, which is the opportunity cost of raising it.

[14] This increase in human capital has the additional effect of increasing the shadow price of child quantity.

In this framework, it can be shown that a unique and interior equilibrium exists (Galor and Weil, 2000; Galor, 2012), and it defines an optimal level of investment in child quality, $e = e$ $[\beta, \pi^e, \pi^n]$. For my purposes, the most important comparative static result is with respect to the cost of education. The optimal level of investment in child quality increases if, all else equal, the costs of education fall ($\frac{\partial e(\beta,\pi^e,\pi^n)}{\partial \pi^e} < 0$). Conversely, investment in quality decreases if the costs of education rise.

Implications for the Analysis

First, section 5.1 of this paper examines the quantity versus the quality of children in relation to income along the lines of Becker (1960) and Becker and Lewis (1973) to see whether there is evidence that richer parents systematically prefer a higher quality per child. The argument that an increase in income generates a decrease in fertility implies that in the cross-section of incomes in a society, richer households have a higher level of quality per child than poorer households. Moreover, if income is the main driver of fertility change, then once we have controlled for income, differences in other factors should not matter for the human capital investment decisions households make.[15]

Second, in section 5.2 I turn specifically to human capital investments as an alternative explanation for the observed fertility patterns across households. Human capital investments in the form of preparing one child for the official state exams were certainly large enough that they could force the household to re-optimize its optimal number of children (see above). In fact, educational expenses were so large that one would not expect that they could be shouldered by poor households, and for these households there would be no quantity-quality relationship. Instead, success cases for these households depend on sheer luck (the occasional brilliant child) together with limited state subsidies. In section 5.2, I show that indeed, the quantity-quality tradeoff existed only for the higher status groups, putting the majority of the population in the realm of Malthus.

Third, if the demand for human capital matters in addition to income, we should observe differences in education and family size within particular income brackets that are related to

[15] At the same time, Becker (1981) notes that the quantity-quality tradeoff may be driven by factors other than income, including the demand for human capital.

factors affecting education costs across households. For example, comparing families with the same number of children, some families may have produced educated children, while others did not. The question is whether these differences between households are random, or whether they are systematically related to differences in the costs of education across households.

In section 5.3 below I examine a potential source of cost differences within high income households. Child education may be less costly for families with older generation members who are themselves highly educated.[16] More educated fathers may have had better connections to resources for education, and more channels through which to influence the outcome. The ability to supervise the educations, access to schools and tutors, or even nepotism may be the reason for lower costs for these households.

Therefore, a testable hypothesis is whether children who came from families sufficiently rich to attempt the examinations were likely to have older family members with high level educations. Specifically: Is there generally a lower level of fertility for the relatively high income households, or rather, is lower fertility observed among the households at high income who are investing in the education of their offspring? The latter scenario would suggest that demand for human capital is an important driving force of lower fertility. The next section discusses the data that will be used to examine these issues.

4. Data

The following section introduces the genealogy as a data source. I also discuss the historical background of Tongcheng County and descriptive statistics of the main variables used in this paper.

4.1 Tongcheng Genealogies

The data are from the genealogies of Tongcheng County, in the prefecture of Anqing, in Anhwei Province. The county is approximately 30 miles by 60 miles, and is situated on the Yangzi River about 300 miles inland from the coast of the East China Sea. The county is about 150 miles from Nanjing, the early Ming Dynasty capital, and 650 miles from Beijing, the later Ming and Qing capital. Anhwei Province was representative of the more developed and densely

[16] Families may also have other shared commonalities, for example, genetic advantages.

settled regions of China, with Tongcheng considered a centrally important economic region in the relatively developed agricultural economies of the lower Yangzi. The region was mainly a rice-producing area where the wealthiest families were typically landowning gentry (Beattie 1979, 130-131). Over the Ming and Qing Dynasties, the region gained some fame for having produced a number of the highest officials of the empire.

The dataset is created from genealogies of seven clans, or families, from Tongcheng County. The purpose of genealogies was to keep a record of the rituals of the family and a record of the achievements of its members.[17] They were compiled and updated by the literate members of the lineage to aid in the ritual of ancestral worship. The genealogies were valued and kept in the hometown of the lineage in ancestral halls, providing future generations with a record of the location of graves, texts relating to grave worship, family rules of conduct, biographies of prominent members, a record of lineage lands, and an overall history of the family.

Genealogies are essentially different in size of compilation. Small family genealogies, for instance, may cover only a few dozen people and have significant sample selection profiles, while large genealogies may list many names with little personal detail. Genealogies compiled from a mid-to large sized lineage of thousands of individuals, such as those underlying the analysis in this paper, provide a balance between biographical detail and sampling of individual data across the socioeconomic distribution of the population (Telford, 1986).

Researchers have found overall consistencies in the way in which genealogical data record the population, supporting their use for demographic study (Harrell 1987; Telford, 1990, 1995). Nevertheless, even within the relatively detailed genealogies, there are both strengths and weaknesses. Coverage of the upper status members of the lineage tends to be more extensive and complete since genealogies were a record of the achievements of the lineage. This is useful for the analysis in this paper because key aspects of this paper focus on households of high status men. In addition, the focus of the present analysis is on the group for which the genealogies have the most complete data: married men. Information on daughters lacks some of the details that are supplied for sons, and infant mortality rates are uncertain.[18] Despite these caveats, since the Chinese government did not collect data on households outside of the imperial hereditary

[17] Surveys of the content and scope of Chinese genealogies are Liu (1978) and Telford (1986).
[18] Permanent out-migrants would also cease to be recorded in genealogies, but the extent of migration was low.

system and the banner military households, genealogies are the most complete source of demographic data available for the vast majority of China's historical population.[19]

4.2 Descriptive Statistics

Although privately compiled, Chinese genealogies follow certain conventions. Chinese genealogies are organized patrilineally. All male individuals were lineage members, and as such they were eligible to be included in the genealogy. The progenitor of each of the Tongcheng clans included in the dataset is recorded sometime before the year 1500, and in some cases considerably before 1500. The earliest birth year recorded is the year 1298 (Chen lineage). About 90 percent of the married men were born in 1650 or after, and the last birth date is 1885. Figure 1 provides a graphical representation of the sample over time, showing that the majority of the observations are in the later part of the sample period.

The average number of years covered for all seven clans is 495 years (ranging between a minimum of 286 years and maximum of 571 years). It is possible to follow the demographic patterns of the seven families for an average of 14 continuous generations, with a maximum of 20 continuous generations. In the sample from which the intergenerational linked data is drawn, there are in total 9,769 married men, all of whom were over the age of 17. Table 1 gives descriptive statistics of the main characteristics for the Status, Birth and death, Marriage, Fertility of these men and their households.

Married men fathered anywhere from 0 to 11 sons. Table 2 shows the frequency and percent of total sons observed across male head of households, in which all sons from all marriages of a particular father are combined. Daughters were 35.6 percent of the sample of children in their father's genealogy, suggesting not all daughters were recorded. In the main specifications, total sons will be my measure of family size, but I will examine the daughter data as well.

Figure 2 shows the fraction of households with different family sizes, for each status grouping to be discussed below. About 19 percent of the married males had no sons that survived beyond childhood. Mortality likely played some part. Life expectancy at birth for all

[19] For the leading study based on official Banner population registers, see Lee and Campbell (1997).

recorded males was about 30 years in the 17th and 18th centuries.[20] Conditional on having reached the age of ten, life expectancy was 36 years overall.[21] Among the sample of men over 14 who also married, mean life expectancy was 52, with a standard deviation of about 14 years. Among the unions that produced children, there are 31,336 entries with information on individual children.

Population growth overall in China was relatively rapid in the 18th and 19th centuries compared to the past. Much of the increase took place on frontier lands, but the population residing in Tongcheng also increased. By 1790, gazetteer data for Tongcheng report a population of about 1.3 million.[22] These numbers indicate the fraction of the total population sampled by the current dataset is around one-half of one percent. The nuclear household consisted of parents and their children. Co-residence among younger and older generations was common practice during the Ming-Qing era. Tax census data for the late 18th century suggests the average size of the extended family was about 7 to 8 persons, typically with the grandparents sharing a household with their sons and grandchildren.

There were 11,378 marriages observed among these men, with vital statistics on month and year of birth and month and year of death reported also for each of their wives. Most men married only once, and those who married more than once typically did so after the death of their spouse. Remarriage upon the death of a spouse accounted for about 12 percent of all marriages. Polygynous unions occurred in less than 2 percent of all married men.

To examine if the fertility patterns recorded in the genealogies are what we would expect from a biological point of view, Figure 3 gives age-specific marital fertility rates, which is a well-known method of summarizing fertility. These curves depict the average number of births (of sons) per woman per year within bracketed 5-year age groups, for each of the seven clans. The genealogies do not record the date or age of the wife at time of marriage, but the timing of first births generally confirms an early marriage age for women in China. Also, births per

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[20] This is well within the range of life expectancies for largely agrarian economies. Compare with England in the 18th century (35-38 years), France in the late 18th century (28 years), Anhwei Province, China from 14th to 19th centuries (28 years). See table 5.2 in Clark (2007).

[21] Lee and Campbell (1997, 60) find life-expectancy among the Banner population for the age group between 10 and 15 years to be on average 48 years for the late 18th to mid-19th century, and life-expectancy at 6 months of age around 33 years.

[22] Gazetteers were local histories about a certain place. Three county-level gazetteers about Tongchong cover the period under analysis: *Tongcheng xian zhi* (1490), *Tongcheng xian zhi* (1696), *Tongcheng xuxiu xian zhi* (1827).

woman per year drop off with age, reaching zero by age 45-49. Overall, the patterns which emerge from the Tongcheng genealogies are broadly consistent with what we know from historical sources about the early marriage of women in China relative to European women, and also with what we would expect to be true biologically about fertility and age. Unlike a completely unregulated, natural fertility curve, which exhibits a clear fertility peak at the 20-24 age bracket, for four of the seven clans, there is a noticeable flat portion between the 20-24 and the 25-29 age groups. This suggests that delaying first births was one way in which some couples kept total fertility below the biological maximum.

Descriptions of each individual's socioeconomic status are contained in the genealogies, and they have been converted into a data code. Table 3, Column (iv) shows the different categories of status descriptions that can found in the Tongcheng genealogies and were systematically coded. Because these descriptions were written about deceased members of the clan, somewhat akin to an obituary, we can infer that these bios represent the highest lifetime achievement for each individual. Annual salary schedules of civil and military officials were established by the Qing court and openly known through official publications. Degree titles were also clearly ranked by the government and reproduced in Chang (1955). Descriptions that fall outside of the government are ranked in a manner consistent with what is known about Ming-Qing society (Ho1962).

While the 23 status categories are interesting, there are few observations in some of these categories, so that the 23 socioeconomic divisions are too finely divided to make robust comparisons. Thus, in order to obtain a breakdown of the percentage of men in each status group that is easier to interpret, I have constructed a status variable that groups the 23 categories into four status groups shown in Table 3, Column (i).

The lowest status category—"Low Status"—consists of men who had no titles, nor notable accomplishments, nor evidence of wealth attached to their names in the genealogy. This applies to the majority of individuals. These households were likely to have been peasant farmers and artisans. The next group— "Moderate Status"—includes men for whom there is some evidence of wealth, but no claim to a recognized title or position. These men may have been a village head, or may have received some honorary or posthumous title because of their contributions to the lineage. Men with no other evidence of status other than having multiple sequential marriages are included also in this category, as are men whose only claim to status is through the status of their father or grandfather.

There are two higher status groups. The "Near-high Status" are men who had more significant indicators of wealth and property in the genealogy, yet did not have any of the high-level official degrees or positions. For example, men who had no official title, but who were able to make substantial contributions, philanthropic or otherwise, were likely to have been wealthier farmers, landowners or merchants. Other men in this category were individuals who may have prepared for, but did not pass their official examinations. These men would have been able to earn incomes as tutors or schoolmasters.[23] Yet others in this category may have purchased minor official titles, or, held relatively minor official positions in the military. The highest status category, designated by the "High Status" label, includes men who had obtained moderate to high degrees, and had or were expecting appointments in the military or civil branches of the government above minor rank.

I will also examine the subset of clan members for whom I have information on the education of the individual himself, as well as the father's and the grandfather's education. The coding of education is in Table 3, (iii). Since I am interested in those that made significant human capital investments, men who had evidence of educations, according to their genealogical bio, are coded with Education equal to 1. Men who not only passed the licensing examination, but also those whose highest lifetime status was having prepared for (but failing) the examinations are also coded with 1 for Education. Others are given a 0 for Education. All educated male heads of households are categorized into one of the upper two status categories, but not all households in the two upper status categories were educated. It was possible to have minor official status through the purchase of a degree, for example. Men who obtained purchased degrees were given an Education code equal to 0.

Descriptive statistics on the Educational Outcomes of this 3-generation linked sample are presented in Table 1. Shown there are means for the education of all heads of household, their father, their grandfather, as well as three measures for the education in their clan. These three measures give the average education of all males that are in the same generation as the father of

[23] The sons of titled officials are placed in this category, rather than in the lowest category, if they did not have other signs of income or status. It is highly likely that these sons were literate, even if they did not obtain degrees. Placing these sons in the Low Status category would not change the qualitative results that follow.

the head of household, the aggregate education of all males in the same generation of the father, and the average education of all males in the same generation as the grandfather of the household head. These variables aim to quantify the extent of education in the clan over members who are most likely to be alive at the same time as the head of household. The table also shows the average breakdowns of education across the seven clans, for all members. The Ma clan, in particular, is an exceptionally well-educated family, where 34% of the married adult men had extensive formal education. By contrast, the percentages for the Chen, Zhao, and Zhou clans are 1%, 2% and 2% respectively.

Table 4 compares the relative percentages of each status in the sample. The upper Panel A is the sample of 9,769 married men. For comparison, the lower Panel B is the linked sample where information on education across 3 generations is available. The status percentages across the two samples are broadly similar. Around 70% of the sample households are of low status, and between 10% and 16% of the married men in the genealogy appear in the upper two status categories, with 3% in the highest category.

The percentages given in Table 4 appear to be plausible. As a privately compiled family record wherein all male members were eligible to be included, the fact that the large majority of the households is Low status is consistent with that. Chang (1955, 1962) estimates that in the early 1800s, there were in total over 1 million men who held official degrees and titles, constituting about 2 % of China's population. These of course are national aggregates, but still, the numbers are not far off from the 3% High Status category that appears in the Tongcheng genealogies. Two additional points are worth noting: first, the present sample, which consists only of married men, can be expected to include a higher share of men with some form of status; and second, Tongcheng must have had a relatively high share of the educated population within Anhwei due to its location and reputation for producing officials.[24]

Figure 4 depicts one of the central relationships that will be examined further in the empirical section of this paper. The three lines show the family size—defined as the total

[24] Another difference between Chang's estimate and mine is that Chang's estimates are based on official quotas for different government positions and degrees, and so it does not include the legions of men who tried but failed the exams. These include the 1-2 million men that sat for the licensing examinations every other year across the empire—we know they must have been educated, because they already had to have passed a series of pre-qualifying tests in their districts. Other than through genealogies, it is not possible to find out who these men and their families were.

number of brothers—of men in the two upper status categories. The upper solid line shows the family sizes of men who were not educated, while the dotted line shows the family sizes of men who were. Over time from the 16th to the 19th centuries, men who were not highly educated came from larger families than those who were. The men who were highly educated had smaller families than what is seen for the entire sample, including all Low status families.

5. Empirical results

The empirical results in this paper come in three sections. I begin by examining the relationship between family size and status. Because status is positively correlated with unobserved income as well as wealth, I use status to investigate whether in this economy the central Malthusian mechanism that higher income translates into additional population growth was at work. The second part turns to the quantity-quality trade-off by examining whether there is a relationship between the number of children and their level of education across households. Finally, I assess the importance of demand for human capital and other factors, in particular birth order, for the relationship between child quantity and quality that will be documented.

5.1 Status and Family Size

The Malthusian model predicts that higher income increases population. Is this the case in our data? Because the data is organized according to the male lineage, the measures below use information on the status—a proxy for income—of the father as the head of household, as well as the number of sons of the father as the main measure of family size. Variants of the following equation, relating the family size of household *h* at time *t* to the status of the male head of the household, are estimated:

$$fam\_size_{ht} = \beta_0 + \beta_1 status_{ht} + \gamma' \mathbf{Z} + u_{ht} \tag{5}$$

where family size is the total number of sons of the household, and u_{ht} is assumed to be a well-behaved error term. The vector **Z** contains a number of additional variables including a time trend as well as demographic characteristics of the household. Equation (5) is estimated by OLS, and, given the non-negative count nature of the dependent variable, other regression models. I am mostly interested in the coefficient β_1. If Malthusian forces are strong in the economy under consideration, then households with higher levels of income at a specific point in time should exhibit larger family sizes, and β_1 is positive.

I begin by estimating equation (1) with *status* and a time trend as the only independent variables by OLS; Column 1 of Table 5 shows the results. The coefficient on *status* is positive, indicating that higher status households tended to have larger families. For the subset of the sample for which I can link each person to more detailed demographic information, the coefficient on *status* is also positive albeit smaller in magnitude (0.078, see Column 2). This indicates that the sample per se does not matter for the qualitative results.

Modifications to the simple Malthusian world start to appear when I allow the coefficient to vary across the four status groups. Now the highest coefficient is found for the Near-High status group. In line with Malthus' hypothesis that increases in income lead to greater population, households of Moderate status have a larger family size than Low status households. However, High status households do not have significantly higher numbers of children than households with Low status (Column 3; Low is the excluded category, with a coefficient of zero by construction).

Higher status households had a number of advantages, including more resources that translated into longer life expectancies, as well as more potential marriage partners. Thus, it is possible that the advantages of high status can in large part be captured by these differences. As one would expect, the number of sons tends to be increasing in the number of wives the head of household had (Column 4). That the inclusion of number of wives lowers the point estimates of status is consistent with the idea that having multiple wives helps to account for a relatively high number of sons. This is true at every status level, even though remarriage occurred more frequently for the higher status men.

Further including the head of household's and wife's age of death reveals that high ages are positively correlated with family size (Column 5). This suggests that when the number of wives and age-at-death are not included, status is essentially picking up their relationship with family size. The Malthusian effect between status and family size is dictated by aspects of the pre-industrial world: short life-expectancies meant that fertility could be cut off by premature death, so how long parents live mattered and whether or not multiple marriages took place are important factors to total family size.[25] While clearly age at death and number of wives are not independent of status, once these are taken into account the picture that emerges is quite different from the one without these variables (compare with Column 3).

First, after the demographic controls are taken into account, family size is significantly lower for Near-High and High status households than for Low and Moderate status households. In the analysis below I therefore will treat the higher two status groups separately from the other status groups. In addition, the negative coefficient on status is larger (in absolute terms), the higher is the status of the household: the coefficient for Near-High is about -0.22 while that for High is about -0.52 (see column 5). This lower fertility in higher status households, even though the means of subsistence are easily surpassed, is suggestive of a deliberate effort of these households to limit family size.

At the same time, households with Moderate status tended to have larger families than the poorer households with Low status, as the positive coefficient on Moderate in column 5 indicates (significant at a 10% level). Thus, conditional on age at death and number of wives, the results are consistent with the Malthusian regime dominating the bottom 88% of the population, while at the same time there is evidence that the top 12% behaved in a rather un-Malthusian fashion.

To address concerns that biases in OLS might arise from the fact that the dependent variable is asymmetric around zero, I use the median regression, which is more robust than OLS in this respect. Column 6 shows that overall the median regression estimates are similar to those obtained with OLS. Moreover, these relationships between status and family size exist within each clan; while introducing fixed effects for each clan affects some of these point estimates, it does not change the main findings (see Column 7).

The last two columns of Table 5 give separate OLS regression results for the period before the year 1600 and after, labeled "Before 1600" and "≥1600." Before the year 1600, there is no strong evidence that family size varies by status conditional on the number of wives and the ages-at-death. Put differently, higher status households had, by and large, more children than lower status households only to the extent that they lived longer and there were more wives. In

[25] Remarriage would take place mainly on the side of the husband, since by custom widows rarely re-married upon the death of her husband.

the post-1600 era however, higher status households have significantly fewer children than low status households in these specifications. Thus, family size in higher-status households falls below what one would expect given their longevity and other indicators of status, and one possible explanation for that is fertility control.

This relationship between status and fertility is also robust to the presence of outliers and an alternative definition of status which distinguishes only two set of households, those with no sign of any form of status, and all others. The former group comprises of the households with Low status, which account for about 70% of the sample. These additional estimates are given in Appendix (section I and Table A).

Overall, these results suggest that early sources of fertility decline may have existed, especially in the higher status groups. One might be concerned that the genealogies systematically under-count the sons of high status households. This, however, is unlikely—genealogies have been criticized for underreporting certain types people, such as criminals and social outcasts, but high status sons is not such a group. Undercounting births outside of marriage is unlikely as well since virtually all births took place within marriage and illegitimacy rates were low.

How large was the difference in family size between higher and lower status groups on average? Beginning with the 17th century, the High status group had about 16% fewer male children than the Moderate status group, if the husband and wife both survived at least to age 40. To gain some perspective, the Princeton European Fertility Project (PEFP) employs a 10% decline in marital fertility as the definition to date the start of a demographic transition. While my analysis is for a smaller population within society compared to the PEFP fertility rates, which are based on country-wide fertility rates, nevertheless a difference of 16% appears to be significant. The next section focuses on what the sources of lower fertility might have been and why they are observed mainly among higher-status households.

5.2 Family Size and Education

Results on the relationship between fertility and human capital investment choices as a function of status are given in Table 6. A convenient starting point is the following linear probability model:

$$educ_{it} = \beta Fam\_size_{it} + \delta_1 M\_Age_{it} + \delta_2 F\_Age_{it} + \gamma' \boldsymbol{X} + u_{it} \qquad (6)$$

where the dependent variable is an indicator variable for substantial educational investments, "education" for short, for male individual i at time t. On the right hand side is the number of i's brothers (Fam_size_{it}), the age of i's mother (M_Age_{it}), the age of i's father (F_Age_{it}), and additional control variables in the vector **X,** including the number of wives of i's father. Equation (6) will be estimated by OLS, where the coefficient β is of key interest.

Because this is a limited dependent variable setting where *educ* takes on only two values, 0 and 1, I start with a probit regression, where the assumption is that the error is normally distributed. First, consider the lower status households (Low and Moderate status levels). In column 1, the coefficient on *Fam_size* is insignificantly different from zero, suggesting that for these groups of society, fertility control to achieve education was not practiced. The corresponding OLS regression yields the same result (Column 2). Also when I constrain the sample to the post-1600 years, where the bulk of the observations are, the same result is obtained (Columns 3 and 4). This is in line with a Malthusian world.

For the higher status groups a distinctly different picture emerges. Now the coefficient on *Fam_size* is negative and significant at standard levels in both the probit and the corresponding OLS specifications (columns 5 and 6). Also note that the coefficient on number of wives (of the father) is positive, in line with the idea that the probability of sons' becoming educated is somewhat greater in families that are more affluent, as measured by the number of wives the father had. Further, the coefficient on the time trend is negative, suggesting that educational investments secularly fell over time. We will return to this finding below.

For the results in Columns 7 and 8 of Table 6, I limit the sample to the post-1600 period to check if the findings are driven by the relationship in the very early periods of the sample. If this was generally a Malthusian world one might expect it to be even more Malthusian in the early compared to the later years, and more importantly, I do not want to give unduly high weight to a relatively small number of observations in the very early period of the sample. The results are qualitatively similar to before: there is evidence for a quality-quantity trade-off among these higher-status groups well before the year 1900.

How robust is the finding of a negative relationship between fertility and human capital investments for the higher status groups? Consider first an alternative definition of higher status which allocates the households with Moderate status not to the lower but to the higher status group. Column 9 shows that the probability of a son from a non-Low status family becoming educated is declining in family size. While the size of the estimate is smaller (in absolute size) than before, this constitutes evidence for a significant quantity-quality tradeoff for the top 30 percent of households in my sample. This is consistent with fertility choices being a factor in the human capital investment strategies of a sizable fraction of all Chinese households during this period.

Second, I broaden my measure of family size to include female children. Clearly it would be preferred to capture family size by the accurately measured number of male *and* female siblings in order to examine the quantity-quality tradeoff. Unfortunately, the data on girls in the genealogies is worse than that for boys. Also the gender ratio in the data, of about 2, suggests that there are "missing" girls. However, the reported gender ratios do not vary much by education among the higher-status households. Specifically, brothers account for 73.4% of all siblings among households where none of the brothers has become educated, whereas brothers account for 73.0% of all siblings among households where one brother did become educated. For this reason it is unlikely that there is a strong systematic under- or overcount of female children as a function of human capital investments. As a consequence, examining the total number of reported children in relation to human capital investments should be informative.

Replacing *Brothers* with *Brothers & Sisters* as the measure of family size yields also a negative relationship between education and family size, in line with a quantity-quality trade-off (Column 10). The coefficient on *Brothers & Sisters* is -0.035, somewhat smaller in absolute value than the coefficient in the corresponding regression with *Brothers* (-0.043, Column 7). There are several explanations for the change in coefficient size. For one, family size may now be measured with greater error, which could cause attenuation bias towards zero. It could also be that, indeed, the quantity-quality trade-off was not as sharp in the presence of female children.[26]

These results give us insight into the quantitative importance of the relationship between fertility and education. For the post-1600 era, the OLS coefficients range from about -4% (in Table 7, column 8) to a value of about -2% (in column 8, Table B). Taking the midpoint of this range, a value of -3% means that for a family with two brothers (the 25th percentile of the distribution of number of brothers), the probability that a son becomes educated is around nine percentage points higher than for a family with five brothers (the 75th percentile). Given that the overall probability of education for the higher status groups is equal to 31%, this indicates that differences in fertility have accounted for a substantial part in human capital differences (the inter-quartile range change of *Brothers* accounts for 0.09/0.31, or about 29%).

Additional results and robustness checks on the negative relationship between human capital investments and family size are presented in the Appendix (section II and Table B). Here I provide a brief summary. The quantity-quality trade-off is not driven by particularly high numbers of children or especially high levels of education in one particular clan (the Ma's), the results obtain even after dropping the Ma clan and large families. The human capital-fertility relationship is still significant after the inclusion of clan fixed effects. Fixed effects capture time-invariant characteristics that might explain the human capital-fertility relationship, such as the geographic area within Tongcheng County where a particular clan settled.[27] At the same time, clan fixed effects reduce the size of the coefficient on family size to about one half, so it is important to understand the mechanisms. The next section will take some first steps at understanding differences in the propensity of families of making human capital investments and fertility choices by considering the possibility that the clans had different effective costs of education.

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[26] Comparing two otherwise similar households with four children, one where all four are male while in the other three are male and one female, it may be that in order to cover considerable expenditures to try and educate one of the sons, the parents with a girl might have felt less constrained if they were willing to reallocate resources away from the girl that they would not have done from a boy.

[27] For example, clans whose main area of residence was closer to the Yangzi river might have more access to low-cost transportation and markets than clans that lived further apart (Shiue 2002), and that might explain to some extent differences in their fertility choices.

5.3 The Demand for Human Capital: Education Costs and Birth Order

In the previous section it was shown that among higher-status households, family size was systematically smaller when significant educational investments were being made for a (male) child. This is consistent with a deliberate effort on the part of the parents to restrict fertility when major human capital investments are planned, and in this section I provide additional evidence on this by exploiting differences in the costs of education across clans. One important alternative explanation for the observed pattern that I will discuss is birth order (Black et al. 2005). Along these lines, higher birth-order children receive more time and resources, including education. Given that the average birth order of a child in smaller families is necessarily lower than average birth order in larger families, the finding that smaller family size is negatively correlated with education can obtain even if no fertility control is exerted whatsoever.

In the following analysis, effective education costs will be analyzed by focusing on differences across clans and what they meant for the educational costs of each individual clan member. As I have noted above, the expenses to prepare for the examinations were substantial, and therefore may have gone over the individual family member's capacity. Certainly in these cases, and perhaps generally it is reasonable to believe that the clan as a whole subsidized in part the educational expenses. The ability to do so would have been positively correlated with the general level of education in a particular clan, both because this is an indicator of resources and because it is an indicator of talent and genetic predisposition. Thus I will ask whether the average level of education in individual *i*'s father's generation, for *i*'s clan, matters for the likelihood that individual *i* becomes educated. Moreover, I will also consider the relationship between individual *i*'s grandfather's generation education, as well as other variables that plausibly affect individual *i*'s effective education costs.

The first set of results for the demand for human capital and the quantity-quality tradeoff is shown in Table 7, Column 1.[28] All specifications focus on the two higher status categories:

[28] Different from before, standard errors are now clustered at the clan level because clan level variables such as the level of education in the father generation will be introduced. Also note that since the education outcome of the son (the left hand side variable) will affect the variables average and sum of education at the father's generation level, as

the Near-high and High status households. Compared to the previous results (Table 6, Column 5), the addition of measures on father's education and education within the clan, leads to a somewhat smaller (in absolute value) coefficient on *Brothers*, -2.7%, from -3.4%. In particular, there is evidence that a higher average level of education in the father's generation (father and uncles in this clan) is associated with a higher probability that one of the sons becomes educated. This presents evidence that effective education costs vary across clans, in the sense that high-education clans tend to have lower costs. In addition, the smaller (in absolute value) coefficient on *Brothers* is consistent with the idea that both the clan network and fertility control are factors determining human capital investment strategies.

In the post-1600 era, also the father's level of education has a significantly positive coefficient, while grandfather's education is positive but not significant (Table 7, Column 3). These relationships may be due to genetic effects in the sense that a son with educated father and grandfather may be relatively talented, thereby lowering effective education costs. The levels of father's and grandfather's education could also be indicative of better access to education. Further, not only the average but also the sum of all attained levels of education in the father's generation is now significantly related to the probability that a son becomes educated, albeit at a decreasing rate as the negative coefficient on the squared term in Table 7, column 3 indicates. Overall, this represents evidence that the clan network plays a role in affecting education outcomes of its members, and it is in line with significant differences in effective education costs across clans. In each case, the OLS results are quite similar to the corresponding probit results, see Table 7.

What is the role of birth order for these findings? Column 5 of Table 7 shows birth order is negatively correlated with education, as expected. In the probit specification, the coefficient on birth order is -2.9%, or, every one rank increase in birth order reduces the probability of education by about three percentage points. Comparing two sons at the third and first birth order, respectively (which is the 75^{th} to 25^{th} percentile of the birth order distribution of higher status households) raises the probability of becoming educated by about 5.8 percentage points (or $0.059/0.31 \approx 19\%$ of the mean probability of being educated). Compared to the estimate in Column 3, where the birth order variable is not included, the coefficient on *Brothers* in Column 5

long as the son is included in the genealogy, this creates a positive relationship between left- and right-hand side variables by construction. Given the relatively long sample period, however, this effect is negligible in my sample.

falls but remains significantly negative at standard levels. These results indicate that while birth order is important to account for the negative relationship between fertility and education, I continue to find evidence that deliberate fertility control is part of what explains the quantity-quality tradeoff in the data.

In Column 7 and 8 I continue to examine birth order by relaxing the linearity assumption implied by simply defining birth order as an integer count 1,2,3,...etc. When giving each birth order, one to five, its own coefficient, it is apparent that the relationship between birth order in this sample is non-linear: the probit point estimates are somewhat above zero for birth order one, around -0.03 for birth orders 2 to 4, and about -0.15 for birth order five (Column 7). Allowing for a more flexible birth order specification does essentially not affect the coefficient of *Brothers*. Given the relatively large coefficient (in absolute value) on fifth birth order, I have re-estimated these relationships dropping fifth and higher birth order cases—these adjustments do not affect the main results. See Appendix (section III and Table C) for further details.

I am also interested in the role that sisters had in affecting the probability that one of the brothers became educated, in the presence of birth order effects. Replacing *Brothers* with the variable *Brothers & Sisters*, defined as the sum of the recorded male and female siblings in the data, yields a probit coefficient on *Brothers & Sisters* of -0.029, somewhat lower (in absolute value) than corresponding the -0.034 that was obtained for *Brothers* (comparing Table 7, Columns 9 and 3, respectively). Similarly, the coefficient in the OLS specification changes from -0.031 to -0.027 (Table 7, Columns 10 and 4, respectively). Overall, the change in the coefficient on family size from including female children is relatively small. Further, when fertility is defined as the number of brothers and sisters, the education variables both at the clan level (average and sum of education levels in the father generation) and the individual level continue to be positive, consistent with the idea that clan success in educating their members lowers the effective cost of education for one of the sons. Birth order also still matters when female children are incorporated into the analysis, in the sense that it accounts for a part (but not all) of the quantity-quality tradeoff that I estimate in this data (see Column 11 and 12 in Table 7).

Additional analysis generally confirms these findings. Specifically, I have re-estimated the relationships after dropping potential outliers—the Ma clan and birth orders beyond 4 sons. I also add period fixed effects and expand the sample to include the top 30 % of society (ie., the top three status categories). In brief, those results still show an educated father, and to a lesser extent an educated grandfather is associated with a higher chance that a son becomes educated. There is also evidence that the average level of education in the previous two generations matters.[29] Although muted, the same general relationship between family size and human capital investments exists when households of Moderate status are added to the top two status groups. Further details on the estimates are provided in Appendix (section III and Table C).

5.4 Changes over time

In the previous two sections I have presented evidence in support of a demand-for-human-capital argument affecting fertility choices in China between the 1300s and the 19th century. Could the demand for human capital, or lack thereof, explain why China did not industrialize at the time when some Western European countries industrialized?

The Chinese government did not expand the number of official positions in proportion to the rising population (see especially Ho 1959, 1962, and Elman 1994). Given that this reduced the probability of obtaining a highly rewarded government office, it is likely that the net return to education fell in China during the Qing dynasty (1644-1911). This may have led overall to households investing less in education, since it was primarily the wealthier families who also had educations that had the wherewithal to produce sons who had a passing chance of succeeding in the civil service examinations of late imperial China. To provide some household level evidence on this, Figure 5 shows the fraction of Tongcheng clan members becoming educated between the years 1340 and 1820. We see that this fraction fell from more than 14% before 1600 to less than 4% after 1800. Falling demand for human capital as a result of the constraints imposed by the non-expanding Qing government system may thus help to explain why China did not industrialize during the late 18th and 19th centuries.

[29] Although there are differences across clans; in particular, for the Ma clan the importance of the father's generation is greater, whereas for the other clans the grandfather's generation appears to matter more; see Table C.

6. Conclusion

Since the process of industrialization involves dramatic increases in the return to human capital, the critical issue in terms of long-run development is the evolution of non-Malthusian dynamics in families investing in human capital. In China, there is evidence of fertility control for human capital objectives starting as early as the 17th century. This presents new evidence that child quantity quality tradeoffs are not necessarily the direct consequence of industrialization, which had not yet occurred in China.

Among Chinese families with at least some attributes of status, family size was smaller, and educational attainment higher. Two reasons are behind this. First, more educated families were more likely to produce more educated sons. This is consistent with the notion of costs of education determining incentives to invest in education, since more educated families were likely to have better access to channels of education. Second, higher educational attainment was typically associated with lower birth order, so constraining family sizes increased average education.

An incidental result of the examination system was that there was the emergence of services that could be provided by men who tried but failed the examinations—doctors, teachers, and writers. Ultimately, however, the government controlled the number of high paying occupations that could be had upon earning an education. Over time, as population increased, the number of such opportunities declined. One might speculate how increasing opportunities for human capital investments should have resulted in the reverse pattern of human capital accumulation for China, in which education continues to increase rather than decrease. In this sense, it may be more appropriate to ask not what triggers the change in behavior from the Malthusian era to today, but rather what allows it to spread within the population.

Further research on other economies within and outside of China is needed to determine how general these findings may be. If Malthusian economies of the past were not purely, and similarly Malthusian, then differences that lie in the pre-industrial era might help to explain why modern technologies do not give all countries the same footing to develop further. These implications are important to our understanding of long-run growth.

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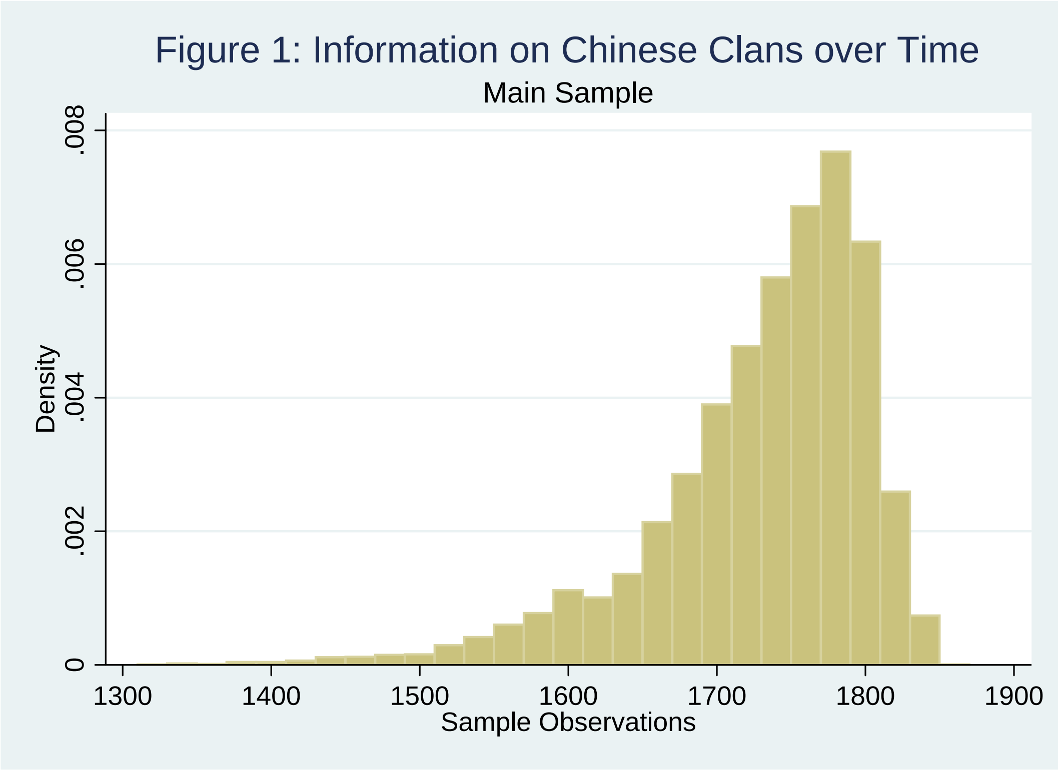
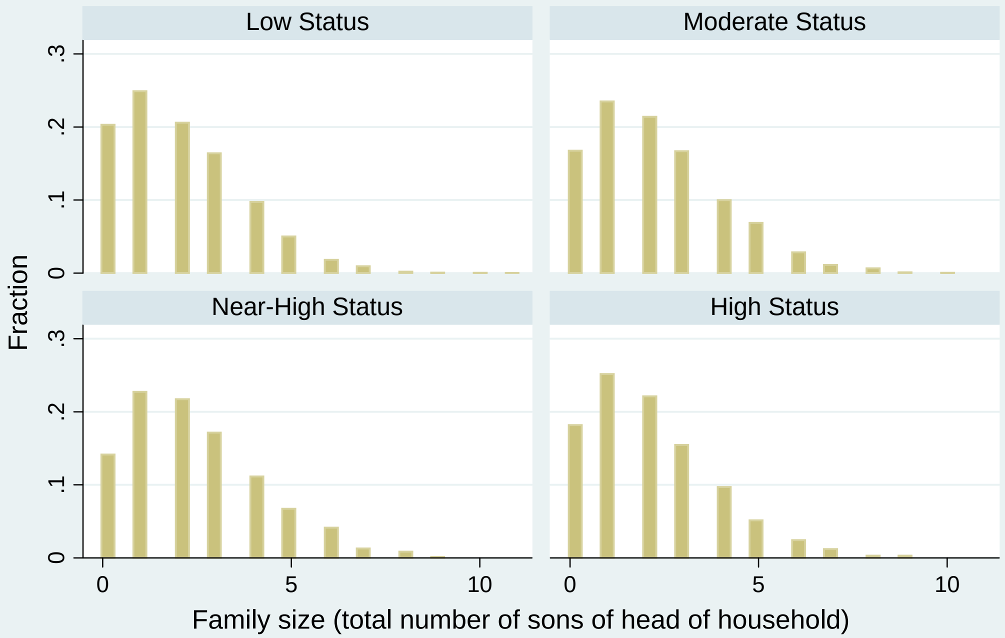


Figure 1: Information on Chinese Clans over Time
Main Sample
Density
0
.002
.004
.006
.008
1300
1400
1500
1600
1700
1800
1900
Sample Observations

Figure 2: Family Size and Status



N = 9,769

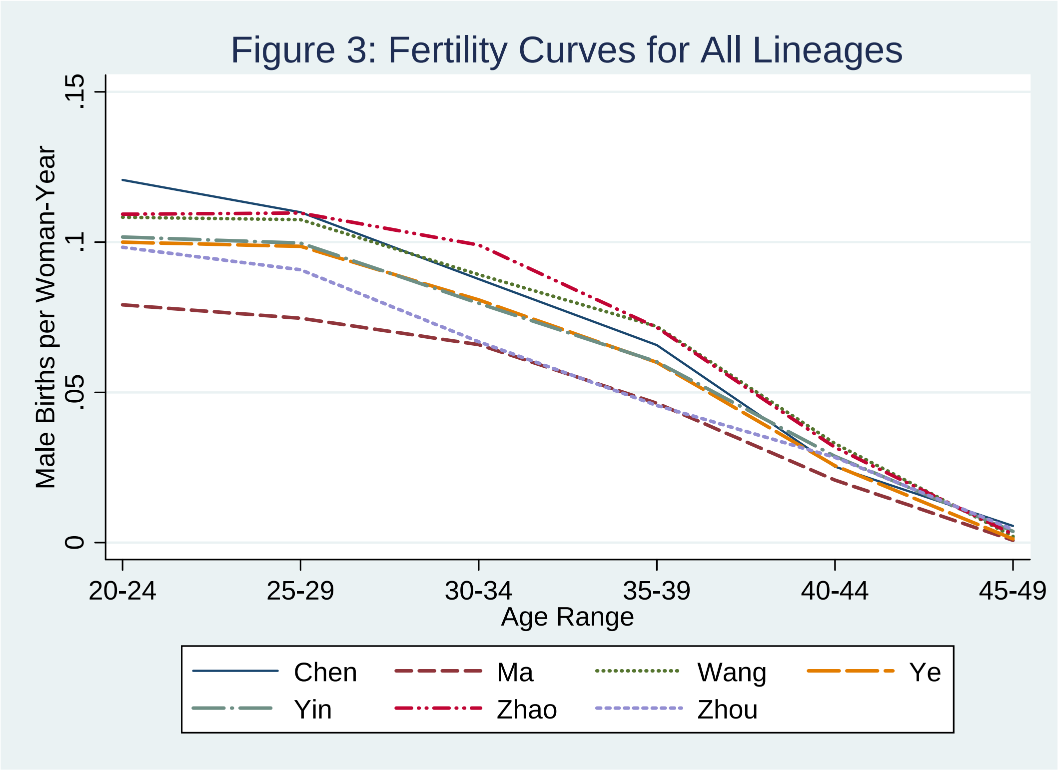


Figure 3: Fertility Curves for All Lineages
Male Births per Woman-Year
0
.05
.1
.15
20-24
25-29
30-34
35-39
40-44
45-49
Age Range
Chen
Ma
Wang
Ye
Yin
Zhao
Zhou

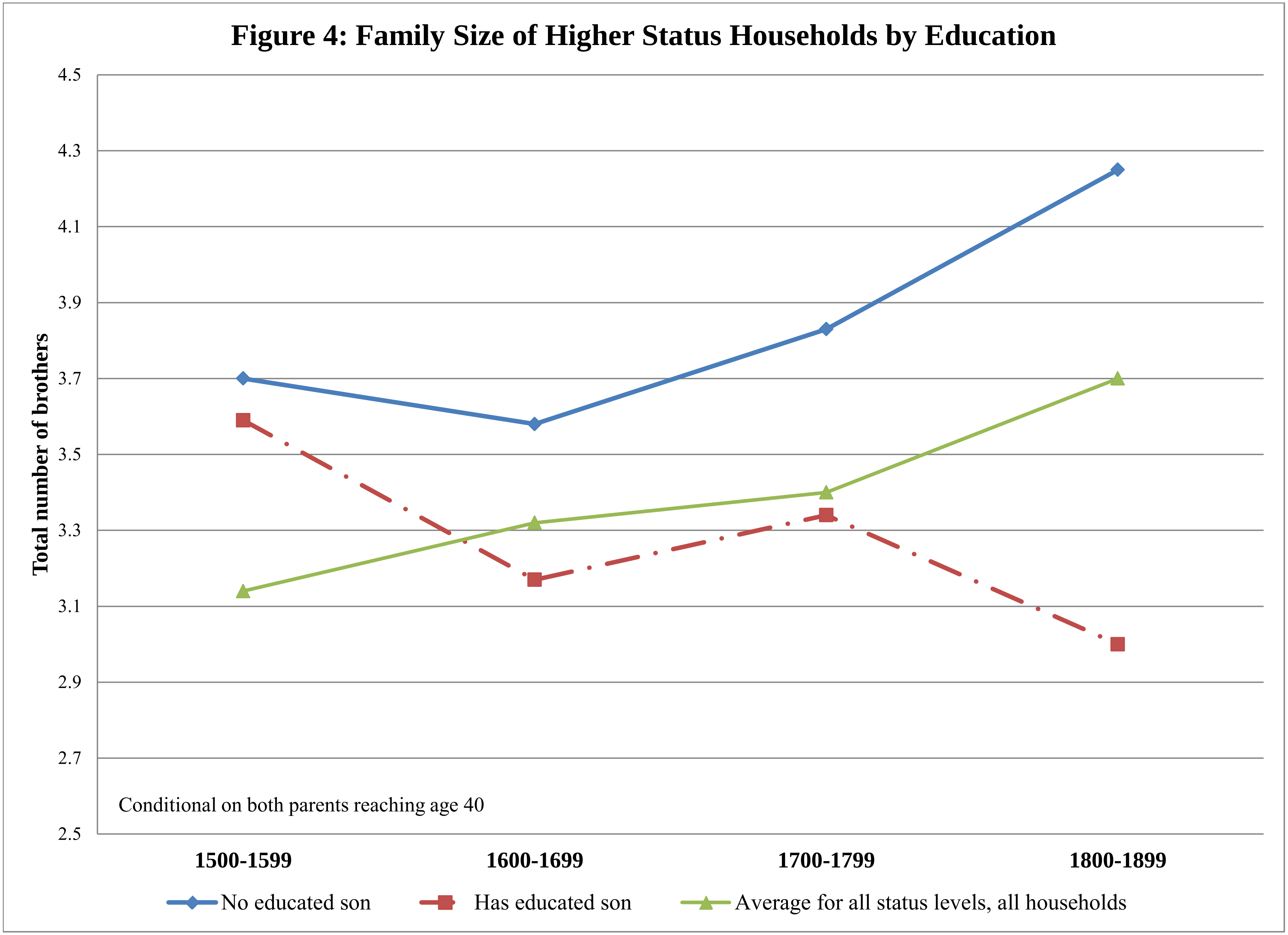


Figure 4: Family Size of Higher Status Households by Education
Total number of brothers
4.5
4.3
4.1
3.9
3.7
3.5
3.3
3.1
2.9
2.7
2.5
Conditional on both parents reaching age 40
1500-1599
1600-1699
1700-1799
1800-1899
No educated son
Has educated son
Average for all status levels, all households

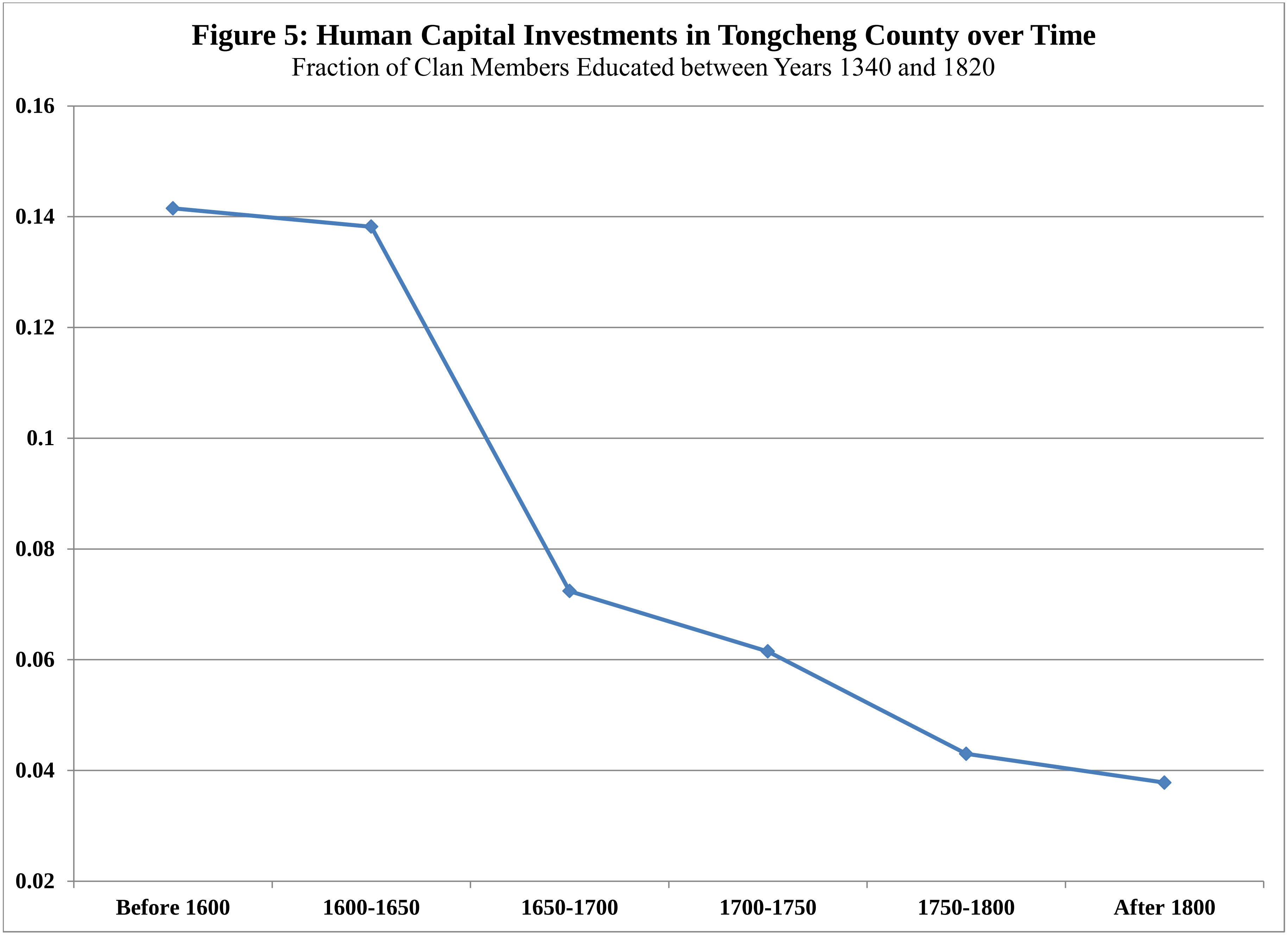


Figure 5: Human Capital Investments in Tongcheng County over Time
Fraction of Clan Members Educated between Years 1340 and 1820
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
Before 1600
1600-1650
1650-1700
1700-1750
1750-1800
After 1800

Table 1: Sample Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Status					
Head of household status	9769	1.6	4	0	22
Birth and death					
Head of household birth year	9769	1761	74.70	1298	1885
Head of household death year	8127	1797	72.53	1348	1929
Father's age at death	8127	49.61	15.62	5.17	90.83
Mother's age at death	7582	46.04	19.06	7.92	96.00
Marriage					
Number of wives	5916	1.11	0.37	1	5
Fertility					
Total sons, by father	9769	2.07	1.69	0	11
Education outcomes--3 generation linked households					
Head of household education	5916	0.07	0.26	0	1
Father's education	6660	0.08	0.26	0	1
Grandfather's education	6660	0.12	0.32	0	1
Average education in generation of father	6660	0.09	0.12	0	1
Sum of education of generation of father	6660	41.94	38.60	0	124
Average education of generation of grandfather	6660	0.13	0.14	0	1
CHEN clan	230	0.01	0.09	0	1
MA clan	525	0.34	0.47	0	1
WNG2 clan	3372	0.04	0.21	0	1
YE clan	1159	0.12	0.33	0	1
YIN2 clan	465	0.03	0.17	0	1
ZHAO clan	642	0.02	0.14	0	1
ZHOU clan	267	0.02	0.15	0	1

Table 2: Family Size

Total Number of Sons of Head of Household

Total Sons	Frequency	Percent	Cumulative
0	1,869	19.13	19.13
1	2,393	24.5	43.63
2	2,038	20.86	64.49
3	1,609	16.47	80.96
4	966	9.89	90.85
5	535	5.48	96.33
6	214	2.19	98.52
7	99	1.01	99.53
8	33	0.34	99.87
9	8	0.08	99.95
10	4	0.04	99.99
11	1	0.01	100
Total	9,769	100	

Table 3: Socioeconomic Status and Education Classifications

Status categories (0-3) (i)	Status (0-22) (ii)	Educated 0/1 (iii)	Description (iv)
Low	0	0	No titles, degrees, office, other evidence of wealth.
Moderate	1	0	Honorary, Posthumous titles; Main guest at the county banquet; Village head.
	2	0	Multiple wives (consecutive marriages, 2 or more not living at the same time).
	3	0	Father a sheng-yuan, minor official, official student, evidence of wealth, *jian-shen* , expectant official.
	4	0	Grandfather a *juren, gongsheng, jinshi* or official.
	5	0	Father a *juren, gongsheng, jinshi* or official.
Near-high	6	1	Educated, scholar, no degrees or office (editor of the genealogy, refused office, prepared for but did not pass examinations.)
	7	0	Concubinage (i.e. polygyny, 2 or more wives or concubines at the same time.)
	8	0	Other evidence of wealth, property (set up ancestral estates, large donations, wealthy farmer, landowner or merchant, philanthropy.)
	9	1	Official students.
	10	0	Military *shengyuan* ; minor military office.
	11	0	Purchased *jiansheng* and/or purchased office.
	12	1	Students of the Imperial Academy (non-purchased).
High	13	1	Civil *shengyuan* ; minor civil office.
	14	0	Expectant official, no degrees.
	15	1	Expectant official, with one of the lower degrees.
	16	1	Military *juren, jinshi* ; major military officer.
	17	0	Civil official, no degree, minor or purchased degree.
	18	1	*Juren, gongsheng* with no office.
	19	1	*Juren, gongsheng* with expectant office.
	20	1	*Jinshi* , no office.
	21	1	*Jinshi* , with official provincial post or expectant official.
	22	1	*Jinshi* , with top-level post in the Imperial bureaucracy (Hanlin Academy, Grand Secretariat, Five Boards, Prime Minister, etc.)

Table 4: Maximum Lifetime Status in Four Categories

Panel A. All Married Men

	Frequency	Percent	Cumulative
Low	6,949	71.13	71.13
Moderate	1,790	18.32	89.46
Near-high	700	7.17	96.62
High	330	3.38	100
Total	9,769		100

Panel B. Three Generation linked sample

	Frequency	Percent	Cumulative
Low	3,401	66.35	66.35
Moderate	894	17.44	83.79
Near-high	668	13.03	96.82
High	163	3.18	100
Total	5,126		100

Note: Restricted to observations post-1600, with at least one son

Table 5: Family Size and Status

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	All Data	Main Sample						Before 1600	≥ 1600
			Individual Status Groups	Re-Marriage	Baseline OLS	Baseline Median Regression	Clan Fixed Effects		
Status	0.126**	0.078**							
	(0.023)	(0.025)							
Middle Status			0.145**	0.021	0.089+	0.115*	0.165**	0.309+	0.074
			(0.052)	(0.059)	(0.052)	(0.046)	(0.048)	(0.165)	(0.055)
Near-High Status			0.260**	0.157*	-0.222**	-0.214**	-0.060	0.307	-0.266**
			(0.075)	(0.079)	(0.074)	(0.083)	(0.090)	(0.238)	(0.078)
High Status			0.009	-0.113	-0.524**	-0.483**	-0.296**	0.200	-0.608**
			(0.108)	(0.109)	(0.102)	(0.124)	(0.111)	(0.332)	(0.106)
Number of Wives				0.216**	0.587**	0.536**	0.534**	0.463*	0.594**
				(0.056)	(0.060)	(0.042)	(0.061)	(0.192)	(0.063)
Head of Household Age at Death					0.030**	0.029**	0.029**	0.037**	0.030**
					(0.001)	(0.001)	(0.001)	(0.008)	(0.001)
Wife Age at Death					0.029**	0.033**	0.033**	0.018*	0.030**
					(0.001)	(0.001)	(0.001)	(0.008)	(0.001)
Time Trend	-0.000	-0.001**	-0.001**	-0.001**	0.001*	0.000*	0.000	0.001	0.001*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Constant	2.310**	3.502**	3.425**	3.363**	-2.399**	-2.306**	-1.540**	-3.469*	-2.625**
	(0.374)	(0.437)	(0.439)	(0.439)	(0.394)	(0.238)	(0.436)	(1.728)	(0.564)
Observations	9,768	6,977	6,977	6,977	6,977	6,977	6,977	394	6,583
R-squared	0.003	0.003	0.004	0.006	0.246			0.240	0.249

Notes: Dependent variable is number of sons of the head of household. Estimation is by OLS except columns (6) and (7) where it is median regression.
The omitted category in columns (3) to (9) is Low Status; clan fixed effects are included in (7); heteroskedastcivity-consistent robust standard errors in parentheses.
** significant at 1%, * significant at 5%, and + significant at 10% level.

Table 6: The Quantity-Quality Trade-off and Status

	Lower Status				Higher Status					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	All Data		Post 1600		All Data		Year 1600 and later		Add Moderate	Add Sisters
	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit	Probit
Family Size: Brothers	0.001	0.001	0.003	0.000	-0.034**	-0.031**	-0.043**	-0.040**	-0.017**	
	(0.001)	(0.001)	(0.001)	(0.001)	(0.009)	(0.009)	(0.010)	(0.009)	(0.006)	
Family Size: Brothers & Sisters										-0.035**
										(0.008)
Number of Wives	0.016**	0.023**	0.014**	0.020*	0.066**	0.063*	0.108**	0.105**	0.036*	0.103**
	(0.005)	(0.009)	(0.005)	(0.009)	(0.009)	(0.025)	(0.027)	(0.028)	(0.016)	(0.008)
Wife Age at Death	0.004	0.004	-0.009	-0.011	-0.341**	-0.330**	-0.325**	-0.310*	-0.118+	-0.322**
	(0.018)	(0.019)	(0.018)	(0.019)	(0.024)	(0.115)	(0.122)	(0.122)	(0.071)	(0.122)
Head of Household Age at Death	0.043**	0.043*	0.040*	0.042*	0.082	0.067	0.239*	0.223*	0.213**	0.281**
	(0.016)	(0.019)	(0.017)	(0.019)	(0.098)	(0.097)	(0.107)	(0.106)	(0.061)	(0.109)
Year	-0.010**	-0.013**	-0.012*	-0.013*	-0.050*	-0.049*	-0.064*	-0.061+	-0.061**	-0.062*
	(0.002)	(0.004)	(0.005)	(0.006)	(0.020)	(0.020)	(0.031)	(0.031)	(0.019)	(0.032)
Observations	4,698	4,698	4,295	4,295	993	993	831	831	1,725	831
R-squared		0.008		0.005		0.037		0.049		

Notes: Dependent variable is education. Marginal effects reported for probits. Heteroskedasticity-consistent (robust) standard errors in parentheses. **/*/+ means significance at the 1%/5%/10% level. In column (9), households of Moderate status are added to the sample; in column 10, the measure of family size is the sum of all brothers and sisters.

Table 7: The Demand for Human Capital and the Quantity-Quality Tradeoff

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All Data		Post 1600									
	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS
Family Size: Brothers	-0.027**	-0.024**	-0.034**	-0.031**	-0.022*	-0.021*	-0.022*	-0.021+				
	(0.006)	(0.004)	(0.007)	(0.005)	(0.010)	(0.009)	(0.010)	(0.009)				
Family Size: Brothers & Sisters									-0.029**	-0.027**	-0.022**	-0.021**
									(0.005)	(0.004)	(0.006)	(0.005)
Father's Education	0.047	0.043	0.056+	0.055+	0.057*	0.057+	0.058*	0.059+	0.061*	0.058*	0.061*	0.061*
	(0.050)	(0.047)	(0.030)	(0.027)	(0.028)	(0.026)	(0.028)	(0.026)	(0.025)	(0.023)	(0.025)	(0.022)
Grandfather's Education	0.090	0.086	0.079	0.073	0.080	0.073	0.081	0.073	0.086+	0.080	0.085+	0.078
	(0.064)	(0.070)	(0.050)	(0.058)	(0.051)	(0.059)	(0.050)	(0.059)	(0.049)	(0.055)	(0.050)	(0.056)
Av. Education Father's Generation	0.554**	0.599*	0.743**	0.833**	0.726**	0.812**	0.731**	0.820**	0.713**	0.802**	0.695**	0.784**
	(0.196)	(0.204)	(0.197)	(0.186)	(0.190)	(0.178)	(0.192)	(0.180)	(0.178)	(0.166)	(0.180)	(0.168)
Log Sum Education Father's Generation	0.272	0.177	0.692**	0.531*	0.742**	0.557*	0.726**	0.554*	0.660*	0.512*	0.708*	0.535*
	(0.363)	(0.318)	(0.246)	(0.163)	(0.272)	(0.175)	(0.287)	(0.179)	(0.281)	(0.186)	(0.285)	(0.187)
Log Sum Education Father's Generation Sq.	-0.473	-0.332	-0.807**	-0.613*	-0.861**	-0.641*	-0.841**	-0.631*	-0.785**	-0.609*	-0.828**	-0.625*
	(0.361)	(0.309)	(0.264)	(0.188)	(0.292)	(0.202)	(0.309)	(0.209)	(0.303)	(0.213)	(0.305)	(0.211)
Av. Education Grandfather's Generation	-0.110	-0.117	-0.253	-0.278	-0.243	-0.266	-0.245	-0.273	-0.235	-0.268	-0.228	-0.257
	(0.207)	(0.226)	(0.169)	(0.184)	(0.172)	(0.187)	(0.174)	(0.189)	(0.168)	(0.176)	(0.172)	(0.180)
Birth Order					-0.029*	-0.024+					-0.029**	-0.024*
					(0.011)	(0.011)					(0.008)	(0.008)
First-born							0.041	0.038				
							(0.055)	(0.051)				
Second-born							-0.030	-0.031				
							(0.064)	(0.060)				
Third-born							-0.019	-0.022				
							(0.046)	(0.044)				
Fourth-born							-0.037	-0.036+				
							(0.022)	(0.018)				
Fifth-born							-0.154**	-0.110**				
							(0.036)	(0.028)				
Observations	993	993	831	831	831	831	831	831	831	831	831	831
R-squared		0.096		0.108		0.111		0.114		0.111		0.114

Notes: Dependent variable is education. All regressions include the number of wives, head of household age at death, wife age at death, and a trend (results not shown). Add one to Sum Education of Father's Generation. Marginal effects for probit are reported. Robust standard errors clustered at the clan level in parentheses.
**/*/+ means significant at the 1%/5%/10% significance level

Appendix – Robustness Analysis

In this appendix I discuss a number of additional results that complement the analysis in the paper. The first set of these, shown in Table A, concerns the relationship between family size and status examined in section 5.1.

I. Family Size and Status

I begin by estimating the relationship between family size, measured by the total number of sons of the head of household, and the status of the household using OLS (Column 1). The coefficient on status is positive and significant, as in the text (Table 5, Column 2), with the only difference being that here the focus is on the post-1600 era. To examine the sensitivity of the results with respect to outliers, the same regression is performed using a method that downweighs observations with an unduly large influence on the results, as judged by the Cook's Distance criterion (using STATA's rreg command). While the status point estimate remains positive, it becomes smaller and ceases to be significant.

For an alternative definition of status, the corresponding results are shown in columns 3 and 4 of Table A. Now status is equal to one for the Moderate, Near-high and High status groups, and zero otherwise. This differs from the baseline status definition in that the Moderate status households are pooled together with the Near-high and High status households the new group: "Some Status". These three status groups are now separated from the Low status households.

On the one hand, this definition of status is broader and might thus weaken evidence for any status-specific patterns of behavior that are observed for China's top households at the time. On the other hand, this definition has the advantage that it is relatively easy to determine whether a particular head of household in the genealogies shows *any* signs of status, which do not have to be further ranked. Looking at the results, households with some status have a larger family size than the Low status groups (Columns 3 and 4).

This analysis is repeated in Columns 5 to 8 of Table A when the remarriage and age-at-death controls are included in the regression. For the baseline status variable, I obtain an OLS coefficient of -0.154, while the outlier-robust estimate is now similar, at -0.161. These results indicated that controlling for remarriage and age-at-death, the number of children was, across all four status levels, decreasing with status.

The same result is obtained using the more crude two-status variable, see columns 7 and 8. From these results it appears that the results discussed in the text are not driven by the particular four-level of status classification that I have adopted.

II. The Quantity-Quality Relationship

I now turn to the relationship between family size and human capital investments. As shown in Table 6, for the households with Near-high and High status, a higher level of education is associated with lower family size (columns 5 to 10). Here I examine this relationship further, focusing on the post-1600 era. Results are presented in Table B.

As a first check I drop the clan of the Ma, whose members over the centuries have a considerably higher level of education than the members of other clans (see Table 1). Note that without the Ma clan the family size coefficient on *Brothers* becomes smaller in absolute value, from about -4% to -3%, and is still significant at standard levels (column 1 of Table B, versus column 7 of Table 6). The coefficients on the control variables remain largely the same. Also the corresponding OLS results suggest that the quantity-quality finding is not unduly driven by one particular clan.

One might also ask whether the results are mainly driven by a few households with relatively high number of children. To see this, I restrict family size to be a maximum of four (sons) from all marriages. The coefficient on family size is reduced to somewhat below -4% but the results remain largely the same (except that the age of the head of household at death is not a significant predictor of son's education anymore).

I have also explored the importance of changing trends in education for the quantity-quality finding. Specifically, it may be that the relationship was quite different during the 18th century, which by many accounts was a relatively stable and prosperous period, much of it under the rule of the famous Qianlong emperor (1735 to 1796). However, including period fixed effects for each century instead of a simple time trend does not change the estimated quantity-quality relationship by much (columns 5 and 6 of Table B, versus columns 7 and 8 of Table 6).

Next, I introduce fixed effects for each of the seven clans so that only within-clan variation is used to identify the regression estimates. For example, as noted in the text the main area of residence of a particular clan within Tongcheng County, may have determined the degree of market access of each clan, thereby in turn affecting the demand for education of the clans differentially. Other channels might be operating as well. Including fixed effects controls for all channels that work through time-invariant heterogeneity across clans to account for differences in observed education levels (without being able to separate the channels).

We see that the coefficient on family size is roughly reduced to one half with the introduction of clan fixed effects (Columns 7 and 8 of Table B, versus Columns 7 and 8 of Table 6). This indicates that heterogeneity across clans plays a role in explaining differences in education. This could capture differences in the effective education costs, as I explore in section 5.3, but also other slow-changing heterogeneity across clans. At the same time, this analysis confirms that the quantity-quality trade-off is present even when one considers only within-clan variation in human capital investments over time.

Another robustness check broadens the analysis to include the Moderate status households (Columns 9 and 10 of Table B); this corresponds to the earlier analysis shown in Table A. The coefficient on family size is now -1.2%, whereas it was -3.5% in the corresponding specification for the Near-high/High sample (Column 9 of Table B, versus Column 10 of Table 6, respectively). The quantity-quality trade-off is less sharp for moderate- than for higher-status households. More surprisingly perhaps, this result says that there is evidence for a significant relationship between family size and human capital investments for a group as large as the top 30% of the Tongcheng sample. This provides some evidence in support of fertility control in a relatively broad segment of society in China during this period.

III. The Demand for Human Capital and the Quantity-Quality Trade-off

Here additional results complementing section 5.3 of the paper are discussed. I focus on the post-1600 era and OLS as the method of estimation; probit results are very similar. I begin by dropping the members of the Ma clan from the sample, which tend to be highly educated compared to the average household in the sample. Results are given in Table C, Column 1.

Excluding the Ma's leads to a somewhat higher estimate on *Brothers*, -2.5% compared to -2.1% in Table 7, Column 6. Another finding is that in the Ma clan the level of education in the father generation is apparently more important than that of the grandfather generation: when the Ma's are eliminated from the sample, the father generation variable is not positive and significant anymore.[30] Birth order has still a negative coefficient, although it is smaller (in absolute value) than with the Ma households in the sample.

Focusing on families with at most four sons yields roughly the same coefficient on family size as before. However the aggregate number of educated family members in the father generation does not play a role anymore (Table C, Column 2). Including period fixed effects instead of a time trend introduces only small changes to the results (Table C, Column 3).

The following analysis expands on the discussion with individual birth order categories. The reference point for comparison is the results in Column 8 of Table 7. Dropping the Ma's from the sample has similar consequences as with the aggregate birth order variable, namely the importance of the average education in the father generation is reduced while that of the grandfather generation is increased. The coefficients for individual birth order follow the same general pattern as before, with the largest (in absolute value) negative coefficient for fifth birth order.

Dropping families with more than four sons from the sample leads to a positive coefficient on the first-born son (Table C, Column 5). This is consistent with the idea that higher levels of resources increase the chance of first-born children to become educated. The focus on households with four sons or less does not greatly affect the coefficient on *Brothers*, and neither does the introduction of period fixed effects instead of a time trend (Table C, Column 6).

The next three columns of Table C assess the robustness of the results when using the measure of *Brothers & Sisters* instead of *Brothers* as the measure of family size. The reference point for comparison is Column 12 of Table 7. Excluding the Ma households changes the coefficient on family size from -2.1% to -1.8%, and for birth order from -2.4% to -2.0% (Table C, Column 7). Also here, there is now a lower coefficient on education in the father generation.

In summary, a focus on households with 4 or less sons, or the introduction of period fixed effects instead of a trend leads by and large to similar results, except that the aggregate level of

[30] In column 1 it is actually negative, which is likely due to the high correlation (about 0.8) between the variables for education in the father generation and grandfather generation.

education in the father generation becomes less important (Table 7, Columns 8 and 9, respectively).

Finally, I present some evidence on the role of the Moderate status households for these results. Adding the households of Moderate status to the sample of Near-high and High status households reduces the family size coefficient to somewhat less than half the size (-2.1% in Table 7, Column 12, and -0.8% in Table C, Column 10). This is consistent with earlier findings that the quantity-quality trade-off becomes less sharp as we move lower in the status distribution.

Overall, the additional results discussed in this Appendix suggest that the patterns emphasized in the text hold quite broadly.

Table A: Family Size and Status -- Additional Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Baseline Status		Dichotomous Status		Baseline Status		Dichotomous Status	
	OLS	Outliers	OLS	Outliers	OLS	Outliers	OLS	Outliers
Status	0.060*	0.036			-0.154**	-0.161**		
	(0.027)	(0.026)			(0.028)	(0.025)		
Some Status			0.146**	0.107*			-0.105*	-0.112*
			(0.046)	(0.045)			(0.049)	(0.046)
Number of Wives					0.684**	0.584**	0.597**	0.496**
					(0.064)	(0.052)	(0.067)	(0.054)
Head of Household Age at Death					0.030**	0.028**	0.030**	0.029**
					(0.001)	(0.001)	(0.001)	(0.001)
Wife Age at Death					0.029**	0.030**	0.028**	0.029**
					(0.001)	(0.001)	(0.001)	(0.001)
Year	-0.003**	-0.004**	-0.003**	-0.004**	0.000	-0.000	0.001	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Constant	7.500**	8.433**	7.509**	8.429**	-2.361**	-1.265*	-2.385**	-1.323*
	(0.703)	(0.710)	(0.702)	(0.709)	(0.636)	(0.624)	(0.637)	(0.627)
Observations	6,427	6,427	6,427	6,427	6,427	6,427	6,427	6,427
R-squared	0.010	0.013	0.011	0.014	0.242	0.262	0.238	0.258

Notes: Dependent variable is number of sons. Estimation in (1), (3), (5), and (7) is by OLS; (2), (4), (6), and (8) regression robust to outliers. "Status" is the four-step variable defined in Table 3; "Some Status" is a dichotomous variable which is 0 for Low Status, 1 otherwise. Included are observations post 1600. Heteroskedasticity-consistent (robust) standard errors are reported in parentheses in (1), (3), (5), and (7); **/*/+ means significant at the 1%/5%/10% level

Table B: The Quantity-Quality Trade-off and Status -- Additional Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	No Ma clan		Four sons max.		Period Fixed Effects		Period Fixed Effects Clan Fixed Effects		Add Moderate Status	
	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS
Family size: Brothers	-0.029**	-0.029**	-0.039**	-0.037**	-0.044**	-0.041**	-0.022+	-0.019+		
	(0.009)	(0.008)	(0.009)	(0.008)	(0.011)	(0.011)	(0.012)	(0.011)		
Family Size: Brothers & Sisters									-0.012**	-0.012**
									(0.004)	(0.004)
Number of Wives	0.159**	0.168**	0.099**	0.097**	0.105**	0.104**	0.084**	0.080**	0.033+	0.032
	(0.030)	(0.034)	(0.025)	(0.025)	(0.029)	(0.027)	(0.021)	(0.027)	(0.019)	(0.020)
Wife Age at Death	-0.319**	-0.283**	-0.319*	-0.308*	-0.315**	-0.299**	-0.166	-0.146	-0.119+	-0.118+
	(0.098)	(0.100)	(0.135)	(0.134)	(0.114)	(0.095)	(0.121)	(0.098)	(0.070)	(0.071)
Head of Household Age at Death	0.388**	0.379**	0.196	0.185	0.241*	0.228**	0.177*	0.167+	0.222**	0.219**
	(0.112)	(0.113)	(0.121)	(0.119)	(0.107)	(0.086)	(0.088)	(0.087)	(0.056)	(0.057)
Constant	-0.533	0.204	2.876*	1.439**	-0.562	0.293*	-5.322**	-0.108	1.243**	1.165**
	(2.128)	(0.573)	(1.451)	(0.504)	(0.445)	(0.130)	(0.374)	(0.133)	(0.335)	(0.359)
Time Trend	Y	Y	Y	Y	N	N	N	N	Y	Y
Period Fixed Effects	N	N	N	N	Y	Y	Y	Y	N	N
Clan Fixed Effects	N	N	N	N	N	N	Y	Y	N	N
Observations	606	606	779	779	832	832	828	832	1,725	1,725
R-squared		0.064		0.040		0.045		0.137		0.019

Notes : Dependent variable is education. Status groups included in the sample are Near-High and High, except for (9) and (10) where also Moderate status is included. Marginal effects reported for probits. Heteroskedasticity-consistent (robust) standard errors reported in parentheses. **/*/+ means significant at the 1%/5%/10% level.

Table C: The Demand for Human Capital and the Quantity-Quality Trade-off -- Additional Results

	(1) No Ma clan	(2) Four sons max.	(3) Period Fixed Effects	(4) No Ma clan	(5) Four sons max.	(6) Period Fixed Effects	(7) No Ma clan	(8) Four sons max.	(9) Period Fixed Effects	(10) Add Moderate Status
Family Size: Brothers	-0.025**	-0.023*	-0.021+	-0.025**	-0.023*	-0.021+				
	(0.005)	(0.008)	(0.010)	(0.005)	(0.008)	(0.010)				
Family Size: Brothers & Sisters							-0.018*	-0.022**	-0.022*	-0.008**
							(0.006)	(0.006)	(0.006)	(0.002)
Father's Education	0.087**	0.064+	0.060+	0.087**	0.064+	0.062+	0.084**	0.067*	0.064*	0.166**
	(0.012)	(0.027)	(0.029)	(0.011)	(0.027)	(0.029)	(0.010)	(0.024)	(0.025)	(0.013)
Grandfather's Education	0.014	0.076	0.080	0.013	0.076	0.079	0.021	0.081	0.085	0.073+
	(0.055)	(0.049)	(0.063)	(0.055)	(0.050)	(0.064)	(0.054)	(0.047)	(0.061)	(0.037)
Av. Education Father Generation	-0.991+	0.825**	0.651+	-0.981+	0.834**	0.654+	-0.921+	0.799**	0.622+	0.659**
	(0.438)	(0.201)	(0.283)	(0.428)	(0.202)	(0.286)	(0.399)	(0.188)	(0.273)	(0.076)
Log Sum Education Father's Generation	0.144+	0.101	0.152	0.144+	0.102	0.150	0.147+	0.102	0.152	0.036
	(0.059)	(0.080)	(0.086)	(0.060)	(0.079)	(0.087)	(0.060)	(0.081)	(0.081)	(0.046)
Log Sum Education Father's Generation Sq.	-0.020+	-0.014	-0.025	-0.020+	-0.014	-0.025	-0.021+	-0.015	-0.025+	-0.009
	(0.008)	(0.011)	(0.013)	(0.009)	(0.011)	(0.013)	(0.008)	(0.011)	(0.012)	(0.008)
Av. Education Grandfather Generation	0.549+	-0.239	-0.056	0.538+	-0.244	-0.058	0.513+	-0.233	-0.047	-0.114
	(0.232)	(0.190)	(0.240)	(0.231)	(0.191)	(0.240)	(0.212)	(0.182)	(0.232)	(0.141)
Birth Order	-0.015*	-0.028+	-0.024+				-0.020**	-0.028*	-0.023*	-0.014+
	(0.005)	(0.012)	(0.012)				(0.005)	(0.011)	(0.009)	(0.007)
First-born				-0.000	0.061**	0.026				
				(0.033)	(0.012)	(0.055)				
Second-born				-0.070	-0.009	-0.042				
				(0.042)	(0.029)	(0.064)				
Third-born				-0.064		-0.040				
				(0.033)		(0.046)				
Fourth-born				-0.037	-0.010	-0.047*				
				(0.023)	(0.040)	(0.016)				
Fifth-born				-0.122**		-0.124*				
				(0.025)		(0.036)				
Observations	606	779	832	606	779	832	606	779	832	1,725
R-squared	0.087	0.104	0.110	0.092	0.106	0.113	0.086	0.107	0.115	0.136

Notes: Dependent variable is education. Regressions by OLS for the post-1600 period. All regressions include the number of wives, head of household age at death, wife age at death, and a trend (in (1), (2), (4), (5), (7), (8), and (10)) or period fixed effects (results not shown). Add one to Sum Education of Father's Generation.
Robust standard errors clustered at the clan level in parentheses. **/*/+ means significant at the 1%/5%/10% significance level