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Abstract: Using China census data from 1990, this paper presents empirical evidence for the hypothesis that adult sex ratios affect propensities to engage in sex-selective abortion through a negative feedback process. The hypothesized mechanism is that parents will adopt a mixed strategy and adjust the degree to which they invest in either sex in response to imbalances in the adult sex ratio so as to maximize their own reproductive fitness. Parents living in areas with a low adult sex ratio should demonstrate a high propensity to engage in sex-selective abortion for a son, and parents living in areas with a high adult sex ratio should demonstrate a low propensity to engage in sex-selective abortion for a son, or even to sex-selectively abort for a daughter. Separate analyses were performed for all first, second, and third order births, as well as additional analyses where the sex composition of previous births was taken into account. No significant relationship was found for first order births, but a large and statistically significant effect was found for second order and third order births. This relationship was also dependent upon the sex composition of earlier births, and the relationship was found to be strongest for those mothers who had previously given birth to sons. The results suggest an interaction between cultural preferences, economic utility-maximizing behaviour, and a desire to maximize reproductive fitness.

INTRODUCTION

Over the past thirty years the sex ratio at birth in China has been rising steadily. A natural sex ratio at birth usually lies between 1.03 and 1.05, meaning 103 and 105 boys born for every 100 girls, and is slightly male biased due to the greater mortality rates found amongst male infants (Fisher, 1930). According to the 2005 China 1% sample census, the sex ratio in children aged one year old or less was 1.19, and in children aged 1-4 the ratio was 1.24 (Zhu, Lu, and Hesketh 2009). In the 2000 census, in provinces such as Guangdong and Hainan, this imbalance had reached levels of 1.30 and 1.35 respectively (Leung and Zhang 2008). The traditionally strong parental preference for bearing a son is historically, culturally, and economically driven (Bannister, 2004; Bossen, 2007), but is essentially rooted in the patrilineal nature of Confucian philosophy.

In the lead-up to the 1970s, the total fertility in China was approximately 6 children per woman. This prompted significant concern amongst the central politburo about the long-term consequences of the corresponding rate of population growth. The outcome of these concerns was the development of a demographic target of preventing the total population size from exceeding 1.2 billion in the year 2000 (Bongaarts and Greenhalgh 1985). The precursor to the one-child population control policy (OCP) was the 'later, longer, fewer' (wan xi shao) campaign, which encouraged couples to have children later, to leave longer time periods between pregnancies, and to have fewer children overall. Following the death of Chairman Mao in 1976, the new leadership of the country committed itself to increasing economic development and saw control over the growth of the population as a key component of achieving that goal (Bongaarts and Greenhalgh, 1985). As a result of this, the OCP was implemented in 1979. By the following year the average total fertility had fallen to 2.2 children per woman, and by 1993 the total fertility stood at 1.9 (Bongaarts and Greenhalgh 1985; Greenhalgh, Zhu, and Li 1994). China's sex ratio imbalance has grown steadily since the introduction of the OCP. Once concerned about how the country should cope with its enormous population, the Chinese government has now awakened to the risks imposed by having an excess male population predicted to be in the region of 33 million by 2020 (Hudson and den Boer 2004).

Since the rise in the sex ratio imbalance at birth was first observed, there has been some controversy over the extent to which the data has reflected reality (Merli and Raftery 2000). Some have argued that the imbalance is simply due to under-reporting of girls in an attempt by parents to avoid the punishments or removal or rewards designed to enforce the family planning policy measures. It has also been suggested that the imbalance might be due to undercounting of females by survey recorders. Although it is widely acknowledged that there is a general under-reporting of births, evidence from the census survey of 2000, and data from the most recent 1% sample 2005 inter-census survey, strongly suggests that the data has been largely correct all along (Zhu et al., 2009; Bannister, 2004). While it is possible for parents to hide very small infants from the authorities, this practice becomes much more difficult as the children age. As a result, children are far more likely to be counted in the census surveys the older they are, and the data from the more recent census surveys show that the sex ratio imbalance for each cohort is generally consistent over time, rather than balancing out to normal levels due to missing girls reappearing in the data (Bannister 2004).

To date, there are no biological or medical explanations that can account for a sex ratio imbalance of the magnitude that has been observed in China (Clark 2000; Sen 1992;

James 2010). Research indicates that at the individual level the probability that a woman will give birth to a son, hereby referred to as p_{male}, is slightly increased by birth order, and that there are small effects related to maternal and paternal age, as well as to plural births such as twins or triplets (Jacobsen, Møller, and Mouritsen 1999). However, when considering large populations, p_{male} typically ranges between 0.505 and 0.520 (James, 1987). The lack of a sufficient biological explanation for the imbalance in the sex ratio at birth overwhelmingly indicates that a considerable proportion of parents in China are actively intervening to ensure that they have a son through the use of sex-selective childbirth practices (Sen 2003). While considerable attention has been directed towards the factors influencing the likelihood of parents engaging in sex-selective abortion, to my knowledge no work has sufficiently addressed the factors underlying the regional variation in the sex ratio at birth. This paper will explore the importance of the adult sex ratio on influencing the decisions that parents make regarding sex-selective abortion practices.

LITERATURE REVIEW

Regional Variation in the Sex Ratio Imbalance.

From the very beginning of the implementation of the OCP there have regional disparities in the exact degree to which it was administered, with the relative level of permissiveness broadly falling into three categories: relaxed, medium, and strict (Attané 2002; Zhu et al. 2009). The provinces where the implementation of the OCP was most relaxed are largely in the outer Northern and Western provinces. These provinces are amongst the most sparsely populated in the country, and are also populated by a considerably higher portion of ethnic minorities relative to the Han ethnic group, the latter being by far the largest ethnic group in China. It should be emphasized that since the beginning of the formulation of the policy, the implementation of the OCP was always intended to apply primarily to Han Chinese (Greenhalgh 1986). The OCP was relaxed in rural areas in the late 1980s to reflect a two-child policy, but this development did not extend to urban areas, where policy implementation remained strict.

However, the provinces in which the sex ratio imbalance was recorded as being most extreme in 2005 were not necessarily those in which the level of permissiveness was highest, or lowest, but instead moderate. In these provinces, at least according to the measure of permissiveness in the late 1980s, couples have been permitted to have two children (Zhu et al. 2009). It has been suggested that a plausible explanation for why rural areas that have a two-child policy have not seen a change in cultural practices is that the increased natural probability of having a son from two births is higher than one, and this has slowed and effectively prevented a cultural evolution away from patrilocal marriage practices towards matrilocal marriage practices (Bossen 2007), or at least in the direction of a mixture of the two. In urban areas matrilocal practices have become more prevalent, and where this is the case, the perceived association for parents between having a daughter and lacking financial and physical support as they enter old age is significantly diminished. Another obvious implication of living in an urban area is that these families are not engaged in agricultural production, and thus are not entitled to a state allocation of land. In these cases the economic opportunity cost of having a daughter is far less salient.

However, despite the importance of considering the role of policy and practice at the provincial level, it is crucial to examine the patterns that are operating at lower levels of aggregation, such as China's prefectures and counties. Investigating the change in the sex ratio imbalance using census data from 2000, Guilmoto and Oliveau (2007) found there were a considerable number of counties with relatively normal sex ratios side-by-side with counties for which the imbalance was highly extreme. An analysis of county data, which is the finest unit for which China's aggregated census data is publicly available, revealed a pattern that was not possible to discern using the information available for larger geographical units. This suggests the importance of seeking explanations at the local level (Murphy 2003). Unfortunately the finest level of geographical aggregation in the publicly available microdata are China's prefectures, but these units also show a considerable degree of variation in the sex ratio at birth. The following discussion will consider two potential explanatory factors for this local variation, which are cultural and economic incentives for sex-selective abortion, and the influence of adult sex ratios upon decisions regarding sex-selective abortion.

Cultural and Economic Incentives for Son-bearing.

The historical patrilineal nature of Chinese society is exemplified by the traditional beliefs regarding the importance of descent lines and ancestor worship. In rural areas lineage temples are common, and these temples contain the names of male ancestors, but not those of females (Bossen 2007). It was, and continues to be, widely believed that the primary duty of the males in a household is to produce a son who will in turn carry on the family name, thereby fulfilling the obligation to their parents and ancestors (Bongaarts and Greenhalgh 1985). The widespread practice of patrilocality means that parents with a son know that they will have both physical and financial support provided in their old age, and this practice is seen as a repayment of the investment and support provided to the son by his parents while he was in his youth. The weight attached to this belief is exemplified by several common names that parents in China still choose for their daughters to this day: laidi (a boy is following); pandi (hoping for a son); and zhaodi (bring us a son) (Guilmoto and Attané 2007).

In rural areas these beliefs and the practices that follow are further supported and reinforced by government policy regarding land allocation. All sons born in these rural agricultural areas are entitled to a plot of land from the state once they reach adulthood. If the son continues to live with his parents, as is very often the case, that plot thereby increases the size of the family's total land holdings (Bossen 2007). Given that the state does not offer a national pension system, the security that this additional land offers to families is very important (Bossen 2007). Unmarried daughters are also, by letter of the law, entitled to this allocation of land, but in practice only sons receive the allocation (Bossen, 2007).

As the relative benefits of having a son over a daughter are numerous for rural Chinese families, many have taken an active role in determining the sex of their child. Evidence for discrimination against females is available for both pre-natal and post-natal practices. However, despite the undoubted importance of cultural influence in shaping sex preferences, stated preferences are not always congruent with observed behavior (Cronk 1991a). Cronk (1991b) found that despite a stated preference for sons, both the sex ratio at birth and patterns of parental investment amongst the Mukogodo of Kenya were biased in favor of the daughters, which was consistent with the reproductive maximization strategy suitable for that particular environmental context. Similar discrepancies between stated preferences and observed behavior have also been found for the Ifaluk people of Micronesia, and the Herero of the Kalahari (Cronk 1991a). These research findings highlight the importance of examining the actual behavior of the study population, which is the strategy for this study.

Adult Sex Ratios.

The economic and cultural incentives discussed above shed some light on why the preference for a son is so prevalent in China, and thus also why sex-selective childbirth practices are so widespread. It is also clear that family planning policies have played an important role in shaping preferences. However, it can be argued that these factors still fail to account for the variation in the imbalance in the sex ratio at the prefecture and county level. Cultural and economic incentives are likely to be relatively consistent in all areas, while family planning policies are reported to be relatively consistent at least within provinces (Cai and Lavely 2007). Another potential explanation that has received barely any attention in the literature on this topic is the potential importance of the adult sex ratio on shaping decisions regarding whether or not to sex-selectively abort for a son.

Research that has been conducted to investigate the importance of the implementation of family planning policies as well as the availability of ultrasound and abortion clinics indicates that these factors play an important role in shaping decisions regarding sex-selective abortion. However, work in this area has suggested that these policies, and the availability of these facilities, is broadly consistent within provinces. Given these reports, the variation in the sex ratio at birth in prefectures and counties that border one another suggests that some other local factor, or factors, must be operating (Guilmoto and Oliveau 2007). One potential explanation is variation in local cultural practices. However, while the sex ratio imbalance at birth is worse in some provinces than others (Zhu et al. 2009), which may be stemming from differences in the strength of local patriarchal customs, it is rather unlikely that this is the explanation for the variation in prefectures and counties that actually border one another.

There is some evidence in the evolutionary biology literature that suggests that a self-correcting relationship between adult sex ratios and the SRB exists in humans (James 1995; Lummaa, Merilä, and Kause 1998; Helle et al 2008). James (1995) has argued that parental perceptions of the adult sex ratio may affect parental hormone levels that subsequently influence the sex of the zygote, leading to a negative feedback process. This study does not intend to seek any biological mechanism for the sex ratio imbalance in China, and it would probably be impossible to do so because of the confounding affect of sex-selective abortion practices. The argument here is that the principle of this negative feedback process should be the same, but that it should result from conscious, or subconscious, decisions made by parents based upon their perception of the adult sex ratio in the area in which they live. Thus, adults living in an area with a high sex ratio should not only be less likely to engage in sex-selective abortion so as to ensure a son, but may even take measures to have a daughter instead.

There are several factors to consider that might shape such a preference. One potential factor is that parents have a preference for their children being able to have a successful family and work life once they have grown to reach adulthood. A second, and related, potential factor is that when having a child, parents are already considering the prospects of having grandchildren. It can be argued that whenever there is variation in the opportunities for offspring of either sex to reproduce, parents should adjust their investment strategies accordingly, so as to favor the sex that will maximize their own reproductive fitness. In the case of sex ratio imbalances in the marriage market, the appropriate strategy would be for parental preferences to adjust in favor of whichever sex is in the minority, as members of this group are not only more likely to find a reproductive partner, but are also more likely to find a reproductive partner of a higher quality because of an expanded choice range, and greater competition amongst members of the supernumerary sex. This proposition is similar to the Trivers-Willard hypothesis (Trivers and Willard 1973), but is not the same, because the Trivers-Willard hypothesis rests upon the animating mechanism that there a difference in the variance of the reproductive potential of members of either sex, which is not the argument being proposed here (Freese 2008).

Although cultural norms in China, as well as the accompanying economic practices, strongly communicate that the family line is passed down through a male descendant, it is not altogether unlikely that parents would rather have grandchildren through a daughter than no grandchildren through a son that could not find a wife. This would certainly be consistent with theoretical assumptions in evolutionary biology and psychology that presume the fundamental biological drive to successfully reproduce one’s genes (Dawkins 2006). This has been a highly controversial topic in sociology since the publication of Sociobiology by Wilson (1975). Without wishing to venture into the nature-nurture debate, I will simply state that it is widely accepted that there is an interaction between these two influences, and it has been pointed out that the concept of an evolved actor has been present in sociological research over a long period of time, and particularly in research on the family (Hopcroft 2009).

A low adult sex ratio would, according to this mechanism, lead to a very high sex ratio imbalance at birth, because couples would see no reason not to engage in sex selective childbirth practices for fear that their son would not be able to find a wife and build a family in the future. As Edlund (1999) argues, in general a married son is better than a married daughter, an unmarried son is better than an unmarried daughter, and a married daughter is better than an unmarried son. Thus, where the superscript indicates whether the individual is married (1) or not (0):

$$U(m^1) > U(f^1) > U(m^0) > U(f^0) > \infty$$

It might reasonably be disputed whether an unmarried daughter would be perceived as being less valuable to parents than an unmarried son, as it is generally socially recognized that a woman has a greater parental right to raise the children born out of wedlock than the man who fathered the children (Edlund 1999). However, in terms of the relationship between adult sex ratios and p_{male}, this latter point is somewhat superfluous. Given this hierarchy of preferences, a high adult sex ratio should discourage parents from intervening to increase the chances that they have a son. Whether they are fully conscious of this consideration or not, it seems reasonable that a couple considering having children will take into account the ability of husbands to find wives in their own cohort, and a serious shortage of women might make them question whether it would be wise to have a son in terms of his ability to find a wife in the future.

To date no empirical research has been conducted to investigate whether sex ratios amongst marriage-age males and females are linked to the likelihood of engaging in sex-selective abortion. Aside from the work discussed above by Edlund (1999), the only theoretical consideration of this issue is a rational choice model for this decision-making process, developed by Yoon (2006). Yoon (2006) suggests that when making decisions regarding whether or not to engage in sex-selective abortion, parents should adopt a mixed strategy. When the sex ratio is high, they should stop engaging in sex-selective childbirth practices to ensure that they have a son, because that son will not be able to find a marriage partner and therefore will not be able to bear grandchildren. In this case, they should allow sex allocation to occur naturally. However, as the sex ratio falls towards parity, sex-selective childbirth practices are likely to increase again. Yoon (2006) also suggests that it is possible that at a sex ratio above the level at which sons are unlikely to be able to find a wife, parents may opt to attempt to produce a daughter.

There is a small amount of literature documenting sex-selective abortion to increase the chances of giving birth to a girl in China (Zeng et al 1993; Das Gupta 2005), but this has generally received far less attention in comparison with abortion practices that have been geared towards having a son. Zeng et al. (1993) were the first to explicitly point out that in 1990 the SRB for third order births for women who had already given birth to two sons was 0.74, and that it was 0.64 for fourth order births to mothers who had previously given birth to three sons. Without entering an extended discussion of this observation, Zeng et al. (1993) suggest that the SRB for these categories was likely to be so low because of prenatal sex identification followed by sex-selective abortion, and that this may have been due to a desire for children of both sexes. This is a plausible argument, and there is evidence for a preference for mixed sex sibships in both the United States as well as Europe (Pollard and Morgan 2002; Hank and Kohler 2000; Andersson, Hank, Rønsen, and Vikat 2006), but nevertheless this theory fails to account for why there is such a degree of regional variation in the propensity to give birth to a son in China.

While the argument presented by Yoon (2006) is somewhat persuasive, it might be contested that a demand and supply model is inappropriate for this particular situation. After all, if parents are factoring the perceived future opportunities of their children to marry into their sex-selective abortion decision-making process, it would make more sense for them to look at the sex ratio amongst infants and adjust accordingly. However, I believe a reasonable argument can be made that the cultural norms encouraging son-bearing might not be questioned unless the parents making this decision had experienced themselves the challenge of finding a marriage-partner in an area with an imbalance in the adult sex ratio. Having faced this difficulty directly, and most probably also observed friends and other family members face this difficulty, they might be inclined to consider in further detail the marriage prospects for their future child.

The literature regarding variation in the degree of post-natal investment in children according to their future reproductive potential amongst humans is somewhat mixed (Cronk 1991a). A particularly strong example in favor of this hypothesis is provided by Bereczkei and Dunbar (1997), investigating female-biased reproductive strategies in the Hungarian Romani population. The authors found that parental investment in daughters was higher in the urban resident Romani population relative to the rural resident Romani population, reflecting the higher levels of exogamy, and thus hypergyny, in the former group due to the much greater proximity to non-Romani Hungarians. Apart from the startling bias towards females in the sex ratio at birth, apparently not due to sex-selective abortion, urban resident Romani groups were also more likely to invest to a greater extent in daughters than sons through longer periods of breast-feeding, and encouraging them to stay in school for longer. In this case decisions about investment in children were based upon the expected reproductive payoffs based upon parents own experience of marriage transitions in the local marriage market, and it seems reasonable to presume that parents in China might make comparable considerations. At the same time it must be acknowledged that there is a substantial body of research that has found no support for variation in the degree of parental investment directed towards either sex in relation to any sort of reproductive strategy (Freese and Powell 1999).

An additional factor to take into consideration at this point is how the MASR might be interacting with birth order. As Zhu et al. (2009) as well as a number of others (Wu, Viisainen, and Hemminki 2006; Bannister 2004) have pointed out, the sex ratio imbalance in China increases by birth order, and does so dramatically. It has also been claimed that, in the early 1990s, most pregnant women did not engage in sex-selective childbirth practices for the first child, but had a strong tendency to do so for their second and third pregnancies so as to improve their chances of having a son (Bossen 2007). This would also suggest that the imbalance in the sex ratio at birth should be worse for mothers who have already given birth to one or more daughters, and should be closer to a natural level for women who already have a son, having fulfilled their goal (Chu 2001).

As mentioned above, previous research has suggested that the sex ratio should increase dramatically with birth order, but this effect should be stronger for women who have only had daughters in the past relative to women who have already given birth to a son. However, the theoretical development posited in this paper is that a high adult sex ratio should decrease p_{male}, regardless of birth order, though this effect might be expected to be stronger for women who have already given birth to a son. This leads to the null hypothesis and three alternative hypotheses:

Hypothesis 0:

There will be no systematic variation in p_{male} according to variation in the marriage-age sex ratio.

Hypothesis 1:

For first order births there will be a negative relationship between the marriage-age sex ratio and p_{male}.

Hypothesis 2:

For second order births there will be a negative relationship between the marriage-age sex ratio and p_{male}. When considering the sex composition of earlier childbirths, the negative relationship between the marriage-age sex ratio and p_{male} should be greater for those who have already given birth to a male relative to those who have already given birth to a female.

Hypothesis 3:

For third order births there will be a negative relationship between the marriage-age sex ratio and p_{male}. When considering the sex composition of earlier childbirths, the negative relationship between the marriage-age sex ratio and p_{male} should be greater for those who have already given birth to two males relative to those for whom the sex composition of previous births was mixed, meaning one male and one female. In turn, the negative relationship between the marriage-age sex ratio and p_{male} should be greater for women who have previously given birth to a mixed pair relative to those who have previously given birth to two daughters.

DATA AND METHODS

This analysis will use data from the 1990 census[1,2]. The census data is microdata, and will provide demographic information on the individuals under analysis, as well as allowing for the calculation of sex ratios at the prefecture level. The prefecture level is the smallest geographical unit available in the dataset.

1990 Census Data.

The 1990 census, China's fourth national population census, was collected by China's National Bureau of Statistics. The microdata are a 1% sample drawn from the complete census. This 1% sample is self-weighted, meaning that it is an EPSEM (Equal Probability of Selection Method) sample. Thus, every individual in the population of interest had an equal opportunity of being selected for the sample.

Dependent Variables.

The dependent variable used in this paper is a binary variable for whether or not a reported live birth was male or not. As the probability of giving birth to a son ranges between 0.505 and 0.520 (James 1987) one would not expect that p_{male} should vary according to socioeconomic characteristics peculiar to a given individual, or any characteristics at the provincial level, unless some sort of active prenatal intervention had taken place. Any significant variation would indicate some kind of intervention in the pregnancy to increase the chances of giving birth to a son, and thus this binary variable essentially operates as a proxy variable indicating propensities to engage in sex-selective abortion (Jacobsen et al. 1999). All the cases used in this analysis are married women, as previous studies strongly suggest that one cannot expect to receive reliable answers regarding abortion and childbirth from women who have not previously been married (Lofstedt, Luo, and Johansson 2004). Furthermore, premarital live birth is rare in China (Sun et al 2003). Since the vast majority of responses regarding live births do already come from married women this does not cut down the number of cases by any great degree.

Although there is always a risk of error in retrospective reporting, the live births data here concerns only births that took place in the eighteen month period immediately preceding the census survey. To be more specific, the births included in the dependent variable are those reported by women who had only given birth to one child in the past eighteen months. A relatively small number of women had reported two live births in the year and a half preceding the recording of the census, but these have been excluded from the analysis both because of the difficulty in identifying the birth order of these two children, which would confuse the birth order analysis, and because of the complicated effects that plural births, such as having twins, can have on sex ratios (Jacobsen et al., 1999). Thus, it can be hoped that the relative proximity of the event should limit the risk of misreporting.

Independent Variable.

Marriage-age Sex Ratio.

The MASR will be calculated as $100 \cdot \sum M_j = \sum F_j$, where M_j denotes all men aged 22-32, and F_j denotes all women aged 20-30. There has been some debate over the degree to which certain measures of the sex ratio are overly restrictive, such as sex ratios that are confined to arbitrarily designated age groups (Fossett and Kiecolt 1991). I am sympathetic to this concern, but I feel that the choice of this particular age band is reasonable because the particular focus of this study is perceived opportunities in the local marriage market. A similarly designated age band has also been used in other research on contextual sex ratios (Angrist 2002). For my analyses I will be using the natural log of the MASR. This is because there is considerable variation between different prefectures, and the raw measure of sex ratios is asymmetric, with a male deficit ranging from 0 to 100 and a female deficit ranging from 100 to ∞.

An example of this asymmetry is that a sex ratio of 50 is equivalent to a sex ratio of 200 in terms of the fact that the former implies that there are twice as many women as men, and the latter implies that there are twice as many men as women. Although it is slightly more difficult to interpret, taking the natural log gives the measure symmetry (Fossett and Kiecolt 1991). Thus, the measure for the MASR is $Log_{100 \cdot \sum Mj = \sum Fj}$, where M_j denotes all men aged 22-32, and F_j denotes all women aged 20-30. Some of the prefectures under analysis have a very small number of births recorded, and this is particularly true when looking at later birth orders. There is reason to be concerned that the inclusion of prefectures that have a very small number of births recorded could provide estimates that do not allow one to draw reasonable inferences regarding the importance of the adult sex ratio on the decision to sex- selectively abort or not. Because of this, I have decided to exclude from each of the eight analyses all prefectures where less than fifty births were recorded[3].

Control Variables.

Maternal age.

Although previous research into the effect of maternal age on sex ratios has not been conclusive, research with large sample sizes in countries where sex-selective abortion is not prevalent has found that it can have a mildly negative effect on sex ratios (Jacobsen et al. 1999). In countries where sex-selective childbirth practices exist it is possible that a negative relationship between maternal age and p_{male} reflects a decreased likelihood to engage in sex-selective abortion as older women are more likely to have had a son through multiple attempts to achieve this goal, though there is no specific evidence to support this.

Education.

Research conducted in India (Clark 2000) has found that Indian mothers with lower levels of education are actually more likely to have a higher proportion of sons than are mothers with a higher level of education. However, in China the limited evidence thus far available suggests that the relationship actually runs in the opposite direction, with higher levels of education being associated with sex-selective abortion (Croll 2000; Bannister 2004). Some qualitative research has suggested that this may be due to the fact that those in higher socioeconomic positions are better positioned to resist sterilization drives, and more able to bribe local family planning officials into allowing them to try for another child (Murphy 2003). Indeed, this might provide some explanation for why some of China's worst sex ratio imbalances at birth have been observed in its wealthier provinces even though the economic incentives previously discussed are not as strong for individuals of a higher socioeconomic class.

Occupational status of spouse.

Occupational status details in the 1990 census are available for 11 categories. These have been recoded into five categories that are consistent with the aim of investigating the propensity to engage in sex-selective abortion by status in a way that provides an accurate reflection of the Chinese context in 1990 (Zhou 2004). The following analysis will use dummy variables for the first four categories, with unskilled workers as the reference category. I have chosen to include the occupational status of the spouse rather than that of the mother as it is quite possible that these women might not be working in this period relatively soon after giving birth.

Ethnicity.

The 1990 census data categorizes each respondent into one of fifty-seven different categories. By far the largest ethnic group, however, is the Han, constituting 92% of the population. Accordingly, this variable has been recoded into two categories: The Han, and all other ethnic groups.

Infant Sex Ratio.

All research into the sex ratio at birth and sex-selective abortion in China has suffered from a lack of detailed information on local family planning policies, as well as the availability, cost, and the degree to which the use of ultrasound and abortion facilities is widespread. These are important variables to take into consideration, and it is important to control for the influence that they have when investigating how alternative factors may be affecting propensities to engage in sex-selective abortion. Unfortunately data regarding these variables in 1990 either does not exist, or they are at least not available in the public domain. Subsequently it will be necessary to use a proxy variable.

The infant sex ratio will serve as an indicator of whether sex-selective abortion practices have been prevalent in the prefectures under analysis in the years preceding the actual year of focus, 1990. Although an imbalance in the infant sex ratio cannot provide details on whether ultrasound and abortion facilities were available, whether local family planning policy fostered these kinds of behaviors, or the extent to which sex-selective childbirth practices were culturally acceptable, it can provide a broader indicator of whether or not these practices have been taking place.

Controlling for this factor at least allows the analysis to take into account the prevalence of sex-selective childbirth practices, and holding this factor constant will make it easier to draw inferences about the relative importance of the adult sex ratio on sex-selective abortion. The infant sex ratio will be calculated as follows: $100 \cdot \sum M_j = \sum F_j$, where M_j denotes all infant males aged 2-4, and F_j denotes all infant females aged 1-4, in each prefecture. Again, the natural log of this raw measure will be used so as to give symmetry to the measure. Thus the infant sex ratio will correspond to $Log_{100 \cdot \sum Mj = \sum Fj}$, where M_j denotes all infant males aged 2-4, and F_j denotes all infant females aged 2-4.

Provincial Macroeconomic Indicators.

It is possible that the reason why there are higher levels of sex-selective abortion in some prefectures than others is due primarily to a greater prevalence of progressive values in some areas in comparison with others. A potential example of this might be that areas with higher levels of foreign direct investment and economic growth and development are less likely to engage in sex-selective abortion to have a son. Because economic development in China in the 1980s was primarily driven by secondary production activities (Tsui 1996), because these activities are particularly labor intensive, and because men are more likely than women to move as labor migrants (Zai and White 1997), areas with high adult sex ratios might be the very same areas that are characterized by more progressive social values. Because of this, I have included two macroeconomic indicators, at the provincial level, to control for this potentially confounding factor. The two indicators I have included in my models are GDP per capita in 1990, and GDP growth per capita in the period 1978-1990. These data are drawn from the National Bureau of Statistics of China (Fan and Sun 2008).

Methods.

Separate analyses will be conducted for all eight dependent variables, which are first order births, second order births, second order births where the first child was a male, second order births where the first child was a female, third order births, third order births where the first two children were males, third order births where the first two children were females, and third order births where one child was male and the other female. It is assumed that the sex of live births has a binomial distribution, and that it is a Bernoulli random variable that takes the value of 1 if the child is a boy, and 0 if the child is a girl (Clark 2000). All eight analyses will use a logistic regression using robust cluster estimation (Moller et al 2003; Primo, Jacobsmeier, and Milyo 2007), which will provide robust standard errors, corresponding to the following equation:

$$\log\left(\frac{p_{male}}{1-p_{male}}\right) = \gamma_{00} + \gamma_{01}\omega_j + \gamma_{10}\omega_{ij} + \gamma_{11}\omega_i x_{ij} + (u_{0j} + u_{1j} + \varepsilon_{ij})$$

The use of a cluster analysis provides standard errors that do not allow errors to be correlated across or within units (Primo et al. 2007; White 1980), and thus there is the corresponding assumption that observations across clusters are independent of one another. The equation above includes a compound error term due to the fact that coefficients are assumed to be random. A multi-level analysis approach was considered, but due to the large size of the China census dataset the computational demands were excessive, and the models failed to converge. However, a detailed comparison of these two approaches has suggested that a clustered analysis is at the very least a satisfactory alternative if all the assumptions have been met (Primo et al. 2007). It has been suggested that 50 clusters are usually sufficient for valid and reliable inferences (Primo et al. 2007).

RESULTS

First Order Births.

The coefficient for the MASR is positive for first order births, but these results were not significant at $p<.05$. Although the direction of these results was not in the direction predicted by hypothesis 1, the relatively large p-value and small size of the coefficients suggests that adult sex ratios were playing, if any at all, a very small role in influencing decisions regarding sex-selective abortion for first order births. It might be noted at this point that the coefficients for the infant sex ratio are positive and statistically significant at $p<.05$. As is evident in all eight analyses, the size of the effect associated with the infant sex ratio is larger at later parities and when the mother has not previously given birth to a son. This suggests that this measure is effectively capturing the proclivity towards sex-selective abortion in the absence of a direct measure of cultural preferences and the availability of sex-selective ultrasound and abortion facilities. It should be added that these models were also run without the inclusion of the infant sex ratio, with no substantial impact upon the effect of the variable of interest, the marriage-age sex ratio. These results are available upon request. As described above, these models have only been run for prefectures where at least fifty births were recorded. I would like to add that the results of these more conservative analyses are fully consistent with the results of the analyses where these prefectures were not excluded. These results are also available upon request.

Second Order Births.

As can be seen in table 2, the analysis for second order births is accompanied by a negative and statistically significant coefficient for the marriage-age sex ratio. The actual impact that the MASR has on the predicted probability of giving birth to a male can be seen in figure 1. The x-axis shows that the MASR ranges from 0.81 to 1.64, and over this range, the predicted probability of giving birth to a son decreases from approximately 0.52 to approximately 0.48. Looking at the other models for second order births, which have also taken into account the sex of the first child, it can be seen that a significant negative relationship between the MASR and pmale exists for those who had a son at the first birth, but not for those who had a daughter at the first birth. This association is illustrated graphically in figure 2. The p_{male} where the MASR is 0.81, meaning 81 men per 100 women, is approximately 0.47, while the pmale where the MASR is 1.64 is approximately 0.42. While the relationship between the MASR and pmale was not significant for births where the previous child had been female, the relationship was in the expected direction. Although these results do not conform entirely to hypothesis 1, which stated that a negative relationship between adult sex ratios and p_{male} would be found at all births, it does strongly suggest that this relationship is genuine rather than being spurious.

<u>Table 1 – Descriptive Statistics</u>

TABLE 1. Descriptive Statistics

Variable	Categories	Live Birth Sex (%)		
		All Births		
		Male	Female	Total
Mother Age:	15-19	51.6	48.4	100.0
	20-24	52.6	47.4	100.0
	25-29	54.3	45.7	100.0
	30-34	54.8	45.2	100.0
	Over 35*	52.9	47.1	100.0
Mother Education:	University	58.5	41.5	100.0
	Secondary	53.3	46.7	100.0
	Primary	53.8	46.2	100.0
	DNC Primary*	52.3	47.7	100.0
Spouse Occupation:	Professional/Managerial	54.2	45.8	100.0
	Clerk/Service	52.9	47.1	100.0
	Agriculture	53.3	46.7	100.0
	Trade/Industry	53.9	46.1	100.0
	Unskilled*	51.0	49.0	100.0
Mother Ethnicity:	Han	53.6	46.4	100.0
	All Other*	51.7	48.3	100.0
Birth Order and Sex Composition:	First Order	51.4	48.6	100.0
	Second Order	54.8	45.2	100.0
	Second Order One Son	50.2	49.8	100.0
	Second Order One Daughter	59.1	40.9	100.0
	Third Order	56.5	43.5	100.0
	Third Order Two Sons	42.3	57.7	100.0
	Third Order Two Daughters	67.4	32.6	100.0
	Third Order Mixed	53.5	46.5	100.0
		Mean	S.D.	
Sex Ratio Measures:				
Marriage-age Sex Ratio		97.01	9.72	
log_{MASR}		4.57	0.09	
Infant Sex Ratio		109.28	6.94	
log_{ISR}		4.69	0.06	

Source: 1990 census
***Reference category**

Figure 1. Predicted Probability of Male Birth for Second Order Births by Log_{MASR}

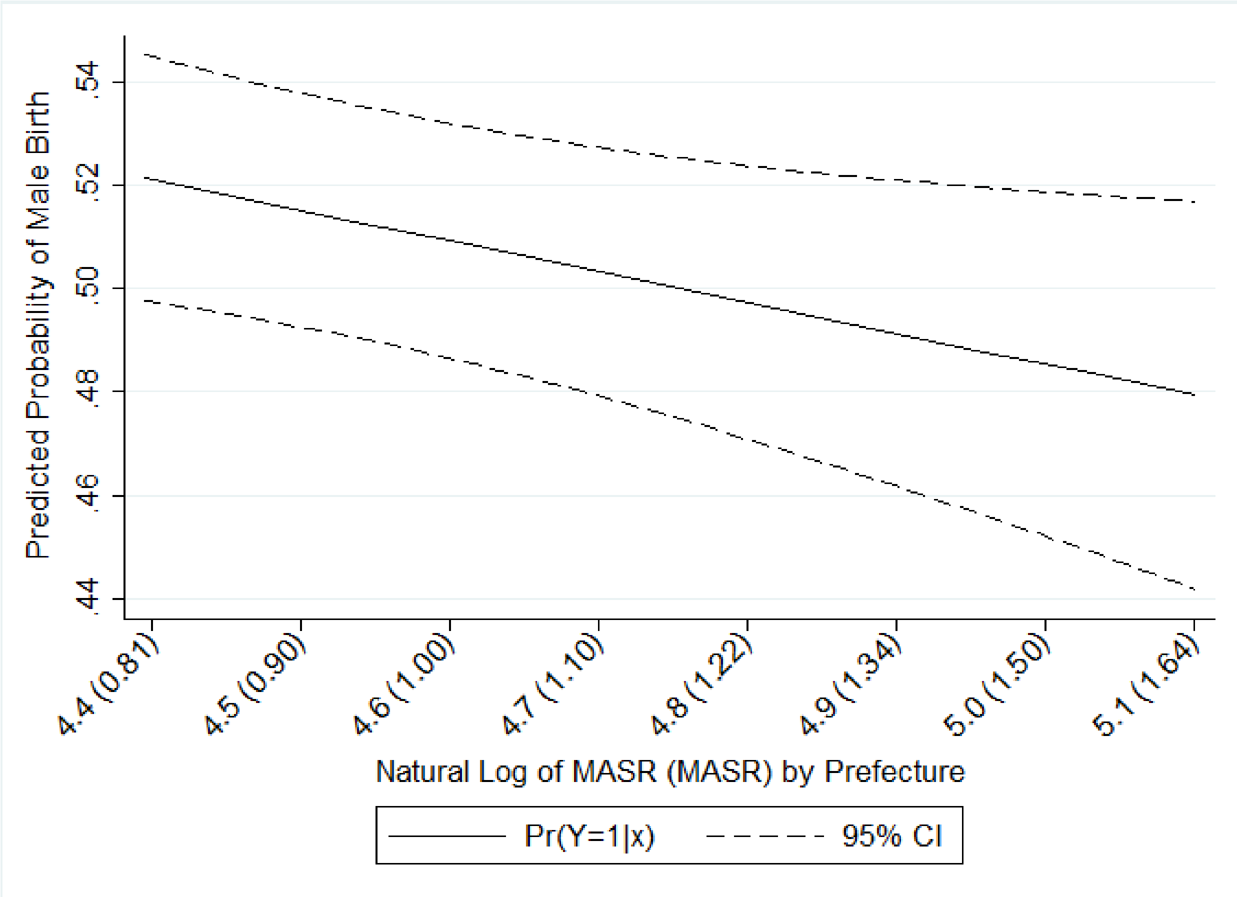
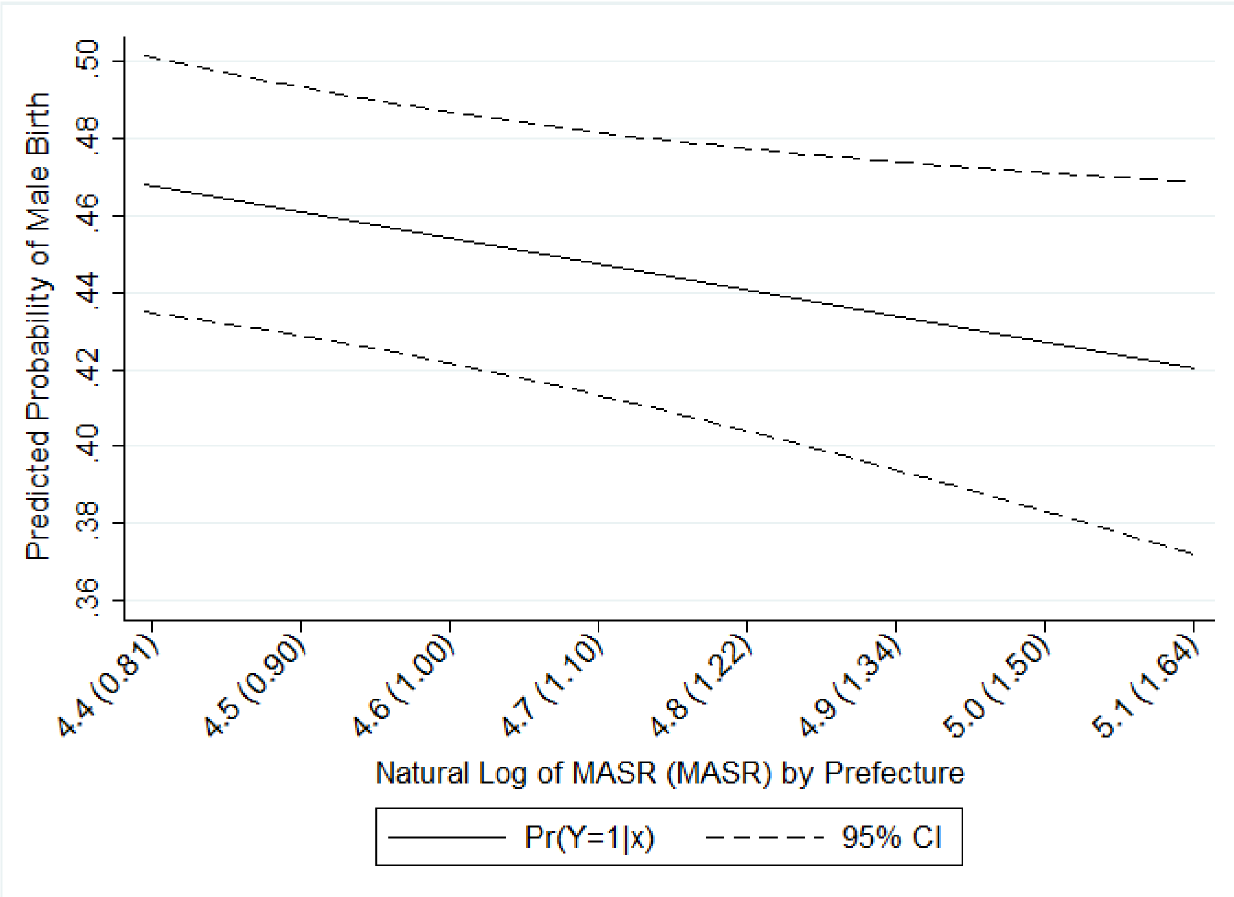


Figure 2. Predicted Probability of Male Birth for Second Order Births for those with a Previous Male Birth by Log_{MASR}



In conformance with hypothesis 2, it makes sense that couples living in areas with a high adult sex ratio that have already had a son would be less likely to abort to have another son, and may even be adjusting strategy in an attempt to have a daughter. These results suggest that cultural norms and reproductive maximization strategies are interacting with one another to shape the decisions that parents are making. Even given the fact that the probability of giving birth to a son decreases very marginally by later birth orders (Sieff 1990), this pattern of male births would not be expected to vary to this degree according to the adult sex ratio unless there was some sort of pre-natal intervention taking place. Furthermore, the probability of giving birth to a son will usually, in the absence of pre-natal intervention, increase very marginally with the number of prior sons (Sieff 1990), but in prefectures with a high MASR the opposite effect is observed in these results. The general pattern observed here is consistent with the pattern observed by Zeng et al. (1993) in terms of the SRB being lower for mothers who had previously given birth to sons, but again this general trend cannot account for geographical variation in the probability of giving birth to a son.

Third Order Births.

The results for the analyses conducted for third order births can be found in table 3. For the pooled analysis for all third order births, the relationship between the MASR and p_{male} was again negative and statistically significant at $p<.05$, a result consistent with hypothesis 3. This relationship is illustrated in figure 3, and it can be seen the p_{male} falls from approximately 0.59 when the MASR is 0.81, to approximately 0.53 when the MASR is 1.64, a decline of 7%. These results suggest that in prefectures with a low adult sex ratio, women are considerably more likely to have a son than would be expected naturally, with a probability that should otherwise fall within the range of 0.505 to 0.520 without any pre-natal intervention (James 1987).

Figure 3. Predicted Probability of Male Birth for Third Order Births by Log_{MASR}

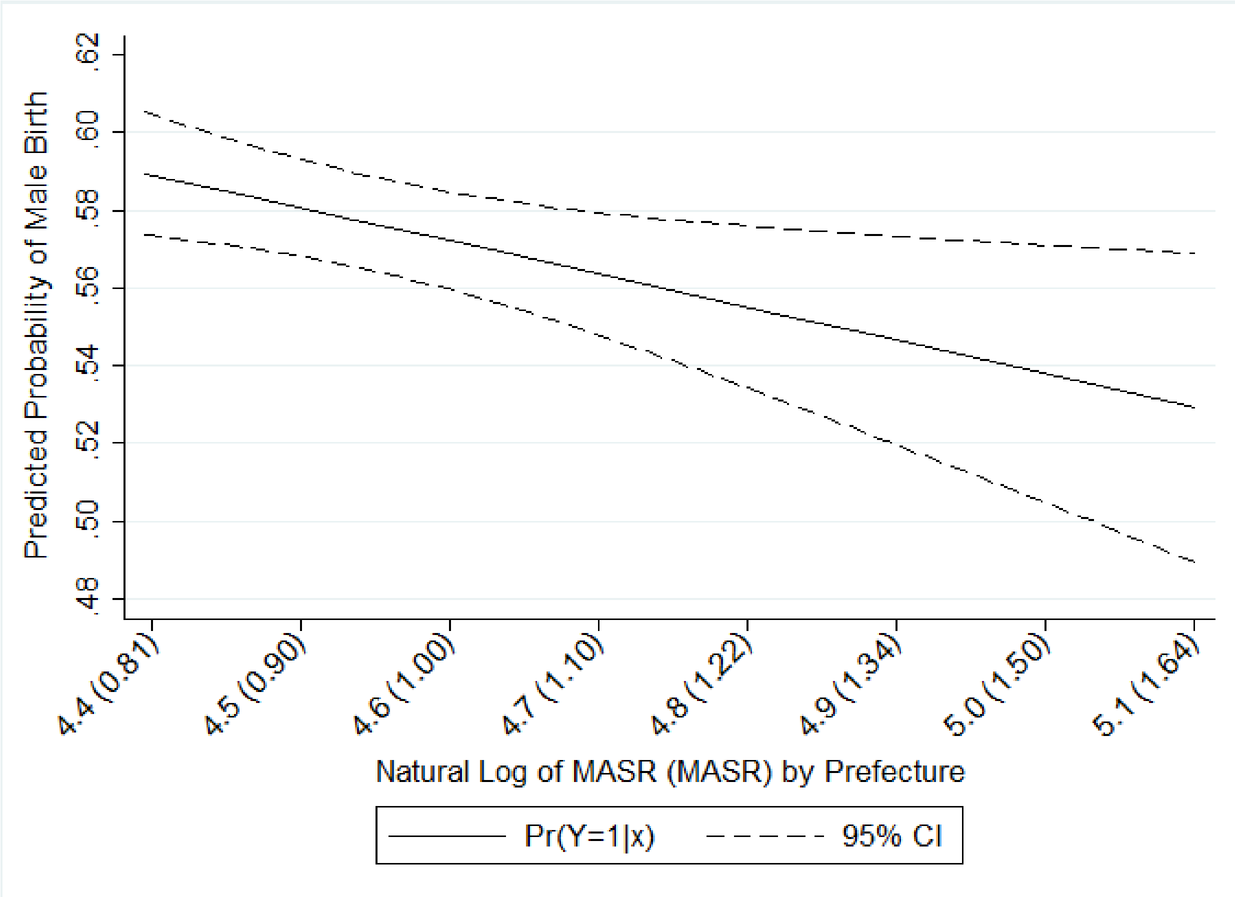


TABLE 2. Logistic Regression Marriage-age Sex Ratios: First and Second Order Births

	First Order		Second Order		Second Order 1 Son		Second Order 1 Daughter	
	β	S.E.	β	S.E.	β	S.E.	β	S.E.
Maternal Age								
15-19[a]	0.562***	0.102	0.079	0.097	0.074	0.137	-0.020	0.145
20-24[a]	0.555***	0.099	0.163***	0.049	0.217**	0.069	0.036	0.073
25-29[a]	0.504***	0.098	0.176***	0.046	0.181**	0.067	0.108	0.069
30-34[a]	0.349***	0.108	0.060	0.054	0.083	0.077	-0.040	0.077
Mother's education								
University[b]	0.444***	0.096	0.401	0.620	0.820	1.189	0.231	0.670
Secondary[b]	0.099***	0.027	0.102*	0.042	0.010	0.060	0.162**	0.061
Primary[b]	0.071***	0.019	0.104***	0.021	0.045	0.030	0.158***	0.029
Father's occupation								
Professional[c]	0.095	0.051	0.186	0.116	0.159	0.148	0.271	0.159
Service[c]	0.038	0.051	0.130	0.108	0.129	0.151	0.183	0.159
Agriculture[c]	0.050	0.048	0.084	0.097	0.155	0.133	0.090	0.145
Industry[c]	0.078	0.051	0.173	0.101	0.239	0.143	0.185	0.143
Ethnicity								
Han[d]	0.022	0.023	0.044	0.027	-0.050	0.040	0.126**	0.048
Macroeconomic Indicators								
GDP per capita	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GDP growth per capita	0.012*	0.005	0.010	0.010	0.011	0.012	0.015	0.016
Infant Sex Ratio								
ISR	0.260**	0.101	0.869***	0.166	0.100	0.230	1.863***	0.300
Marriage-age Sex Ratio								
MASR	0.128	0.068	-0.238*	0.110	-0.274*	0.132	-0.258	0.220
Constant	-2.524***	0.578	-3.317***	0.916	0.345	1.219		
n	108,854		66,394		30,466		32,510	
Clusters	317		283		219		241	

Source: 1990 China census

*p < 0.05; **p < 0.01; ***p < 0.001

[a]Aged over 35; [b]Did not finish primary school; [c]Unskilled; [d]All Others

TABLE 3. Logistic Regression Marriage-age Sex Ratios: Third Order Births

	Third Order		Third Order 2 Sons		Third Order 2 Daughters		Third Order Mixed	
	β	S.E.	β	S.E.	β	S.E.	β	S.E.
Maternal Age								
15-19[a]	0.360	0.380			-1.452	1.261		
20-24[a]	0.177**	0.062	-0.906***	0.284	-0.337*	0.144	0.744	0.697
25-29[a]	0.185***	0.050	-0.751**	0.265	-0.300*	0.124	0.062	0.113
30-34[a]	0.110	0.056	-0.503	0.265	-0.163	0.140	-0.037	0.092
Mother's education								
Secondary[b]	-0.041	0.071	-0.159	0.307	0.028	0.153	-0.070	0.113
Primary[b]	0.078**	0.030	-0.038	0.152	0.131*	0.062	0.007	0.048
Father's occupation								
Professional[c]	-0.050	0.222	1.839	1.183	0.012	0.507	-0.102	0.425
Service[c]	-0.094	0.223	1.093	1.076	-0.417	0.475	0.236	0.407
Agriculture[c]	-0.176	0.203	1.086	1.051	-0.491	0.457	-0.084	0.392
Industry[c]	-0.051	0.207	1.103	1.189	-0.302	0.481	-0.035	0.404
Ethnicity								
Han[d]	0.028	0.051	-0.638	0.364	-0.324	0.226	-0.139	0.085
Macroeconomic Indicators								
GDP per capita	-0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000	0.000
GDP growth per capita	0.024	0.015	0.070	0.138	0.069	0.038	0.040	0.025
Infant Sex Ratio								
ISR	1.116***	0.244	3.332	1.911	3.460***	0.861	0.857*	0.377
Marriage-age Sex Ratio								
MASR	-0.346*	0.141	-0.162	2.039	-0.944	0.790	0.103	0.225
Constant	-3.632**	1.291	-15.095	13.435	-10.606	6.014	-4.355	2.235
n	23,325		1,436		5,186		7,995	
Clusters	166		23		69		95	

Source: 1990 China census
*p < 0.05; **p < 0.01; ***p < 0.001
[a]Aged over 35; [b]Did not finish primary school; [c]Unskilled; [d]All Others

Although these results suggest that sex-selective abortion had still been taking place to increase the chances of having a son even in prefectures with a very high adult sex ratio, the p_{male} is much closer to the naturally occurring level in areas where the MASR is high.

The results for the models that have been broken down the sex composition of previous births did not reveal any significant effects for the relationship between the MASR and p_{male}. There are several possible explanations for these results. The first is that the analysis conducted for third order births where the mother had previous given birth to two sons has a rather small sample, 1,436 births, and that these births come from twenty-three prefectures, which is insufficient in terms of the number of clusters necessary to draw reliable inferences from the results (Primo et al. 2007).

The reason for the small number of births for mothers who had previously given birth to two sons can be attributed to the fact that, because of the one-child policy, seeking to have a third child is a considerable challenge for Chinese women. While some reports have suggested that some degree of latitude is granted to mothers who have only previously given birth to daughters, and evidence for this is apparent in the higher number of births for women in that category in the relevant analysis conducted here, mothers who had already given birth to two sons would not have benefitted from this condition. The results for the analysis conducted for third order mothers who had previously given birth to two daughters was consistent with the equivalent analysis for second order births, with the results showing a negative coefficient that, despite being rather large, was not statistically significant. Thus the support for hypothesis 3 is limited to the results for the pooled analysis for third order births.

DISCUSSION AND CONCLUSION

To summarize the results, no relationship was found for first order births, but a strong, negative and significant relationship was found for second and third order births. This relationship was significant where women had previously given birth to sons, but not daughters. These results suggest an interaction between a cultural son preference, economic incentives for having a son in the Chinese system, and a parental investment strategy to maximize reproductive fitness. The lack of a substantive or significant relationship between adult sex ratios and p_{male} for first order births suggests that cultural preferences are strong enough that even parents living in a prefecture with a large imbalance in the adult sex ratio will not take that into account in the first instance. It is possible that for first order births parents are sufficiently keen to have a son that they will ignore concerns about the future prospects of that child.

The interaction between cultural preferences and economic and reproductive considerations is evident in the results for second order births when looking at the sex composition of previous children. Parents living in areas with a high sex ratio who already have sons are less likely to engage in sex-selective abortion than parents living in areas with a high sex ratio who have not yet had a son. On the other hand, for parents who have only previously given birth to daughters, the adult sex ratio is less salient in their decision making process, because of the still strong cultural preference for a son and concurrent economic incentives for having a son. The results for this relationship between adult sex ratios and the p_{male} are particularly striking given the fact that the demographic data available from China shows that the sex ratio at birth usually rises dramatically by birth order. Between 1980 and 2001 the national sex ratio for first order births was 1.06, and this rose to 1.24 for second order births and 128 for third order births (Hesketh et al. 2005). The results from the 2005 1% intercensus survey were even more extreme, with the sex ratio rising from 108 for first order births, to 1.43 for second order births, and 1.57 for third order births (Zhu et al. 2009). This analysis suggests that despite this strong pattern of rising sex ratios by birth order, a very high sex ratio amongst adult males and females may not only discourage sex-selective abortion in aim of achieving a son, but in some cases even encourages sex-selective abortion in favor of a daughter.

By investing in daughters over sons in an area with a high adult sex ratio, parents would have been maximizing their reproductive fitness in response to contextual conditions that they may have perceived as being important in terms of the future marriage opportunities for their offspring. This does, however, raise again the question about whether parents would be looking to the sex ratio within their own cohort as a guide to the future marriage-market and reproductive opportunities for their children, very few of whom would be likely to form a partnership with anybody in the parents' generation. If the intention is to specify strict assumptions of rationality then it would certainly be true to say that this mechanism does not really make sense. If anything, parents should be looking at the sex ratio at birth, or the sex ratio amongst infants, and basing their decisions upon those demographic conditions. However, the dynamic of this behavior is arguably not that simple. The sex ratio imbalance in China is comparable to a tragedy of the commons. Suppose for the moment that the cultural and economic incentives for having a son remain relatively constant, and the undersupply of females in China does not lead to an increase in their perceived worth or standing in society. In this case, despite the fact that an enormous excess of males is likely to precipitate negative consequences for everybody, not engaging in sex-selective abortion merely means that parents incur the costs associated with not having a son, or having a daughter. If they are acting according to utility-maximizing assumptions, parents should continue to use pre-natal intervention to ensure that they have a son.

There are, however, some problems with this line of reasoning. The first is the initial assumption that the relative value of females will not change even in the case of a severe undersupply of this population group. It is hard to know exactly how the societal perceptions of females may change under these conditions. It is possible that females may become even more suppressed within China's strong patriarchal system, but it would also not be unreasonable to suggest that the value accorded to females will increase. If specifying a utility-maximizing rational model of behavior it would be inconsistent to state that parents would not take that possibility into account, which would thereby reduce the perceived relative future value of having a son. A further problem of trying to fully explain these patterns using a utility-maximizing model of behavior is that even assuming that cultural son preferences and the economic incentives for having a son remain constant, the vast majority of Chinese parents are not able to afford to have multiple sons. This is because in many rural areas parents must bear the cost of their son's wedding, as well as providing a home for him and his wife. As Chu (2001) reports, this may cost a family as much as US$4,000. This cost makes it prohibitive for the vast majority of families to have more than two sons, and considering the rural poverty in China it can be imagined that the costs incurred by having one son would already be burdensome indeed.

While an understanding of the cultural and economic factors involved in shaping patterns of sex-selective abortion behavior is very useful, it is difficult to see how these factors could account for the variation in the predicted probability of giving birth to a son that is seen across areas with different imbalances in the adult sex ratio. When excepting the lack of an effect for first order births, a negative relationship was found between adult sex ratios and p_{male} for all analyses but one, third order births with a mixed sibship from previous births, though the relationship was not statistically significant in every case, particularly when the parents had previously only given birth to daughters. A brief consideration should also be made of the dependent variable, which is the self-report by potential mothers of whether they had given birth in the past eighteen months, and reports of the sex of previous births for higher birth order women. Given that the dependent variable covers births in the past eighteen months, it may also be capturing a certain amount of perinatal or postnatal mortality (Wu et al 2003), and may also underestimate the extent to which couples may give up their daughters for adoption, though evidence on the degree to which this practice is prevalent is mixed (Chu 2001; Johnson et al 1998). However, while this is not a perfect measure of fertility behavior, it is arguably the best that one might hope to obtain short of a detailed population fertility register drawing from hospital and community records.

One of the more concerning limitations of this study is that details regarding local family planning policy, as well as details regarding the availability of ultrasound and abortion facilities, are not available on a national scale. However, there are three reasons why one can have a relative degree of confidence in the results that have been shown and described above. The first is that the large size and statistical significance of the coefficients obtained for the variable for the infant sex ratio indicates that this was capturing proclivities towards sex-selective abortion in the prefectures under analysis. Secondly, research into family planning policy in China suggests that the implementation of these policies is relatively consistent within provinces (Cai and Lavely 2007), and so substantial variation between neighboring prefectures is relatively unlikely. Finally, parents have successfully been able to conduct sex-selective childbirth practices, if not abortions, for many years, and so if substantial motivations to have a child of either sex were prevalent, as it is clear they are, the absence of ultrasound or abortion facilities would not be likely to greatly hinder this behavior (Chu 2001).

To conclude, it is perhaps worth reiterating that while it is impossible to precisely ascertain the decision-making process that has taken place, it does not seem unreasonable that when making decisions regarding sex-selective abortion, potential parents would have consulted both their own personal experience of finding a marriage partner, as well as the observed experiences of friends and members of their extended family. The experience of local marriage-markets with an oversupply of either males or females is likely to have highlighted for these parents the potential challenges that might await any child that they give birth to, and therefore also raise the question of the potential reproductive success of their children and the chances of having grandchildren. The results of these analyses suggest that these considerations do indeed affect patterns of parental investment, though the variation of the results according to birth order and the sex composition of previous births strongly suggests that reproductive maximization strategies are interacting with cultural and economic considerations. The extent to which this relationship between adult sex ratios and abortion behavior is responsible for the geographical variation observed for the SRB in China is difficult to assess, particularly without access to more recent data. It can, however, be argued that this theory offers at least a partial explanation for the pattern that has been observed.

NOTES

[1] Source: Minnesota Population Center. Integrated Public Use Microdata Series, International: Version 6.0 [Machine-readable database]. Minneapolis: University of Minnesota, 2010. I would also like to acknowledge the contribution of the National Bureau of Statistics, China.

[2] This is the most recent data on China that is suitable for this analysis that is available through open access.

[3] The analyses were repeated with twenty and thirty births as the minimum number per prefecture, with no discernable effect upon the results.

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