Demography
DOI 10.1007/s13524-011-0030-7

Estimating a Dynamic Model of Sex Selection in China

Avraham Ebenstein

© Population Association of America 2011

Abstract High ratios of males to females in China, which have historically concerned researchers (Sen 1990), have increased in the wake of China's one-child policy, which began in 1979. Chinese policymakers are currently attempting to correct the imbalance in the sex ratio through initiatives that provide financial compensation to parents with daughters. Other scholars have advocated a relaxation of the one-child policy to allow more parents to have a son without engaging in sex selection. In this article, I present a model of fertility choice when parents have access to a sex-selection technology and face a mandated fertility limit. By exploiting variation in fines levied in China for unsanctioned births, I estimate the relative price of a son and daughter for mothers observed in China's census data (1982–2000). I find that a couple's first son is worth 1.42 years of income more than a first daughter, and the premium is highest among less-educated mothers and families engaged in agriculture. Simulations indicate that a subsidy of 1 year of income to families without a son would reduce the number of "missing girls" by 67% but impose an annual cost of 1.8% of Chinese gross domestic product (GDP). Alternatively, a three-child policy would reduce the number of "missing girls" by 56% but increase the fertility rate by 35%.

Keywords Sex-selective abortion · China · One-child policy · Dynamic programming

Introduction

In the wake of China's one-child policy, which began in 1979, a growing imbalance in the number of male and female births has emerged in China. The 2000 China

Electronic supplementary material The online version of this article (doi:10.1007/s13524-011-0030-7) contains supplementary material, which is available to authorized users.

A. Ebenstein (✉)
Department of Economics, Hebrew University of Jerusalem, Jerusalem, Israel
e-mail: ebenstein@mscc.huji.ac.il

Published online: 19 May 2011

Population Census reflects that for parents bearing children in the past two decades, roughly 9 million females are "missing" relative to naturally occurring birth patterns, distorting the sex ratio of males to females. A consensus has emerged that sex selection via infanticide and abortion is the principal explanation for the rising sex ratio in China (Chu 2001; Zeng et al. 1993). This pattern is also found in India, where slowing fertility in northern states has been associated with an increase in sex-selective abortions (Arnold et al. 2002). Although scholarly work has focused on documenting the presence of sex selection, modeling of sex-selection decisions has been limited.[1] Chinese government figures indicate that the female deficit at birth has continued to grow, with the overall sex ratio at birth reaching 118 boys born for every 100 girls in 2005, providing further justification for a closer analysis of this phenomenon and policies that may reduce the practice of sex selection (China Daily 2007).

To reduce the imbalance in the sex ratio at birth, China has recently launched a nationwide initiative to subsidize parents with daughters, known as the Care for Girls campaign.[2] There is broad disagreement, however, regarding the required size and structure of monetary incentives necessary to reduce the practice of sex selection in rural China (Li 2007). Other scholars have instead advocated for a relaxation of the one-child policy to address the sex ratio distortion, which would allow more parents to have a son without resorting to sex selection (Zeng 2007). However, policymakers fear that such a shift would lead to a large increase in fertility rates, and population control remains a stated goal of the Chinese government.

In this article, I present and estimate a dynamic model of parental fertility choices using Chinese census data (1982, 1990, and 2000) that aims to predict the impact of these policy options on fertility rates, the sex ratio at birth, and the budgetary consequences of monetary subsidies to parents without a son. The model's parameter estimates identify the value of income to parents of having a son relative to a daughter, which characterizes the intensity and distribution of son preference in modern China, and provides information necessary for predicting the efficacy of financial subsidies to parents without a son. The model is estimated by exploiting quasi-random variation in the fines that parents were forced to pay for violating the one-child policy, which vary considerably by province, year, and parental ethnicity, and variation in the fine rates provides plausibly exogenous variation in the incentives to childbearing necessary for parameter estimation. Additionally, the model aims to make a theoretical contribution by explaining the recent patterns in China's sex ratio at birth in a rational choice framework.

The "missing girls" phenomenon began to receive widespread attention after Amartya Sen (1990) alerted Western researchers to a "sex bias in relative care"—decades of mistreatment and neglect of China's women.[3] He suggested that this bias was responsible for the high Chinese sex ratio, and estimated that 50 million Chinese

[1] One notable exception is Kim (2005), who examined the predicted effect on the sex ratio and overall fertility in response to the introduction of ultrasound technology.

[2] China's Care for Girls campaign began in 2000 in 24 counties and subsidizes parents who have only daughters. Preliminary reports indicate the programs have lowered the sex ratio at birth (Embassy of the People's Republic of China 2006).

[3] See D'Souza and Chen (1980) for an early paper on gender bias and sex ratios, examining excess female mortality in rural Bangladesh.

women and 100 million women worldwide were unaccounted for relative to natural birth and mortality rates. Sen also pointed to the painful choices faced by parents forced to comply with fertility limits well below their desired fertility, which coincided with the sharp increase in the sex ratio. As shown in Table 1, Sen's observation that the male fraction of births in China rose from 51.6% to 53.3% masks a pattern that emerges when the births are examined by parents' successive number of children (birth parity) and separately following daughters or sons. The 2000 China census reflects that the high overall sex ratio at birth is due to extremely large fractions of sons following daughters, and very low fertility for those who already have sons. The analysis also indicates that following sons, parents appear willing to engage in sex selection, to a lesser degree, to ensure the birth of a daughter, indicating a Chinese preference for gender balance.

The dynamic model of parental fertility choices presented in this article serves to explain this pattern of "missing girls" in a rational choice framework. Building on existing models of home production (Becker and Lewis 1973), I consider a model of fertility behavior in which parents jointly determine the quantity and "quality" of children, in a context where gender represents a dimension of quality, and parents assign different relative prices to sons and daughters. The model aims to explain several stylized facts, such as the rise in the sex ratio of births in regions of stricter enforcement of China's one-child policy (Johansson and Nygren 1991) and the aforementioned sex selection in favor of daughters following male births. Lastly, the model provides a framework for examining the impact of improvements in prenatal screening technology (e.g., ultrasound): specifically, how the falling price of sex

Table 1 Fertility patterns in China by sex of existing children

		Proportion Who Have Another Child			Proportion Male (of next birth)		
Parity	Sex Combination	1982	1990	2000	1982	1990	2000
	Overall				.516	.520	.533
First	None				.511	.510	.515
Second	One boy	.71	.54	.35	.51	.50	.50
	One girl	.75	.60	.49	.52	.55	.62
Third	Two boys	.53	.30	.18	.50	.43	.39
	One girl, one boy	.54	.29	.16	.52	.52	.53
	Two girls	.68	.55	.46	.54	.61	.70
Fourth	Three boys	.40	.24	.17	.48	.40	.37
	One girl, two boys	.36	.17	.11	.51	.49	.52
	Two girls, one boy	.44	.23	.14	.52	.55	.58
	Three girls	.62	.54	.50	.56	.64	.72

Notes: Data in thousands. Sex ratio (boys/girls) at birth is calculated by assigning weights to each male and female that account for differential mortality rates by age, sex, and year. China life tables are taken from Banister and Hill (2004).

Source: China 1982 census (1% sample), 1990 census (1% sample), and 2000 census (.10% sample). Data are for married women ages 21–40 and their matched children ages 0–18.

selection may raise the sex ratio of births following daughters and lower the sex ratio of births following sons.

I estimate the model using regional variation in the financial punishments for violating China's one-child policy, which, in fact, imposes a one-child limit to urban parents and allows many rural couples a second or even third child. The fertility fines provide plausible exogenous variation in the net cost to childbearing in different regions of the country in different years, allowing for identification of the model parameters.[4] The parameterized model is able to reproduce a distribution of fertility outcomes similar to what is observed in the actual census data in Table 1, suggesting that several key features of the decision process underlying China's fertility are captured by the parameters. Because the model's parameters are identified by monetary fines on excess fertility in China, the parameter estimates also provide important information about parental preferences. I find that a first-born son is worth, on average, 1.85 years of income, and that a first-born daughter is worth 0.43 years of income, with lower values associated with second and third children of either gender. Simulations using the parameterized model indicate that a three-child policy would reduce the number of "missing girls" by 56% but increase the fertility rate by 35%. Alternatively, a subsidy of 1 year of income to families without a son would reduce the number of "missing girls" by 67%, but impose an annual cost of 1.8% of Chinese GDP.

This article is organized as follows. The second section provides background information regarding China's fertility policies and the proliferation of ultrasound technology in rural China. Following that, I present the model and the intuitions generated regarding how parents will respond to increasing penalties on fertility and improvements in sex selection technology. Then, I empirically estimate the parameters of the model of sex selection and perform a set of policy simulations using the calibrated model. I conclude with a brief discussion of fertility policy options for China based on the findings in this article.

Background

Chinese parents have historically favored large families, and following a famine associated with Mao's Great Leap Forward (1958–1960), total fertility exceeded six births per mother throughout the 1960s (Banister 1987). The rapid population growth alarmed Chinese officials, and the Communist Party subsequently enacted a series of fertility control policies, culminating in the one-child policy of 1979. Additional children were generally excluded from free public education, and parents were subject to fines. Following a forced sterilization and abortion campaign in 1983 that created domestic unrest, Chinese policymakers began considering revisions to the policy. By allowing some mothers to have a second child, the government hoped to discourage violations and increase public support for the policy (Gu et al. 2007).

[4] Recent work that has exploited the one-child policy as a natural experiment that induced a reduction in fertility include Qian (2009) and Edlund et al. (2008). I describe how the fines are calculated in detail in Online Resource 1. I also examine whether changes in fertility enforcement are correlated with changes in fertility tastes that would bias the coefficients.

In 1984, the Chinese government instituted a localized fertility policy in which residents of different provinces were subject to different mandated limits (Greenhalgh 1986). Although the one-child limit was enforced on urban residents, mothers of a daughter in several rural provinces were allowed to have a single additional birth (a 1.5-child policy), and families in remote areas, a second or third child. Today, Chinese fertility policy imposes: a one-child limit on urban residents, who make up about one-third (35%) of the population; a 1.5-child policy limit on most rural areas (54%); and a two-child (10%) or three-child (1%) policy limit for provinces in remote areas. The policy also grants exclusions to various groups, including Chinese ethnic minorities and those employed in dangerous occupations.

In China, parents have historically directed family resources to sons at the expense of daughters and, in some circumstances, discarded daughters upon birth (Coale and Banister 1994). In the 1960s, when fertility was high and infant mortality was low, this pattern was temporarily muted by the fact that most mothers were likely to have at least one surviving son without resorting to sex selection. However, while the female deficit was reduced, high fertility and low infant mortality were contributing to unsustainable population growth. Prior to the one-child policy, during the late 1960s and early 1970s, the Chinese government promoted a Two is Enough campaign, and the sex ratio following first- and second-born daughters began to rise.

Although the extent of prenatal sex selection during this period was limited by the unreliability of traditional methods of identifying sex *in utero*, the introduction of ultrasound technology greatly facilitated the availability of sex-selective abortion.[5] Population control officials sent portable ultrasound machines to hundreds of cities across the nation in the early 1980s, and ironically, these machines were later used to aid in sex-selective abortion in these areas (Ertfelt 2006). These machines represented a major advancement because the use of ultrasound can reliably determine the sex of a fetus roughly 20 weeks into a pregnancy, allowing mothers to abort and reconceive with less time and potentially less psychological distress than following infanticide. The 2000 census reflected that tighter fertility control and better sex selection technology combined to create an unprecedented increase in the sex ratio. Later in this article, I present a model to consider how these two factors affect parental choices for the number and gender of their children.

Stylized Facts

The fertility patterns in Table 1 reflect several important empirical facts that merit further exploration in a behavioral model. First, the table indicates that the "missing girls" phenomenon is due to sex selection following daughters, and the 2000 data indicate a sharpening of this pattern. In the 1982 Chinese census data, when parents faced a weaker fertility-control policy, after bearing a single daughter, 52% of births were male. By 2000, after the majority of parents were subject to the 1.5-child

[5] Several recent empirical analyses should be noted. Abrevaya (2009) found evidence of sex-selective abortion in United States natality data among immigrants from China and India. Lin et al. (2008) found evidence that Taiwan's sex ratio at birth increased in the wake of the legalization of abortion. In recent work, Liu (2009) examined the impact of China's one-child policy on per-child investment levels and child outcomes by comparing areas of weaker and tighter fertility controls.

policy, 62% of births following a single daughter were male. This rise in the sex ratio of second births is a key component to the increase in China's sex ratio, and the high male fraction of births after a single daughter is responsible for 8 million of the 9 million girls observed in the China 2000 census sample (Ebenstein 2010). After two daughters in 1982, 54% of births were male; and in 2000, 70% of these births were male. The data thus reflect an increase in the share of parents who engage in sex selection at each parity.

A second fact that merits explanation is that the Chinese census data indicate that mothers with sons practice sex selection to ensure the birth of a daughter[6]: mothers with two sons who have a third child have a 61% chance of having a daughter (Table 1). Therefore, an appropriate model of behavior recognizes that the value of sons or daughters might be lower for those who already have a son or daughter.[7] It is also noteworthy that parents appear to prefer a first daughter to a third son, and even engage in sex selection to ensure the birth of a daughter following sons, thus indicating that son preference in China is more nuanced than what the overall sex ratio indicates. Specifically, the premium to a *first* son must be large, and there also must be some premium to a *first* daughter as well.[8]

The third stylized fact that the model aims to explain is the increase in the sex ratio in regions of stricter enforcement of China's fertility policy and periods with stricter enforcement of the policy. The sex ratio of first births remained stable during the 1980s and rose during the government crackdown on second births during the 1990s (see Fig. 1). So, the model aims to explain how the enforcement of fertility limits will affect fertility rates and the sex ratio of births when parents have access to sex selection technology.

Theoretical Framework

In the section Solving the Two-Child Model by Backward Induction, I present a simple model of parental fertility choice when parents exhibit sex preference and have access to a sex selection technology. The model is dynamic in that both fertility and sex-selection decisions are made with knowledge of one's preferences and the anticipated decisions regarding future conceptions. First, I present a simple two-child model in which parents can engage in sex selection for first or second births, and second children are subject to a monetary fine. The two-child model provides the key insights regarding how couples evaluate whether to engage in sex selection when having their last or penultimate birth. The basic intuition generated by the framework is that increasing the punishment to excess fertility or lowering the cost of sex selection will

[6] Chu (2001) in field work found that 7% of male fetuses at higher birth parities are aborted following ultrasound. The other known cause for low sex ratios following sons is the adoption of unwanted girls by Chinese families with no daughters (Johansson and Nygren 1991).

[7] Fertility surveys suggest that mothers in China prefer "two or more (surviving children), and at least one surviving son" (Wang 1996). The preference for a daughter among parents who already have sons is partly driven by the expectation that daughters help more with family chores (Chu 2001).

[8] As one anonymous reviewer noted, sex selection in favor of daughters is much less common, and the most pronounced pattern of fertility is sex selection in favor of sons. Simpler models of fertility in China can be derived by focusing on the premium to having a first son. I proceed with the expanded version in this article, which treats the decisions symmetrically.

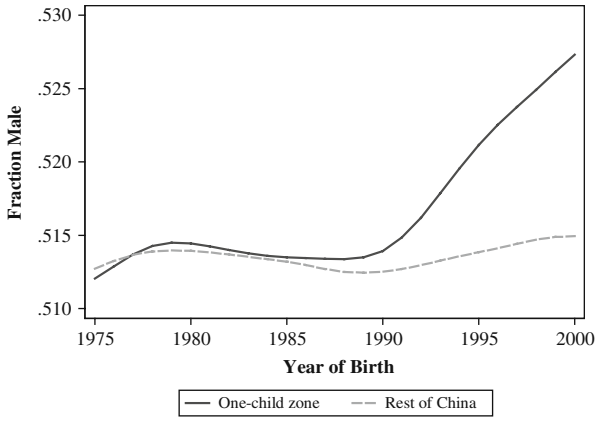

Fig. 1 Rising sex ratio among first births in China. The graph was created by the running-mean smoother applied by the lowess command using STATA 9 software. *Source*: China census 1982–2000

increase the sex ratio of births and encourage parents to engage in sex selection at earlier parities. In the section Estimating the Model of Sex Selection section, I present results for an extended version in which parents are allowed up to three births, and sex selection is allowed in favor of either sons or daughters.

Solving the Two-Child Model by Backward Induction

Suppose that parents are allowed only a single birth and also that a second birth K_2 will require the parents to pay a fine F. Parents, however, also have access to a technology S that is 100%-effective for sex selection that for price A will convert a female conception into a male birth. One might imagine that A captures the cumulative cost of a sequence of conceptions and abortions until a male fetus is carried to full term. Assume that a first boy B is worth θ, a first daughter is worth γ, and a second daughter is normalized to have no value (in excess of the cost to raise her). Also suppose for simplification that parents with a son never have a second birth. The decision tree is displayed in Fig. 2.

Given that parents can anticipate the decisions that they will have to make in the course of determining the size and sex composition of their offspring, the model of

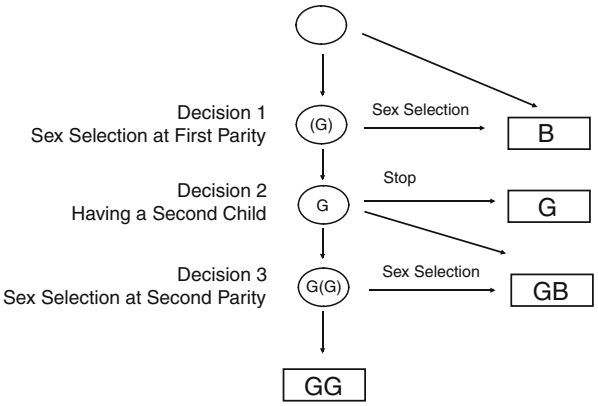

Fig. 2 Decision tree of model of sex selection. The two-child model consists of three decisions. The completed fertility outcomes are in boxes and the intermediate outcomes are in ovals

sex selection can be solved by using the solution concept of backward induction, beginning with the optimal decision at the final decision node (if that node is reached). For the third and final decision node in the model, the parent's decision-making problem becomes a single period maximization in which she chooses between *GG* or *GB*, knowing that she is expecting a second daughter and can exercise sex selection. The payoff to each option for the *i*th couple in the third stage (stage denoted by a superscript) is as follows:

$$V^3_{S_2=1} = \theta_i - A_i - F + \gamma_i + \varepsilon^3_{S_2=1} \tag{1}$$

$$V^3_{S_2=0} = -F + \gamma_i + \varepsilon^3_{S_2=0}. \tag{2}$$

In the final stage, parents perform a static optimization over the choice to abort a second daughter S_2, perfectly observing the payoffs. The parents who choose sex selection receive an additional payoff of θ_i but incur a cost of A_i. The shocks are assumed to be distributed *ev*(1), so the difference of the two shocks has a logistic distribution[9] and provides the following closed form expression for the probability of sex selection in the final stage in terms of the model's parameters. The probability of practicing sex selection at the second parity ($S_2 = 1$) is as follows:

$$\Pr(S_2 = 1) = \frac{e^{\theta_i - A_i}}{1 + e^{\theta_i - A_i}}. \tag{3}$$

When the couple's benefit from a son θ_i is large relative to the cost of sex selection A_i, they are likely to choose sex selection. Mothers have equal probability of aborting or carrying to term when $\theta_i = A_i$, and the probability of aborting is higher when factors increase the value of a son θ_i or when technology lowers the price of sex selection A_i.

At the second decision node, the parents face the decision to continue childbearing or to stop. The payoffs to having a second child ($K_2 = 1$) and stopping, respectively, are as follows:

$$V^2_{K_2=1} = .51\theta_i - F + .49\left[E\left(V^3\right)\right] + \gamma_i + \varepsilon^2_{K_2=1} \tag{4}$$

$$V^2_{K_2=0} = \gamma_i + \varepsilon^2_{K_2=0}. \tag{5}$$

The payoff to having a second child is the value of a son θ_i multiplied by the probability of conceiving a male (.51), minus the fertility fine F, plus the anticipated value of reaching the third stage of the model if the conception is female ($E(V^3)$) multiplied by the probability that the conception is female (.49). Note that the anticipated value of reaching the final stage (V^3) is the expected maximum of the two options the parents will face in that stage, which is to engage in sex selection or abstain. When a mother has a higher value of $\theta_i - A_i$ (the sex-selection option), she will anticipate a higher payoff in the third stage (V^3) and be more likely to have a second child, and so higher fines induce a selection effect

[9] See the appendix for a more complete description of the stochastic assumptions underlying the model and the calculation of the likelihood function.

where the mothers most likely to have a second child are those willing to engage in sex selection. The probability of practicing sex selection at the second parity (K_2=1) is as follows:

$$\Pr(K_2 = 1) = \frac{e^{.51\theta_i - F + .49[E(V^3)]}}{1 + e^{.51\theta_i - F + .49[E(V^3)]}} \tag{6}$$

Lastly, in the model's first round, parents who conceive a daughter decide whether to engage in sex selection (S_1). For parents subject to a harsh penalty on second births F, those who desire a son will be compelled to engage in sex selection at the first parity. For example, among parents who are both determined to have a son (large θ_i) and subject to the one-child policy, when $F > .51A_i + \gamma_i$, parents will engage in sex selection at the first parity.[10] This implies that increasing punishments on second births will affect the sex ratio of first births, consistent with the increase in the sex ratio among first births in the one-child policy region (Fig. 1).

The model, therefore, generates the prediction that higher fines and reduction in sex-selection costs will increase the sex ratio when parents prefer sons.[11] First, fines will discourage second births among those who do not place great weight on having a son or are unwilling (or unable) to practice sex selection, lowering the share of second births which are completely random. Second, fines will encourage parents who are willing to engage in sex selection to do so at an earlier parity to avoid the fine. This has the consequence of increasing the share of mothers who fail to naturally conceive a son.

The model's results are easily translated to a three-child limit, in which second and third births are subject to fines that vary by province, ethnicity, and other factors. Parents execute a sequence of five decisions in which parents have three opportunities to engage in sex selection. The model begins with the mother pregnant and knowing the gender of the fetus. If the fetus is male, the mother carries the conception to full term and receives payoff θ. If the fetus is female, the mother moves to the first decision node and decides whether to engage in sex selection. She can either receive a male for cost A and receive payoff θ, or she can carry the daughter to full term and receive payoff γ.

At the second decision node, the mother already has either one son or one daughter. Then, she decides whether to continue fertility. If she stops, she completes her fertility with her existing payoff. Otherwise, she conceives and moves to the next node. The third decision node is similar to the first node (for the second child) and the fifth node (for third and last child). In the second and fourth node, the decisions

[10] For parents who are extremely likely to abort a female conception if they reach the final round, the decision to have another child can be simplified by plugging in $\theta_i - A_i$ for $E(V^3)$ in Eq. 6. The decision to abort a female conception at the first parity can be expressed as $\theta_{1i} - A_i - \gamma_{1i} - (\theta_i - F - .49A_i)$ or $F - .51A_i - \gamma_{1i}$. Intuitively, if the fine exceeds 51% of the cost of sex selection and the value of a first daughter, these parents are better served by avoiding the fine and aborting first-parity female conceptions until a son is born because the only benefit to abstaining from sex selection at the first parity is a 51% chance of avoiding sex selection at the second parity, and the value of a first daughter.

[11] Note that this is also consistent with the patterns in the sex ratio at birth in China during the fertility crackdown of the late 1980s and early 1990s. The birth-planning campaign was held after the diffusion of ultrasound in rural China, and the reduction in village fertility was accompanied by a rising sex ratio at birth (Greenhalgh and Winckler 2005).

faced by the mother are also the same (whether to have an additional child). After the mother has at least one son and one daughter, she does not face the decision to have a sex-selective abortion (for simplification). The three-child model has the same assumptions as the aforementioned two-child model, and the likelihood function is described in greater detail in Online Resource 2. The empirical results are reported for the extended model in the section Estimating the Model of Sex Selection.

Heterogeneity

I introduce individual observed heterogeneity by allowing the value of a couple's first son or daughter (θ_{1i}, γ_{1i}) to take on a different value for parents of different observed characteristics. I impose a functional form assumption that θ_{1i} and γ_{1i} are each linear in a function of the mother's education and whether the family is engaged in farming.[12]

$$\theta_{1i} = \beta_1 + \beta_2 Educ_i + \beta_3 Farmer_i \tag{7}$$

$$\gamma_{1i} = \beta_4 + \beta_5 Educ_i + \beta_6 Farmer_i. \tag{8}$$

These variables are chosen because they are available in China's census samples, and they identify important predictors of the value to a couple's first son or daughter and improve the model's precision. The values of second and third sons or daughters are also estimated but are assumed invariant to the characteristics of the parents.

$$\theta_{2i} = \beta_7; \theta_{3i} = \beta_8; \gamma_{2i} = \beta_9; \gamma_{3i} = \beta_{10}. \tag{9}$$

For A_i, I allow for heterogeneity in the behavior of parents at different distances from the nearest fertility clinic. Again, while the required travel time may have a direct impact on maternal behavior via its impact on the cost of sex selection, it may be that it only proxies for access to a doctor willing to perform a sex-selective abortion. Nevertheless, this observed heterogeneity may allow for a tighter fit of the model.[13] I also directly allow the cost of sex selection to vary by year because the model is attempting to capture the impact of technological innovation in sex selection (e.g., ultrasound) on the sex ratio at birth. Note that only the mothers in the 2000 census sample had access to ultrasound during their fertility window.

$$A_i = \beta_{11} \qquad \text{if}\left[Year_i = 1982 \,\middle|\, Year_i = 1990\right] \tag{10}$$

$$A_i = \beta_{12} Clinic_i + \beta_{13} \qquad \text{if}\left[Year_i = 2000\right]. \tag{11}$$

[12] In Taiwan's KAP survey (2003), desired children and sex preference are negatively correlated with a mother's education. The value of sons and daughters may also be different for those engaged in farming. For example, Qian (2008) found evidence that local sex ratios are higher in areas where the crops planted require more male labor.

[13] An alternative to this specification would be to allow parents to be selected from a mixture distribution, in which some share of parents never abort. I have explored estimating the model in this manner, and the estimation procedure indicates that roughly 52% of parents would practice sex selection, as estimated by MLE. I proceed with the simpler version of sex selection costs because the results are more stable, but the parameter estimates are reasonably close using either specification. The results are available from the author upon request.

To address potential concerns that the fines are determined in an endogenous manner, I allow the value of a first son or daughter to vary by policy region and year, so that the estimated parameters can be thought to be derived from a differences-in-differences framework.

$$\theta_{1i} = \theta_1 + \{\beta_{14} \cdot [Policy_i = 1.5] + \beta_{15} \cdot [Policy_i \geq 2] + \beta_{16} \cdot [Year_i \geq 1990]\} \quad (12)$$

$$\gamma_{1i} = \gamma_1 + \{\beta_{17} \cdot [Policy_i = 1.5] + \beta_{18} \cdot [Policy_i \geq 2] + \beta_{19} \cdot [Year_i \geq 1990]\} \quad (13)$$

In this manner, the model explicitly incorporates variation in fertility preferences that may have existed prior to the policy's implementation, or may be particular to a census-year sample and not related to the underlying preference for sons. I provide further details regarding the identification of the model's parameters in the next section.

Lastly, I allow heterogeneity in the continuation value of completing the first three births without a son because for parents in the 1982 or 1990 census samples, many who failed to have a son in the first three births have a son at the fourth or even the fifth parity. Because fourth births are exceedingly rare in the 2000 census, the continuation value is assumed to be 0 (zero) for these parents, and so I specify the continuation value in the following manner:

$$E(V_6 | GGG) = \beta_{20} \cdot [Year_i = 1982] + \beta_{21} \cdot [Year_i = 1990]. \quad (14)$$

Identification

The likelihood function can be written in terms of the model's parameters, which are estimated by choosing the value that best reproduces the empirical distribution of fertility outcomes. At the model's sex-selection nodes following daughters, the algorithm will identify the *difference* between θ and A by using the information embedded in the share of parents who have a son at each parity. A high sex ratio can reflect either a high θ or low A, and so the relative values of each are identified. Conversely, for parents with only sons, observing large numbers of female births may reflect either a high γ or a low A. At the model's fertility nodes (stages 2 and 4), the algorithm will observe the fines F facing the parents and the share who choose to have a second or third child, which allows the algorithm to identify the *level* of the parameters for θ and γ. After the optimal choice of θ and γ is made, and the difference between θ and A is identified, the value of A is identified as well.

The coefficients in (7) and (8) are identified from the heterogeneity in fine values across birth orders and across regions and time in China, and the coefficients in (10) are identified from the sex ratio distortion and from the estimate of θ and γ. The fine variation is necessary for the parameters governing θ, γ, and A to be identified in terms of years of income, which is a quantity interesting for characterizing preferences and necessary for counterfactual policy simulation of monetary subsidies. Inasmuch as the fines are measured noisily, or are correlated with unobserved factors affecting son preference, the scale of the coefficients will be

inefficiently estimated or biased. In the next section, I provide details regarding the calculation of the fines.

One might be concerned that provincial fine regimes are correlated with preexisting patterns of son preference: that is, provinces with higher or lower son preference are more or less likely to enact strict fertility regulations and high fertility fines. For the fines to identify the parameters of son preference, the fines *should not* be correlated with patterns in the sex ratio prior to the implementations of the one-child policy. The fines *should*, however, be positively correlated with the sex ratio in recent years, consistent with the claim that the female deficit is related to the stringency of fertility control. As shown in Table 2, the average fine in each prefecture is uncorrelated with the sex ratio following the policy, and positively correlated with the sex ratio following the implementation of the fine policy.

In column 1, I regress the male fraction of births in each of China's 345 prefectures prior to the policy (1975–1979) on the fine rate in each prefecture in 2000. The correlation between the male fraction of births and the fine is small (–.004) and statistically insignificant, suggesting that the fines in my data are not systematically related to preexisting patterns of son preference.[14] In column 2, I perform the same regression but control for regional characteristics in each of the prefectures (e.g., share with electric or gas fuel) and again find only a weak correlation between the fines (–.007) and the male fraction of births. In column 3, I regress the male fraction of births in years *following* the policy (1996–2000) on the fine rate. During this recent window in the post-policy period, the fines are positively correlated with the sex ratio (.008), and the relationship is statistically significant at the 10% level. In column 4, I perform the same regression with controls for regional characteristics, and find that the estimated relationship is positive (.011) and statistically significant at the 5% level. This suggests that the impact of the fertility fines on the sex ratio in recent years is not simply related to preexisting features of the regions.[15] Enforcement of fertility regulations is responsible for the connection between sex ratios and fertility fines, rather than a spurious regional correlation between lower fines and lower son preference. In Online Resource 1, I present further evidence that the fines provide for the necessary variation in the net prices of childbearing to estimate the model parameters.

The model's identification strategy can also be thought of as a difference-in-differences strategy because I include policy region and year parameters that allow the value of either sons or daughters to vary flexibly across region and year. Therefore, preexisting differences to mothers observed in a particular region or year will be absorbed by these coefficients. In a difference-in-differences design, the appropriateness of the identifying variation can be assessed by comparing the control and treated samples trends in the outcome variable, before and after the treatment. As shown in Fig. 1, the sex ratio of first-born children

[14] The prefecture variable is available only in the 2000 census, so the male fraction of births is proxied by the male fraction of adults who report living in the same prefecture five years earlier.

[15] A legitimate concern may be that parents under higher urban fine regimes would have fewer children than those in rural areas, even in the absence of the policy. Fertility surveys still indicate that most parents would prefer to have at least two children (Zhang et al. 2006), and so the fertility limit (and therefore the fine) is a binding constraint for most parents.

Table 2 Regression (OLS) estimates of male fraction of five-year birth cohort (LHS) on fertility fines (RHS)

	Five Years Before One-Child Policy (1975–1979)		Five Years Before 2000 Census (1996–2000)	
	(1)	(2)	(3)	(4)
Fertility Fine	–0.0038	–0.0068	0.0083†	0.0111*
	(0.006)	(0.005)	(0.005)	(0.004)
Controls for Regional Characteristics	No	Yes	No	Yes
Observations	345	345	345	345

Notes: The fine is measured in years of household income, taken from Scharping (2003). Each regression examines the partial correlation between a five-year age group and the fertility fines in 2000 by prefecture. China's 2000 census is broken into 345 prefectural boundaries, and this is the finest geographic breakdown available in the data. Controls for regional characteristics are the share of individuals with access to tap water, the share with electric or gas fuel, the share with concrete or brick households, and the average education of those 30–39 years old. The male share of births is proxied by the living share of those in each cohort. Standard errors are robust and are clustered at the province level.

Source: China 2000 census (.10% sample).

† $p \leq .10$; * $p \leq .05$

remained similar in both the one-child policy area and areas with weaker regulations until the late 1980s. In the late 1980s, when the one-child policy was enforced in earnest, the sex ratio began to rise but remained similar in the areas where two children were allowed before and after the crackdown. While the exogeneity of the fines is fundamentally untestable, the data indicate a strong correlation between the timing of the policy's introduction and the increase in the sex ratio at birth in areas of strict enforcement.

Estimating the Model of Sex Selection

Data

The Chinese census samples (1982, 1990, and 2000) provide a unique opportunity to assess the responsiveness of fertility outcomes to changes in the costs of childbearing. Although almost no parents in the 1982 census faced fertility limits (because they were having their children between 1964 and 1981), the parents observed in the 2000 census were subject to strict fertility regulations enforced by fines and other punitive measures. Data on fines are taken from Scharping (2003), who provided a detailed account of the financial and nonfinancial punishments meted to mothers with unauthorized births between 1979 and 2000. The fines represent an important aspect of the fertility policy; as Scharping described, "Chinese policy has preferred the application of economic, administrative and disciplinary measures to resorting to criminal law" (p. 136). The fine rates vary by province and year, and are also a function of one's registration (*hukou*) and ethnicity, implying that they vary by individual for a given province and year. The fines are

imputed to the mothers in the census sample, and I provide a detailed description of how this is executed in Online Resource 1.[16]

The model is estimated by using a matched sample of parents with five or fewer children as well as the imputed fine rates faced when making fertility choices (see Table 3). The sample is constructed to represent the women for whom we can accurately measure their fertility outcomes, which may be slightly different than the overall population.[17] The sample is restricted to mothers age 35–40 who are likely to have completed their fertility.[18] For the mothers in the 1982 sample, the data reflect higher fertility, with the average mother having 3.18 births. In contrast, the mothers in the 2000 census averaged only 1.83 births, presumably because their peak fertility years followed the introduction of China's one-child policy. For the 1990 and 2000 census samples, I exclude about 10% of mothers for whom the number of matched sons and daughters is different than the mother's reported fertility.[19] I also exclude those who report having lived in a different *hukou* for the 2000 sample, to ensure that the sample is composed of parents for whom the most accurate fine data can be assigned.[20]

Note that although the model is designed to explain the practice of sex selection and its impact on the sex ratio at birth, I rely on data on living children for estimation of the model. Although females in China experience slightly worse than expected survival rates relative to Western patterns, the main contributor to the "missing girls" is prenatal and neonatal sex selection, rather than higher childhood mortality rates (Banister and Hill 2004).[21] In fact, females in China who reach age 1 have similar survival rates to males, indicating that sex selection is the main driver of China's "missing girls" and that the sample in Table 3 is roughly similar to the sex ratio of the family's births. An additional concern worth noting is the presence of "hidden girls": namely, females whose births are not registered by their family because they are born in violation of the country's fertility policy. However, because most "hidden girls" are registered by the age of 7 (upon school enrollment), the sample in Table 3

[16] Note that the fine measure should be thought of as a proxy for all financial pressures on parents to minimize "out-of-plan" births. I can impute only the financial punishment, and other components of the total punishment and reward structure have to go unmeasured. It is known, however, that the financial fines are a major component, outweighing (for example) rewards. This is documented in the China Health and Nutrition Survey (1993) in which the median reward is 60 yuan, and the median fine is 2,800 yuan. The nonfinancial penalties are informal and exercised optionally, and are assumed random in the data. This article's results should be interpreted up to a scale in which the imputed fines presented here represent the full sum of financial punishment meted out for excess fertility.

[17] Results comparing the fertility patterns among women in the census and in the matched sample are available upon request. The patterns are broadly similar between the restricted sample and the overall sample.

[18] Very few women in China during the years of the One Child Policy give birth past age 35 (Ding and Hesketh 2006).

[19] For 2000, the sex ratio of those dropped from the sample is 1.16, and the sex ratio of those remaining in the sample is 1.18, suggesting that this decision is not critical. As in the previous section, the results are robust to the inclusion or exclusion of these mothers. Results are available upon request.

[20] The results are robust to the inclusion or exclusion of the roughly 11% of the 2000 sample who switched *hukou*. Note that migration is available only in the 2000 sample.

[21] Banister and Hill (2004) created life tables for this period by examining repeated samples of China's census data and mortality surveys. This analysis should be interpreted subject to the caveat that I have appropriately adjusted the sex ratio of living children using these life tables to estimate the sex ratio of births.

Table 3 Demographic characteristics and fine rates of mothers ages 35–40

Statistic	1982	1990	2000
Total Children per Mother	3.18	2.23	1.83
Number of boys	1.65	1.16	0.98
Number of girls	1.53	1.07	0.85
Sex ratio (boys/girls)	1.08	1.09	1.15
Size of Fine on Second Births Following a Son	0.016	0.514	1.264
Size of Fine on Second Births Following a Daughter	0.013	0.412	1.012
Size of Fine on Third Births	0.046	1.320	2.900
Years of Education	2.459	3.556	8.336
Farmer (1 = yes)	0.724	0.652	0.588
Imputed Distance to Fertility Clinic	0.941	0.862	0.615
Observations	28,170	36,279	38,501

Notes: The fine is measured in years of household income, taken from Scharping (2003). Fines are different for those with a son than for those with a daughter because special provisions in certain provinces for a second allowed birth following a daughter. Families that report working in the agricultural sector are considered to be farming families. Years of education is inferred from a census question on completed education. The distance to a fertility clinic is imputed using the 1989 China Health and Nutrition Survey responses, which contains information on the distance to a clinic for each participant, and the average distance by education and rural/urban status to mothers in the census.

Source: China 1982 census (1% sample), 1990 census (1% sample), and 2000 census (.10% sample). For comparability with the 2000 census sample, one-tenth of the 1982 and 1990 1% samples are used for estimation of the model.

should roughly approximate the actual births that the family experienced (Cai and Lavely 2003). Lastly, I am unable to observe adoption in my data. Although foreign adoption of girls represents a trivial share of the "missing girls,"[22] adoption of unwanted daughters by other villagers (who generally already have sons) is common within China. Although I cannot distinguish sex selection from within-China adoption, the practice should not affect this article's core result regarding the female deficit associated with sex selection because the adopting family will enumerate the daughter. As such, the sample used in Table 3 should be interpreted as the combined impact of female conceptions terminated and unwanted daughters adopted by a different family within China.

Parameter Estimation

In Table 4, I present the parameters identified by maximum likelihood estimation (MLE) for the values of sons and daughters, and also the costs of sex selection. The parameter estimates provide an additional layer of information regarding the patterns observed in Table 1 for the chance of having an additional child at each parity and also the observed sex ratio at each parity. As mentioned earlier, provided that the

[22] In 2005, the United States naturalized nearly 8,000 Chinese adopted children, and more than 95% of the children were female. The Chinese government reported a total of 60,000 adopted births sent to foreign countries between 1992 and 2006 (Goodman 2006).

Table 4 Parameter estimates for three-child sex-selection model, China 1982–2000

	Son		Daughter
Panel 1: Parameter Estimates for First-born			
Years of education	–0.213**		–0.196**
	(0.05)		(0.05)
Farmer (1 = yes)	3.04**		2.20**
	(0.51)		(0.32)
Constant	0.703		–0.077
	(1.29)		(0.93)
Average predicted value	1.85		0.43
Panel 2: Parameter Estimates for Second-born and Third-born			
Marginal value of second	1.059†		0.234
	(0.60)		(0.64)
Marginal value of third	–0.251		0.234
	(0.79)		(1.44)
Panel 3: Parameter Estimates for Costs to Sex Selection			
Distance from a clinic		0.02	
		(1.24)	
Constant (year = 2000)		3.82*	
		(1.55)	
Cost after ultrasound (year = 2000)		3.83	
Cost before ultrasound (year < 2000)		5.44**	
		(1.48)	
Observations		102,950	
Log-Likelihood (ln L)		–232,414	

Notes: The estimation of the model is performed using MATLAB 7 software. The results in the table reflect the implied value of children in years of income for mothers of different demographic characteristics, as well as the implied dollar value of the costs of sex selection. Fixed effects are included for the policy region and period for the value of a first son or daughter (not shown).

Source: See Table 3.

†$p \leq .10$; *$p \leq .05$; **$p \leq .01$

model is specified appropriately and that the fines represent exogenous variation after accounting for policy region and year fixed-effects, these parameters reveal the willingness to pay for a first, second, or third son or daughter as well as the implied cost of engaging in sex selection. The model's design is principally geared toward discerning patterns in the first child of any particular gender because sex selection is rare after parents achieve a gender mix (and ruled out by the model).

In panel 1, I present the estimated coefficients for the value of having a first son θ_{1i}. Note that parents receive this value whether the son is the first birth or a later birth. θ_{1i} is decreasing in mother's education, with each extra year of education reducing its value by 0.21 years of income. The data also indicate that households employed in the agricultural sector are more determined to have a son, with these families assigning a full 3.04 years of extra income to a son, relative to those employed in other sectors of

the economy. For farmers, a higher θ_{1i} might reflect their increased need for sons to work on the farm, or it may reflect that they anticipate living with their adult son in retirement. The average value of θ in the entire sample is 1.85, which indicates that having a son is worth approximately 1.85 years of income, but is much higher among agricultural families and those with less education. I report in panel 2 that the value of a second and third son are much lower than the first, with these being valued at 1.06 and –0.25 years of income, respectively.[23]

The parameter estimates for γ_{1i} indicate that the average value of a first daughter is 0.43 years of income (panel 1). Daughters appear to have lower value for those who are better educated, with each year reducing the value by –0.20 years of income. Farming families, who place large values on sons, also place more value on daughters as well, with 2.20 years of income premium associated to a daughter among farmers. This implies that farmers assign nearly two more years of income to having a first son; and because farmers represent more than one-half of the sample (59% in 2000), much of the "missing girls" phenomenon is driven by low-educated peasants who desire large families and face large penalties on third births. Note that sex selection in favor of sons after daughters also implies that additional daughters provide low value to parents. In panel 2, I report the values of a second (0.23) and third daughter (0.23), which are both lower than the value of a first daughter (0.43). These values are equivalent because the MLE choice of the parameters is executed subject to the constraint that the value of a second daughter is no lower than the value of a third daughter, which is binding at the parameter estimates. Note that the model is principally designed to identify the value of a first son or daughter, and the value of second and third sons or daughters is difficult to estimate precisely.

Panel 3 indicates that the cost of abortion A_i is increasing in the imputed distance from an abortion clinic, although each unit increase in the log distance from the nearest clinic associated with a 0.02 increase in years of income in the cost of sex selection.[24] The parameter estimates for the cost of sex selection before and after ultrasound reflect the increased attractiveness of sex-selective abortion relative to infanticide. For mothers observed in the 2000 census, they made fertility decisions following ultrasound's diffusion in China in the late 1980s, and the parameter estimate indicates that the average cost of sex selection declined from 5.44 years of income to 3.83 years of income. The parameter estimates suggest that ultrasound's diffusion, in combination with China's one-child policy, led to the steep rise in the country's sex ratio. Note, however, that the coefficients on the costs of sex selection (A_i) provide less information than those on the factors affecting the value of sons and daughters because very little information is available regarding the factors affecting the ease of engaging in sex selection, such as access to ultrasound. Their primary function is not to provide evidence of causal relationships, but instead to facilitate a more flexible functional form that can better fit the data.

[23] Greenhalgh et al. (1994) cited one rural village in which villagers refer to a second son as *fudan zhong*, or a "heavy burden," because a second son requires a new house at the time of his marriage, which may cost up to 10 years of annual income.

[24] This measure is imputed from the China Health and Nutrition Survey (1989), using information on the average distance in kilometers from a clinic imputed to the census with the parent's urban status and education. Those in urban areas with more education are assigned a shorter distance to the nearest clinic.

In Table 5, I report the results of a measure of the model's goodness of fit by showing the correspondence between the actual distribution of fertility outcomes and the distribution created from a simulation using the calibrated model. The table reflects that several of the patterns in fertility in Table 1 are captured by the model: declining fertility, rising sex ratios following daughters, and declining sex ratios following sons are observed in both the actual and simulated data. The sharp decline in fertility following sons is evident in the simulated data, reflecting that the model is capturing a key element in China's sharp rise in the sex ratio due to the strict fertility control among parents who already have a son. In addition, because the 2000 simulated agents face lower sex-selection costs and higher fine rates, they are more likely to engage in sex selection at earlier parities. For example, the male fraction of births following a single daughter rose from 0.51 in 1982 to 0.57 in 2000, which reflects that high θ mothers are more likely in the recent data to avoid the harsh punishment on a third birth of either gender. Although the in-sample forecasting in Table 5 does not imply that the model is valid for out-of-sample policy simulation, it does suggest that the simplified rule structure presented herein captures many of the essential elements of the fertility decision, and provides an opportunity to explore the benefits and costs to changing these incentives.[25]

A Policy Application of the Sex-Selection Model

Recently, the Chinese government has both reinstated the one-child limit (Yardley 2008) and declared that correcting the sex ratio at birth by 2016 is a national priority (Li 2007). However, China's recent experience suggests that these two interests may be at odds. Without either a reduction in son preference or an increase in the costs of sex selection, an alternative policy may be necessary to reduce the sex ratio. In the following analysis, I use the estimated model to examine two potential methods for reducing the sex ratio. In the first set of simulations, I explore how China's fertility rate and the sex ratio at birth would respond to either tightening or relaxing the fertility restrictions. Intuitively, because the fertility restrictions are partially responsible for the higher sex ratio, reducing these restrictions would partly offset this impact by allowing more parents to have a son without engaging in sex selection. This induces a reduction in the number of "missing girls" at the expense of an increase in fertility. In the second set of simulations, I explore the potential efficacy of a subsidy to parents who fail to have a son, similar in spirit to the recent Care for Girls campaign, which provided financial incentives to parents who had only daughters.[26] The simulations indicate that

[25] I also perform this calculation where one-half of the sample is used for estimation of the parameters, and the other half is used for comparing actual and simulated outcomes. Results are available from the author upon request.

[26] The Care for Girls campaign chose 24 counties of China with extremely high sex ratios, and provided incentives to reduce the female deficit, including free public education for daughters. The program explicitly subsidizes parents with daughters, whereas I simulate parents having a lower value to sons. These are slightly different because a simulation in which I increased the value of daughters could generate the perverse result that parents are subsidized for unauthorized births. Note, however, that because the Care for Girls campaign is instituted in counties with strict fertility limits, it is unlikely that births born in violation of the policy would be subject to the subsidies, and thus the demographic effect of the subsidy that I simulate would have similar empirical properties.

Table 5 Sex outcomes in China by sex of existing children: Actual versus simulated fertility patterns

		Actual Proportion Who Have Another Child			Simulated Proportion Who Have Another Child			Actual Proportion Male (of next birth)			Simulated Proportion Male (of next birth)		
Parity	Sex Combination	1982	1990	2000	1982	1990	2000	1982	1990	2000	1982	1990	2000
	Overall							.52	.54	.56	.52	.53	.55
First	None							.51	.51	.52	.51	.51	.53
Second	One boy	.94	.73	.55	.94	.75	.59	.51	.50	.49	.51	.51	.50
	One girl	.95	.81	.70	.95	.80	.70	.53	.55	.59	.51	.53	.57
Third	Two boys	.74	.38	.22	.73	.39	.22	.50	.43	.40	.51	.47	.41
	One girl, one boy	.75	.38	.20	.75	.38	.19	.52	.52	.54	.51	.50	.52
	Two girls	.86	.66	.54	.86	.63	.45	.55	.61	.69	.51	.54	.64

Notes: The calculations in the table reflect the fertility outcomes by simulating decision-making from the census samples for China (see Table 3) using the likelihood function described in the text and the parameter estimates from the maximum likelihood estimation by MATLAB 7 software. The actual fertility patterns will not exactly match those in Table 1 because the sample is composed of only mothers who are likely to have completed fertility (ages 35–40).

Source: China 1982 census (1% sample), 1990 census (1% sample), and 2000 census (.10% sample). Data are for married women ages 35–40 and their matched children ages 0–18. See Table 3.

such a policy could both lower fertility and reduce the sex ratio but at a large financial cost to the government. The results of these simulations and the efficacy of these two policy options are described next.

Changing Fertility Limits

In Table 6, I simulate birth outcomes under a set of policy changes to the regime faced by the mothers in the census sample of 2000. In panel 1, I compare the fertility outcomes of the actual sample to the baseline simulation in which fertility rules are determined by the MLE routine, which indicates a reasonably close correspondence between the sex ratios and fertility rates between the actual and simulated fertility outcomes. In panel 2, I simulate the impact of changing the current fertility regulations. First, I examine the impact of a removal of the 1.5 child exemption. This is interesting because the model predicts a decline in fertility (1.81 to 1.75) and a rise in the sex ratio (1.14 to 1.15), which is consistent with an interpretation that this exemption is important to keeping the sex ratio of first births relatively undistorted. I then consider relaxations to the fertility regulations faced by this cohort of mothers by considering the impact of China adopting either a two-child or three-child policy by running simulations in which fertility decisions are made with respect to no fines on second births (two-child policy) and no fines on second or third births (three-child policy).

Interestingly, the two-child policy increases fertility to 2.00 but reduces the sex ratio only from 1.14 to 1.13. This can be explained in part by the large share of rural parents in these cohorts who were allowed a second birth, and so there is only a mild

Table 6 Counterfactual policy simulations using the model, China 2000

	Fertility Outcomes				Subsidies to Mothers Without a Son	
	Sex Ratio	Total Fertility	Total Births	Missing Girls	Total Subsidy (% of GDP)	Yuan Cost per "Saved Girl"
Panel 1: Comparison of Actual and Simulated Outcomes						
Actual outcomes	1.14	1.80	36,803	2,560		
Baseline simulation	1.14	1.81	37,036	2,528		
Panel 2: Alternatives to Current Fertility Limits			Δ Total Births	Δ Missing Girls		
Remove 1.5-child exception	1.15	1.75	–2,164	397		
Two-child policy	1.13	2.01	7,616	–185		
Three-child policy	1.09	2.43	23,838	–1,439		
Panel 3: Targeted Subsidy to Those Without a Son						
Subsidy of 3 months	1.12	1.80	–447	–422	0.40	55,024
Subsidy of 6 months	1.11	1.78	–906	–817	0.83	59,092
Subsidy of 9 months	1.10	1.77	–1,371	–1,184	1.28	63,338
Subsidy of 12 months	1.08	1.76	–1,874	–1,705	1.77	60,763

Notes: Panel 1 represents a comparison between the decisions observed by mothers in China's 2000 census, and a set of numerical simulations in which mothers are assigned a fertility outcome using a decision rule determined by maximum likelihood estimation. Panel 2 presents simulations in which China no longer allows a second birth to parents without a son, allows all couples a second birth, or allows all couples a third birth (removing all fines on these births). Panel 3 presents a set of simulations in which parents who fail to have a son are directly subsidized by a share of their annual income. Data for total births and missing girls are in thousands.

Source: China 2000 census (.10% sample). Data are for mothers ages 35–40 (N = 38,501); see Table 3.

benefit to such a policy. It also points to the fact that allowing additional births (lowering fines) does not have a strictly monotonic positive effect on the sex ratio. Imagine a parent who values daughters and sons, and is willing to comply with the policy after having a daughter, and have only one child if the fine is greater than the value of a son. Lowering the fine could potentially induce a subsequent birth and sex selection if the cost to sex selection was sufficiently low relative to the premium of a first son versus a second daughter. However, the simulation indicates that the impact of a three-child policy is dramatic, with simulated fertility rising to 2.43 and the sex ratio falling to 1.09, implying a much smaller female deficit and a 56% (1,439/2,560) reduction in the number of "missing girls." These simulations do not indicate how fertility would respond in China to a revision to the current policy because these parameters are estimated for parents age 35–40 in 2000, who may have different preferences than the families who will be making their fertility decisions in the next decade. They also can only be interpreted with proper caveats regarding econometric assumptions embedded in its formulation, and data limitations in its estimation.

Subsidies to Parents Without a Son

In panel 3 of Table 6, I simulate birth outcomes under a set of policies that subsidize families who fail to ever have a son for an increasingly generous program that would

provide three months, six months, and up to 12 months of income to parents who complete their fertility without a son. The proposed plan would deduct from each household some portion of annual salary, to be distributed to those without a son, and is similar in spirit to China's Care for Girls campaign, which subsidizes parents who fail to have a son by supporting the education of daughters and providing cash payments to those who fail to have a son (Li 2007). In the first simulation shown in panel 1, I calibrate the model to reproduce the fertility patterns observed in the census data. Then, the model is re-executed with parents assigned incrementally lower values for θ_{1i}. So, for each couple, I first impute θ_{1i} as a function of their observable characteristics using the coefficient estimates from the MLE. Then, I lower θ_{1i} by the amount of the proposed subsidy. I then recalculate the fertility and sex selection probabilities had the parents been behaving as if they had a lower value of θ_{1i}. The results indicate that the proposed policy would lower fertility and reduce the skew in the sex ratio. Intuitively, when mothers make fertility decisions, they experience a lower payoff to having a son, and so they are less inclined to have an additional child. Among those who have an extra child, they are less likely to pursue sex selection because the cost of sex selection relative to the payoff from having a son is lower as well. Both factors serve to reduce the total number of "missing girls."

The projected impact of a moderate subsidy in which mothers receive three months of household income when they fail to have a son decreases the sex ratio from 1.14 to 1.12, reducing the distortion to the sex ratio by roughly one-fifth (17%).[27] Because the premium on a son has been measured in years of income, the anticipated impact on the government budget can be calculated for each policy. For the small-scale subsidy, the annual cost to the government of subsidizing mothers is 0.4% of GDP. If parents are subsidized for 12 months of income, the sex ratio drops to 1.08, only slightly higher than the natural rate (1.06), reducing the number of "missing girls" by 67% (1,705/2,560) in this sample. The cost per "saved girl" is rising slightly with the generosity of the subsidy, from 55,024 to 60,763 yuan per saved girls, as more generous policies involve higher spending on mothers who would complete fertility without a son even in the absence of a subsidy. These estimates are not meant to capture the exact impact of a potential subsidy, but characterize some of the potential trade-offs of a widespread introduction of a subsidy to parents who fail to have a son.

The model can also be thought to represent a forecast for fertility patterns if son preference were to decline over time or because of secular changes in China, such as the effective implementation of a wider old-age support program currently being discussed (Diamond et al. 2005), or a diminution of son preference as witnessed in Korea (Chung and Das Gupta 2007). The motivation for a direct subsidy of sons is clear because rural areas of China are unlikely to rapidly modify, in an acceptably short period of time, modes of peasant life that have existed for centuries. In recent efforts to make old-age insurance in rural areas available, parents without sons were more likely to participate, indicating that the value of sons will continue provided families expect more old-age support from sons than daughters (Ebenstein and

[27] An alternative proposal that has been explored in rural areas is the direct subsidy of those who undergo sterilization for those with two daughters and no sons. Although I would like to compare my results with those found in areas with this policy, the data are, unfortunately, unavailable.

Leung 2010). The proposed subsidy will limit sex selection, discourage fertility, and mitigate the pain of an old age without sons, while improving the prospects of future men for the marriage market. The anticipated cost of such a program could also be lowered by taxing sons. Although I outline the costs of the program as a direct subsidy to those without a son, the model's predictions are valid if this policy were implemented as a tax to those who have a son.

Implications

In any population with stable growth and a historical preference for sons, some share of mothers will need to "fail to have a son" to maintain a sex ratio close to the natural rate. Intuitively, for a policy that requires mothers to have no more than N children, roughly $(1/2)^N$ mothers will need to fail to have a son for effective fertility control without sex selection. The simulation results indicate that the expected cost of a subsidy proposal is large, but would improve the incentive structure created by the current fertility policy in China. Stories in rural China today of widows working in the fields past the age of 70 serve as a warning to today's mothers that heeding fertility policies may be costly in the future. The historical experience for China indicates that parents were disinclined to leave this to chance, and in light of the technological innovations in ultrasound, parents with son preference were able to have a son at an early parity, with the phenomenon most pronounced in areas with the strictest fertility control. This pattern is also found in other countries with son preference, such as Taiwan, Korea, and India; and, like in China, sex ratios following daughters are highest among parents who desire the fewest children.

Although India has no current limit on fertility, the advancement of women and other modernizing forces has lowered the desired fertility of the country's educated women. As shown in Table 7, these fertility declines have been associated with

Table 7 Male fraction of births and total fertility by mother's education, India and Taiwan

		India (2006)				Taiwan (2000)			
Parity	Sex Combination	Illiterate	Primary	Middle	High School+	Less Than Primary	Primary	High School	BA+
First	None	.51	.51	.51	.52	.52	.52	.52	.52
Second	One girl	.53	.53	.53	.58	.52	.52	.52	.52
Third	Two girls	.53	.55	.58	.70	.55	.56	.59	.57
Fourth	Three girls	.52	.59	.62	.75	.60	.62	.62	.63
Total Fertility Rate		3.34	2.82	2.28	1.77	2.25	1.99	1.76	1.71

Note: The education categories are based on years of school: illiterate or less than primary is defined as 5 years of school or less, primary is defined as 6 years of school, middle is defined as 9 years of school, high school is defined as 12 years of school, high school+is defined as more than 12 years of school, and BA+ is defined as 16 or more years of school.

Source: Calculations for India are based on the 2006 Demographic and Health Survey (MEASURE DHS 2006) for all living children of ever-married women ages 15–49. Calculations for Taiwan are based on the 2000 census (100% sample) for married women ages 21–40 and their children ages 0–18.

higher sex ratios following daughters. Among third births following two daughters, 70% of high school graduates bear a son, whereas only 53% of illiterate mothers have a son. In Taiwan, a similar although weaker pattern is observed in the 2000 census, with 59% of high school graduates and only 55% of mothers with less than a primary degree having a son. The higher sex ratios among the educated are somewhat surprising in light of lower son preference among the less–educated[28] but are sensible in light of educated women's lower desired fertility and potentially better access to sex selection technology (e.g., ultrasound).

Existing research has noted a correlation between education and the sex ratio at birth and concluded the relationship is due to poorer parents preferring daughters to ensure their children succeeding in a competitive marriage market (Edlund 1999). I present an alternative interpretation in the model presented here—specifically, the mechanism for a positive correlation between education and the sex ratio at birth is due to higher-educated mothers wanting (or being forced[29]) to have fewer children, and therefore engage in sex selection at an earlier parity, leading to a higher overall sex ratio at birth. Alternatively, it may also be true that higher-educated mothers have lower costs of sex selection, providing a second reason why one may observe a correlation between education and the male fraction of births.[30] As the model predicts, parents who incur a larger cost to additional children and better access to sex selection technology will engage in sex selection at earlier parities, and this is observed in both China and India.

Conclusion

Although rapid industrialization and large changes in fertility have reshaped China in the past 40 years, sex preferences have survived the transition. In an earlier era of high fertility, they were manifested in higher stopping probabilities following sons and had a muted effect on the overall sex ratio. Today, fertility in China has slowed, but the imbalance in the sex ratio has become a pressing concern, and the situation appears to be worsening. Chinese government figures indicate that the female deficit has worsened since the 2000 census, with the overall sex ratio at birth reaching 118 boys born for every 100 girls in 2005 (*China Daily* 2007).

The imbalance in China's sex ratio is anticipated to leave roughly 22 million men from these cohorts unable to marry (Ebenstein and Sharygin 2009). Although one-quarter of young women married in Taiwan are from mainland China (Tsay 2004), no similar solution will present itself for the tens of millions of extra males in rural China. Recent reports that Chinese gangs are beginning to

[28] Fertility surveys in Taiwan indicate that higher-educated women are less likely to report having a gender preference for births (Taiwan's KAP Survey 2003).

[29] In China, urban areas have stricter fertility limits, and mothers also have, on average, more education.

[30] Note that the Trivers and Willard hypothesis (1973) also predicted a positive correlation between status and education if a species can vary the male fraction of births in response to anticipated success in mating (because males have more variable mating outcomes). This hypothesis is not thought to apply among human populations in a matter that would affect the male fraction of births by more than a few percentage points (Norberg 2004).

traffic in Vietnamese and North Korean women for would-be husbands are particularly alarming and suggest that the China marriage market squeeze could become an even larger policy issue. Economic realities as well as persistent religious beliefs make it unlikely that the problem will solve itself by parents choosing to prize daughters because of their scarcity.

The historical lesson to policymakers in family planning is that encouraging or forcing people to change their fertility behavior without addressing their fundamental preferences may have unanticipated consequences. The future course of the sex ratio in China is yet to be determined. In light of the Chinese government's decision to maintain the one-child policy, future policies must be formulated to address the need to discourage fertility *and* sex selection. This could be addressed by directly subsidizing mothers who fail to have a son. Empirical estimates presented here suggest that this could indeed be an effective option, with a one-year subsidy reducing the number "missing girls" by 67%. Future research in this area should compare these estimates with the empirical results of China's current efforts to implement similar policies, such as the Care for Girls campaign. Chinese authorities may wish to consider experimentation by varying the size and structure of subsidies to parents in rural China who fail to have a son, in order to supplement the structural estimates here as well. China's high sex ratio at birth is a pressing policy issue, and this article presents evidence that the practice of sex selection could be reduced dramatically through the implementation of corrective policies. Failing to act may prove costly for the next generation.

Appendix on Estimation of the Model

Econometric Model of Sex Selection

In this model, parents are assumed to choose the option at each decision node that maximizes the expected payoff given their anticipated choices tomorrow. They are unable, however, to perfectly anticipate future decisions due to stochastic factors that change the payoff to childbearing or sex selection. In China, several features of fertility policy make this assumption plausible. Because fines F are enforced by local officials, and enforcement is not perfect, they may appear stochastic to the couple (Scharping 2003). The cost of sex selection A also has a random element because parents cannot know in advance precisely how many conceptions and abortions will be required to conceive a son. Let parents make choices to maximize V, the payoff (or value) of reaching any final branch of the decision tree, denote each path choice by D, and each option by the subscript j.

$$V_{D_j} = V^*_{D_j} + \varepsilon_{D_j}, \qquad j = 0, 1.$$

Parents are aware of the anticipated payoff to each option $V^*_{D_j}$ prior to reaching the node, but in the period in which they make the decision D to pursue option j, they observe an unanticipated error term ε_{D_j}, or "shock," that either increases or decreases the attractiveness of option j. Note that at each decision node, parents are faced with a binary choice because the decision to have a child is binary, and the

decision to practice sex selection is binary. As such, the probability of making decision D to pursue option j can be written as follows:

$$\Pr(D=1) = \Pr(V_{D=1} > V_{D=0}) = \Pr(V^*_{D=1} - V^*_{D=0} > \varepsilon_{D=1} - \varepsilon_{D=0})$$
$$\text{Assume } \varepsilon_{D_j} \sim ev(1) \text{ iid.}$$

The error term for each option is assumed to be an independently and identically distributed extreme value, which has the convenient property that the difference between the two errors has a logistic distribution.[31] The extreme value distribution provides slightly fatter than normal tails, allowing for more aberrant behavior than a normally distributed shock, and also provides a closed-form solution for the likelihood function.[32]

The extreme value distribution is characterized by two additional parameters, τ and γ, which represent the scale and shift parameters respectively. In the context of the two-child model presented in the paper, this yields the following closed-form solution for the expected value of the payoff in the final stage:[33]

$$\begin{aligned} E(V^3) &= E\left[\max\left(\theta_i - A_i - F + \gamma_i + \varepsilon^3_{S_2=1}, -F + \gamma_i + \varepsilon^3_{S_2=0}\right)\right] \\ &= \tau\left\{\gamma + \log\left(1 + \exp\left[\frac{\theta_i - A_i}{\tau}\right]\right)\right\}. \end{aligned} \tag{15}$$

Likelihood Function for Basic Two-Child Model

In the model's simplest formulation, the likelihood of reaching each sex outcome can be written in terms of the three choice probabilities, which are expressed in the text in terms of θ, γ, A, and the fine regime imposed on a mother. Each mother in the sample is placed in one of four completed fertility outcomes: B,G,GB,GG.[34] The following represents the likelihood function, and it is easily verified that the total probability of reaching one of these four outcomes is equal to 1.

$$\Pr(B) = [.51 + .49\Pr(S_1)] \tag{16}$$

$$\Pr(G) = [.49 - .49\Pr(S_1)] \times [1 - \Pr(K_2)] \tag{17}$$

$$\Pr(GB) = [.49 - .49\Pr(S_1)] \times \Pr(K_2) \times [.51 + .49\Pr(S_2)] \tag{18}$$

$$\Pr(GG) = [.49 - .49\Pr(S_1)] \times \Pr(K_2) \times [.49 - .49\Pr(S_2)] \tag{19}$$

[31] The shock associated with current outcomes is assumed to have variance λ, which is known as the scale parameter because it affects only the levels of coefficients and not the relative size of each. λ is set equal to unity, which implies the parameters are identified in the same units as the fines (i.e., years of income).

[32] The claim that the difference in errors in each period is independent across periods requires that random factors affecting the attractiveness of options are uncorrelated with future or past shocks experienced by the individual.

[33] See Train (2003) for a thorough treatment of the estimation of discrete choice models. In the calculation of the model, I assume the scale parameter τ is equal to 1, and so the scale of the coefficients is set to the level of fines. I assume that the location parameter γ is equal to 0 (zero).

[34] The likelihood function for the three-child model comprises 14 outcomes and is available in Online Resource 2.

Robustness of Model Results

To examine the sensitivity of the results to particular specification choices, I estimate the parameters of the three-child model separately for 2000 without allowing for the region and period parameters presented in the main results. The results, shown in Table 8, indicate that the value of a first-born son is 0.94, 1.47, and 1.86, respectively, in the census samples. These results are reasonably similar to what is observed in the pooled sample (1.42), but I present in the main text parameters that include fixed-effect model parameters to absorb region- and period-specific factors that affect the value of a first son or daughter. Also note that the estimates are more precise in the 1990 and 2000 census samples, in which the majority of mothers were subject to fines, and therefore are estimated exploiting more variation in the fine rates. In fact, the table reflects that in 1982, prior to the policy, the model is unable to produce statistically significant parameter estimates. This is encouraging that the model fails to produce precise parameter estimates in the pre-policy period, but

Table 8 Parameter estimates for three-child sex-selection model, separately estimated

	1982		1990		2000	
	Son	Daughter	Son	Daughter	Son	Daughter
Panel 1: Parameter Estimates for First-born						
Years of education	–0.23	–0.24	–0.38**	–0.33**	–0.32**	–0.26**
	(0.30)	(0.21)	(0.10)	(0.09)	(0.08)	(0.07)
Farmer (1 = yes)	1.96	1.55	3.01**	2.28**	2.79**	1.72**
	(2.37)	(1.54)	(1.04)	(0.65)	(0.63)	(0.41)
Constant	0.39	0.25	1.027	0.257	2.91**	1.83†
	(1,161)	(1,209)	(1.08)	(1.02)	(1.07)	(0.82)
Average predicted value	0.94	–0.18	1.47	0.31	1.86	0.64
Panel 2: Parameter Estimates for Second-born and Third-born						
Marginal value of second	0.755	1.474	0.748	0.408	0.499	–0.078
	(1,164)	(1.05)	(0.89)	(0.93)	(0.60)	(0.67)
Marginal value of third	0.755	1.474	–0.713	0.408	–1.264	–0.078
	(1,163)	(1,210)	(1.30)	(1.24)	(1.68)	(1.36)
Panel 3: Parameter Estimates for Costs of Sex Selection						
Distance from clinic	4.72		1.171		2.58†	
	(78,991)		(3.63)		(1.53)	
Constant	9.749		3.549		2.34†	
	(78,991)		(4.03)		(1.35)	
Average predicted value	4.97		4.65		3.92	
Observations	28,170		36,279		38,501	
Log-Likelihood (ln L)	–72,040		–82,019		–77,076	

Sources: China 1982 census (1% sample), 1990 census (1% sample), and 2000 census (.10% sample). Data are for married women ages 35–40 and their matched children ages 0–18. See Table 3.

†$p \leq .10$; **$p \leq .01$

produces much better estimates in the 2000 sample, where most of the parents faced the fines, and therefore the parameters are better identified.

Acknowledgements This manuscript is taken from my graduate dissertation, and I am greatly indebted to my advisors, David Card and Ronald Lee, for their counsel and support. I would also like to thank Jerome Adda, Rodney Andrews, Richard Crump, Monica Deza, Simon Galed, Alexander Gelber, Gopi Shah Goda, Jonathan Gruber, Damon Jones, William Lavely, Claudia Sitgraves, Kevin Stange, Kenneth Train, and Ebonya Washington.

References

Abrevaya, J. (2009). Are there missing girls in the United States? Evidence from birth data. *American Economic Journal: Applied Economics, 1*(2), 1–34.

Arnold, F., Kishor, S., & Roy, T. K. (2002). Sex-selective abortions in India. *Population and Development Review, 28,* 759–785.

Banister, J. (1987). *China's changing population*. Palo Alto, CA: Stanford University Press.

Banister, J., & Hill, K. (2004). Mortality in China 1964–2000. *Population Studies, 58,* 55–75.

Becker, G., & Gregg Lewis, H. (1973). On the interaction between the quantity and quality of children. *Journal of Political Economy, 82,* 279–288.

Cai, Y., & William, L. (2003). China's missing girls: numerical estimates and effects on population growth. *The China Review, 3*(2), 13–29.

China. (1982). 1% Sample of the 1982 China Population Census. Data provided by Minnesota Population Center (2008), Integrated public use microdata series-international: Version 4.0 [Machine-readable database]. Minneapolis, MN: University of Minnesota. Originally produced by China's National Bureau of Statistics.

China. (1990). China Population and Information Research Center, 1% Sample of the 1990 China Population Census Data. Accessed from the Texas A&M University China Archive. Originally produced by China's National Bureau of Statistics.

China. (2000). 10% Sample of the 2000 China Population Census. Originally produced by China's National Bureau of Statistics.

China Health and Nutrition Survey. (1989). Originally produced by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention.

China Health and Nutrition Survey. (1993). Originally produced by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention.

China Daily. (2007, January). Rising sex-ratio imbalance "a danger." Retrieved online at http://www.chinadaily.com.cn/china/2007-01/23/content_789821.htm

Chu, J. (2001). Prenatal sex determination and sex-selective abortion in rural Central China. *Population and Development Review, 27,* 259–281.

Chung, W., & Gupta, M. D. (2007). The decline of son preference in South Korea: The roles of development and public policy. *Population and Development Review, 33,* 757–783.

Coale, A., & Banister, J. (1994). Five decades of missing females in China. *Demography, 31,* 459–479.

Diamond, P., Asher, M., Barr, N., Lim, E., & Mirrless, J. (2005). *Social security reform in China: Issues and options* (Policy Study of the China Economic Research and Advisory Programme). Retrieved from http://econ-www.mit.edu/faculty/pdiamond/papers

Ding, Q. J., & Hesketh, T. (2006). Family size, fertility preferences and sex ratio in China in the era of the one child policy: Results from national planning and reproductive health survey. *BMJ, 333,* 371–373. doi:10.1136/bmj.38775.672662.80

D'Souza, S., & Chen, L. (1980). Sex differentials in mortality in rural Bangladesh. *Population and Development Review, 6,* 257–270.

Ebenstein, A. (2010). The "Missing Girls" of China and the unintended consequences of the one child policy. *Journal of Human Resources, 45,* 87–115.

Ebenstein, A., & Leung, S. (2010). Son preference and access to social insurance: Evidence from China's rural pension program. *Population and Development Review, 36,* 47–70.

Ebenstein, A., & Sharygin, E. J. (2009). The consequences of the missing girls of China. *World Bank Economic Review, 23,* 399–425.

Edlund, L. (1999). Son preference, sex ratios, and marriage patterns. *Journal of Political Economy, 107,* 1275–1304.

Edlund, L., Li, H., Yi, J., & Zhang, J. (2008). *More men, more crime: Evidence from China's one-child policy* (IZA Working Paper No. 3214). Bonn, Germany: Institute for the Study of Labor.

Embassy for the People's Republic of China in the United States of America. (2006, September 29). Gender Imbalance Worries China, Gov't Takes Action. Retrieved from http://www.china-embassy.org/eng/xw/t273191.htm

Ertfelt, S. (2006, August 18). Study confirms China forced abortion policy created gender imbalance. Reuters News Release. Retrieved from http://www.freerepublic.com/tag/coercedabortion

Goodman, P. S. (2006, March 12). Stealing Babies for Adoption. *The Washington Post*. Retrieved from http://www.washingtonpost.com/wp-dyn/content/article/2006/03/11/AR2006031100942.html

Greenhalgh, S. (1986). Shifts in China's population policy, 1984-86: Views from the central, provincial, and local levels. *Population and Development Review, 12,* 491–515.

Greenhalgh, S., Chuzhu, Z., & Nan, L. (1994). Restraining population growth in three Chinese villages, 1988-1993. *Population and Development Review, 20,* 365–395.

Greenhalgh, S., & Winckler, E. (2005). *Governing China's population: From leninist to neoliberal biopolotics*. Stanford, CA: Stanford University Press.

Gu, B., Wang, F., Guo, Z., & Zhang, E. (2007). China's local and national fertility policies at the end of the twentieth century. *Population and Development Review, 31,* 129–147.

Johansson, S., & Nygren, O. (1991). The missing girls of China: a new demographic account. *Population and Development Review, 17,* 35–51.

Kim, J. (2005). Sex selection and fertility in a dynamic model of conception and abortion. *Journal of Population Economics, 18,* 41–67.

Li, S. (2007). *Imbalanced sex ratio at birth and comprehensive intervention in China*. Prepared for 4th Asia Pacific Conference on Reproductive and Sexual Health and Rights.

Lin, M.-J., Qian, N., & Liu, J.-T. (2008). *More women missing, fewer girls dying: The impact of abortion on sex ratios at birth and excess female mortality in Taiwan* (NBER Working Paper No. 14541). Cambridge, MA: National Bureau of Economic Research.

Liu, H. (2009). *Is there a quality-quantity tradeoff? Evidence from the relaxation of China's one child policy* (Working paper). Singapore: National University of Singapore.

MEASURE DHS. (2006). *India Demographic and Health Survey 2006*. Calverton, MD: ICF Macro.

Norberg, K. (2004). Partnership status and the human sex ratio at birth. *Proceedings of The Royal Society, 271,* 2403–2410.

Qian, N. (2008). Missing women and the price of tea in China: the effect of sex-specific earnings on sex imbalance. *Quarterly Journal of Economics, 123,* 1251–1285.

Qian, N. (2009). *Quantity-quality and the one child policy: The positive effect of family size on school enrollment in China* (NBER Working Paper No. 14973). Cambridge, MA: National Bureau of Economic Research.

Scharping, T. (2003). *Birth control in China, 1949–2000*. New York: Routledge Curzon.

Sen, A. (1990). More than 100 million women are missing. *New York Review of Books, 37,* 61–66.

Taiwan. (2000). Directorate General of Budget, Accounting, and Statistics (DGBAS). Taiwan Population and Housing Census.

Taiwan. (2003). Taiwan provincial institute of family planning. Survey of Knowledge, Attitudes, and Practice of Contraception (KAP).

Train, K. E. (2003). *Discrete choice methods with simulation*. New York: Cambridge University Press.

Trivers, R., & Willard, D. (1973). Natural selection of parental ability to vary the sex ratio of offspring. *Science, 179,* 90–92.

Tsay, C.-L. (2004). Marriage migration of women from China and Southeast Asia to Taiwan. In G. W. Jones & K. Ramdas (Eds.), *Un-tying the Knot: Ideal and reality in Asian marriage* (pp. 173–191). Singapore: National University of Singapore Press.

Wang, F. (1996). A decade of the one-child policy: Achievements and implications. In A. Goldstein & W. Feng (Eds.), *China* (pp. 96–116). Boulder, CO: Westview Press.

Yardley, T. (2008, March 11). China sticking with one-child policy. *New York Times*. Retrieved from http://www.nytimes.com/2008/03/11/world/asia/11china.html?_r=1

Zeng, Y., Ping, Tu, Baochang, Gu, Yi, Xu, Li, B., & Li, Y. (1993). Causes and implications of the recent increase in the reported sex ratio at birth in China. *Population and Development Review, 19,* 283–302.

Zeng, Y. (2007). Options for fertility policy transition in China. *Population and Development Review, 33,* 215–246.

Zhang, L., Feng, X., & Zhang, Q. (2006). Changing patterns of desired fertility. In D. Poston, C.-F. Lee, C.-F. Chang, S. L. McKibben, & C. S. Walter (Eds.), *Fertility, family planning, and population policy in China* (pp. 86–105). New York: Routledge Curzon.