Son Preference and Early Childhood Investments in China*

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Abstract

Where the fraction of male births is abnormally high, heterogeneity in son preference would suggest that parents of sons may have a stronger son preference than parents of daughters. Child sex may have become a stronger signal of parental sex preferences over time as the cost of sex selection has declined and sex ratios at birth have increased. In this paper, we build on Meng's 2009 analysis of ultrasound diffusion across counties in China, which was found strongly predictive of increased sex ratios at birth. Here, we consider whether ultrasound diffusion changed the pattern of early childhood investments in girls versus boys. If parental investments (like sex ratios) respond to parental sex preferences, postnatal investments in girls should increase with the diffusion of ultrasound and increased prenatal sex selection. In contrast, the prediction for investments prior to birth is ambiguous. For pregnancies carried to term, ultrasound revealed sex as much as six months prior to delivery, enabling gender discrimination in *in utero* investments. In contrast, sex selective abortions would tend to increase *in utero* investments in girls through preference sorting.

We evaluate these competiting predictions using microdata on investments in children using the 1992 UNICEF Chinese Children Survey, conducted by the National Bureau of Statistics. We find no effect of ultrasound access on the gender difference in postnatal investments. In contrast, we find early neonatal mortality of girls increased relative to boys with ultrasound access. As neonatal mortality tends to reflect pregnancy conditions, we infer that prenatal investments for girls carried to term may have fallen relative to boys once fetal sex was revealed.

JEL Classification: J13, J16, O33

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1 Introduction

Does knowledge of fetal gender during pregnancy alter parental investments? Previous studies have documented differential treatment of baby girls in South and East Asia (Das Gupta, 1987; Basu, 1989; Burgess and Zhuang, 2001; Pande, 2003; Borooah, 2004; Mishra et al., 2004; Park and Rukumnuaykit, 2004). To this, we add a natural experiment in parents' knowledge of the sex of their child during pregnancy provided by the roll-out of ultrasound technology across the counties of China (Meng, 2009). Changes in investments that affect female fetuses are of concern not only because they can affect health and mortality, but also because they can impair the later-life health and human capital of females. With prenatal sex determination, gender biased investments could occur at an earlier and potentially more-sensitive stage of development. Thus, our research question engages both the son preference and "fetal origins" literatures.[1]

Observationally, deliberate sex selection by parents may obscure the effect of knowing fetal gender on early childhood investments. The diffusion of ultrasound technology across China during the 1980s allowed parents to observe and exercise son preference through sex-selective abortion: local access to ultrasound strongly predicts increased male-to-female ratios at birth (Meng, 2009). If some Chinese parents had a stronger son preference than others, those choosing to abort females might have a stronger son preference than those who delivered daughters despite newfound access to ultrasound. Thus, Meng's result suggests that with increased sex ratios, parents were increasingly sorted according to son preference. In this respect, parents of girls may have benefited from increased investments.

To disentangle the effect of access to prenatal sex determination technology from parents' preference for sons, we use data on the year in which ultrasound machines were introduced into each of the roughly 1,500 counties from issues of the *Local Gazetteer*. This data set is then matched with a comprehensive microdata set that contains more than 500,000 live

[1] See Lhila and Simon (2008) for an early contribution in this vein that focussed on Asian immigrants to the US.

births in China from 1975 to 1992, a time of rapid expansion in ultrasound access. Using a difference-in-differences approach, we compare outcomes of females versus males before and after the introduction of ultrasound. Furthermore, our data allow us restrict comparisons to those within the family by including maternal fixed effects, which can address biases arising from differences across families, e.g. in fertility behavior and son preference. In our richest specification, the effects of ultrasound availability are identified using variation in ultrasound between children in the same families, after controlling flexibly for year fixed effects, county fixed effects, county time trends, and observed characteristics of the mother.

We find that postnatal investments do not seem to change as a result of preference-sorting induced by the availability of ultrasound. Nevertheless, we estimate a sizable increase in female neonatal mortality relative to male neonatal mortality following ultrasound availability. No significant effects are found for post-neonatal mortality measures, which implies that the effect of the availability of ultrasound on child health are concentrated soon after birth. Overall, these mortality results suggest that parents withheld investment in female fetuses relative to males after prenatal sex determination became available.

The remainder of the paper is organized as follows. Section 2 provides necessary background about son preference and the diffusion of diagnostic ultrasound in China. Section 3 discuss the ways in which the knowledge of fetal gender may affect parental investment in children. Section 4 describes the empirical strategy. Section 5 discusses the data and presents some descriptive statistics. Section 6 reports the empirical results. Section 7 concludes the paper.

2 Background

2.1 Son Preference and Gender Bias in China

China has a long history of son preference (see, e.g., Banister 1987 or Edlund 1999). The concept of male superiority is part of the Confucian values that are deeply rooted in Chinese culture. This tradition stresses the importance of continuing the family line through male offspring, and thereby reinforcing male dominance within a household. These values shaped marriage patterns and family structures that were strictly patriarchal.

In a patriarchal family, sons may be more valued more than daughters for economic reasons. Daughters are usually lost to their natal family after marriage. Sons, however, normally stay with their parents and are expected to provide labor for the farm or family business. Parents also have to depend on their sons for old-age support.

The strongest evidence of gender bias in China has been an abnormally high sex ratio (number of males per 100 females) at birth. It has been estimated that tens of millions of Chinese women are "missing" (Coale, 1991; Sen, 1990, 1992). Sen (1992) suggested that a substantial excess female mortality was responsible for the huge deficit of females in China. The recent years have seen a worsening of the "missing women" problem in China as the ratio of male to female births continued to rise significantly. Recent studies suggested that the primary explanation for China's risng sex ratio at birth since the 1980s is sex-selective abortion (Ebenstein, forthcoming; Meng, 2009). The previous literature has also documented discrimination against *surviving* girls. For example, there is empirical evidence which shows that girls have lower school enrollment rate relative to boys (Brown and Park, 2002; Gong et al., 2005). More recently, there are a number of studies that document gender bias against girls in intra-household allocation (Burgess and Zhuang, 2001; Park and Rukumnuaykit, 2004).

2.2 Ultrasound and Prenatal Sex Determination

While there exist a variety of reliable diagnostic procedures for fetal sex determination, ultrasound examination is used most frequently in China because it is the least expensive and most easily accessible method.[2] Ultrasound-B machines were originally designed for diagnostic purposes such as monitoring fetal development and checking intrauterine device placement. Ultrasound examination is also capable of prenatal sex identification, based

[2]Other modern methods of prenatal sex determination include chorionic villous sampling, amniocentesis, hematological tests, and so on.

on direct visualization of the external genitalia of the developing fetus. The accuracy of the technique is substantially improved from 15 to 16 weeks of gestation onwards.[3] With the recent development of high-resolution ultrasound equipment, and with the advent of transvaginal sonography (TVS), a diagnosis (although relatively inaccurate) can be made even as early as 11 weeks (Whitlow et al., 1999; Efrat et al., 1999). Most, if not all, of the obstetric ultrasound scans in China in the study period were by transabdominal sonography (TAS), and the lower-resolution equipment hindered accurate fetal sex determination in early pregnancy. The diagnostic procedure of ultrasound scan is painless and safe, with results immediately available at the time of visit. More importantly, the service is relatively inexpensive and readily affordable by any ordinary household. In China, it has been the most prevalent form of prenatal sex determination since its introduction.

In 1979, China was able to manufacture its very first ultrasound-B machine. Since the early 1980s, large numbers of imported and Chinese-made ultrasound machines have been introduced into the market. By 1987, the number of ultrasound-B machines being used in hospitals and clinics was estimated to exceed 13,000, or roughly six machines per county. According to official records, the number of imported ultrasound machines peaked in the late 1980s; over 2,000 state-of-the-art color ultrasound machines were imported in 1989 alone. It was also estimated that in the early 1990s, China had the capacity to produce over 10,000 machines annually, the equivalent of four additional machines per year for each county. By the mid-1990s, all county hospitals and clinics, as well as most township clinics and family planning service stations, were equipped with ultrasound devices that could be used for prenatal sex identification.

The popularization of ultrasound has made sex selection easier. Concurrent with the rapid growth of access to ultrasound, China witnessed an unprecedented rise in the sex ratio at birth during the 1980s (Chu, 2001). In 1989, having realized the potential disastrous consequences of the abuse of this technology, the Chinese government outlawed fetal sex

[3] For a review of the medical literature on this subject, see, for example, Mielke et al. (1998).

determination for non-medical purposes and legislated substantial penalties for physicians performing such tests. The government regulations, however, proved ineffectual in practice. The misuse of ultrasound was often hard to police, and doctors continued to do so as a favor to relatives, friends, or people who paid bribes (Zeng et al., 1993). In addition, the problem was made worse by the incentive structure under the One Child Policy. After all, the local officials who were pressed to meet the birth planning targets that emphasized solely the number of births would rather turn a blind eye at the use of sex-selective abortions than pay the consequences of missing their targets.

3 Hypothesized Effects of Knowing the Fetal Gender

First, consider the case of postnatal investment. Apparently before diagnostic ultrasound was available, parents would know the fetal sex prior to making postnatal investment decisions. However, the availability of ultrasound makes prenatal sex selection feasible. If there is heterogeneity in son preference across families, the increases in the sex ratio at birth after the introduction of ultrasound would suggest that following ultrasound availability, girls are born to parents with weaker son preference, relative to parents of girls prior to ultrasound. Therefore we hypothesize that postnatal investments in girls would increase relative to boys following ultrasound availability.

Second, consider the case of prenatal investment. One hypothesized effect of ultrasound access is to cause a reduction in prenatal investments in girls relative to boys. Before ultrasound was available, child gender was presumably unknown until delivery, which would tend to equalize prenatal investment in girls versus boys. However, after ultrasound was available, parents would have better knowledge of the fetuses. For those parents whose abortion costs outweigh the distaste for having a girl, they would decide to carry the baby to term. However if these parents still favor boys, knowing the fetal gender in advance could induce them to invest differently. Specifically, they might withhold prenatal investment in female fetuses. Meanwhile parents would tend to increase investment when they know the fetus is male with higher certainty. On the other hand, for the same reason as in the postnatal case, increased preference sorting with ultrasound access would tend to increase prenatal investments in girls relative to boys. After all, the prediction for prenatal investments in girls relative to boys following ultrasound availability is *ambiguous*.

4 Empirical Approach

Under a difference-in-differences framework, we estimate the difference in the impact of the introduction of diagnostic ultrasound on birth outcomes and parental investment measures for female children relative to male children. Specifically, the estimating equation is:

$$\begin{aligned} y_{ijct} &= \beta_1\, \mathsf{girl}_{ijct} + \beta_2\, \mathsf{ultrasound}_{ct} + \beta_3\, (\mathsf{girl}_{ijct} \times \mathsf{ultrasound}_{ct}) \\ &+ X_{ijct}\gamma + \mu_c + \nu_t + \mu_c \times t + \epsilon_{ijct} \end{aligned} \quad (1)$$

Here i indexes individual birth, j indexes mother, c indexes county, and t indexes year. y_{ijct} is the outcome of interest. girl_{ijct} is a binary variable which takes the value one if the child is female. $\mathsf{ultrasound}_{ct}$ is a dummy variable indicating whether ultrasound technology has been introduced into county c in year t, when the mother became pregnant. Any gender difference in outcome in the absence of diagnostic ultrasound is captured by β_1. β_2 measure the change in outcome for boys after the introduction of ultrasound. Our key parameter is β_3, the coefficient on the interaction between girl_{ijct} and $\mathsf{ultrasound}_{ct}$. It measures the difference between girls and boys in the change in outcome following the introduction of ultrasound. X_{ijct} is a vector of individual- and mother-specific controls for ethnicity, maternal education, maternal age at birth, and its square term. μ_c is a vector of county of birth indicators and ν_t a vector of year of conception indicators. $\mu_c \times t$ is the county specific linear time trends.

One possible threat to identification is that mothers with potentially worse (or better) birth outcome could be induced to bear children after the introduction of diagnostic ultrasound, which is an improvement of the local health facility, and at the same time can coincide with other improvement of medical technologies within that area. Suppose the error term

ϵ_{ijct} consist of a mother-specific component α_{jc}. Let $\epsilon_{ijct} = \alpha_{jc} + u_{ijct}$. In estimating Equation (1), selection bias could arise if any of the mother-specific unobservables are correlated with the availability of ultrasound. An arguably better way to avoid this possible compositional bias is to estimate a model with mother fixed effects. By differencing out the with-mother means, the portion of bias that is due to unobserved mother (or household) characteristics that are constant across the siblings is eliminated. This second model is given by:

$$
\begin{aligned}
\Delta y_{ijct} &= \beta_1 \, \Delta \mathsf{girl}_{ijct} + \beta_2 \, \Delta \mathsf{ultrasound}_{ct} + \beta_3 \, \Delta(\mathsf{girl}_{ijct} \times \mathsf{ultrasound}_{ct}) \\
&+ \Delta X_{ijct} + \Delta \nu_t + \Delta(\mu_c \times t) + \Delta u_{ijct} \qquad (2)
\end{aligned}
$$

where Δ differences across siblings. All variables are now of the form $\Delta x_{ijct} = x_{ijct} - \bar{x}_{jc}$ where $\bar{x}_{jc}$ is the with-mother mean of x_{ijct}. In this specification, only within-mother variation are used for identification and children without any siblings will be dropped out of the sample. Now β_3 is identified by siblings of the opposite gender and "straddle" the introduction of ultrasound. Comparing the within-mother estimates from Equation (2) to the between-mother estimates of Equation (1) (using the sibling sample) gives and idea of the potential selection bias present in the former.

5 Data Sources and Descriptive Statistics

This paper makes use of two primary data sets. The first data set documents the timing of county-level ultrasound adoption. This information is collected by examining many volumes of Local Gazetteer. The Chinese Government has a long tradition, lasting over one thousand years, of publishing issues of Local Gazetteer from time to time to record the development in a certain locality, typically a province, a city, or a county. Local Gazetteer is a copious official publication that embraces all types of information concerning history, economy, administration, culture, development, and so on. As such, it is often regarded as the authoritative encyclopedia of various particular locations in China.

In the early 1980s, the age-old tradition was revived when a new collection of Local Gazetteers were published to reflect the dramatic social changes that had taken place since the last major revision in the 1920s. Each local government set up its own Local Gazetteer Compilation Committee and performed a systematic review of its jurisdiction in a host of areas. A volume of Local Gazetteer was published as the final product of this bureaucratic effort. The new Local Gazetteers usually do not have a uniform framework in general, but most contain a chapter on public health issues. In this chapter, the time of the introduction of ultrasound machines was often recorded as a remarkable achievement in the public health sector for many counties.

The geographic distribution of counties with ultrasound over time is illustrated by a series of maps of China (see Figure 1), where the counties that had the ultrasound device between 1980 and 1995 are represented by areas shaded in dark blue, compared to areas where ultrasound was not yet available, which are denoted with light blue shading.[4] It appears that the technology expansion did not follow any clear geographic pattern (for example, from the coast to interior areas). Figure 2 tabulates the cumulative percentage of counties that had adopted ultrasound in each year in our data set. A few counties started to have ultrasound machines as early as 1965 (not shown in the figure). The coverage increased relatively slowly during the 1970s. Since the early 1980s, the expansion accelerated. In 1985 alone, over 500 counties adopted ultrasound, and the fraction of counties with ultrasound devices more than doubled. Virtually all the counties had their own ultrasound equipment by the end of the 1980s. This tabulation indicates that our microdata span a period of rapid diffusion of ultrasound technology.

The second data set is a microdata set from the Chinese Children Survey, which was conducted by the National Bureau of Statistics of China in June 1992. Funding and support for this project was provided by the United Nations Children's Fund, the Ministry of Education of China, the Ministry of Health of China, and the All-China Women's Federation. The original purpose of the survey was to study child welfare in China. This is a large and representative sample of 560,000 households and two million individuals (including children,

[4]Grey shaded areas are counties for which the information on ultrasound adoption is unavailable.

their parents, and other family members) throughout China.

What makes this survey well suited for our analysis is the pregnancy history form for all women who have ever been pregnant since 1976. The qualified respondents were asked questions regarding each pregnancy. Each pregnancy record contains information on the pregnancy order, approximate time of conception, use of prenatal care, gestation length, and its final outcome (miscarriage, induced abortion, live birth, and others). For live births, gender and date of birth are also recorded. The mother identifier ensures accurate matching of a given mother's births and their respective parities. One of the key variables for identifying *in utero* ultrasound "exposure" is the year of conception. The data provide the year of conception and the exact date of birth of each child. For about 1% of the sample, the reported year of birth is either earlier or two years later than the reported year of conception. In this case, we use the reported gestation length and year of birth to infer the conception year to minimize measurement error.

Our analysis is confined to the sample of children born in and after 1975. The main sample with non-missing ultrasound information contains nearly 300,000 live births. The summary statistics are described in Table 1, Panel A. The top row of the panel shows that about 47% of the births are boys. The implied sex ratio at birth is 113, well above the biological norm of 105 boys per 100 girls. The next rwo shows that for around 36% of the births in the sample, ultrasound machines have already been introduced into the county when the mother became pregnant. It is unfortunate that prenatal investment of individuals is not observed in our data. Instead, only information on the early-life mortality is available. Neonatal mortality, which is infant death within 28 days of life, is usually linked to the health environment during pregnancy (Grossman and Jacobowitz, 1981). It is therefore useful to use the neonatal mortality as an outcome variable that may capture the impacts on child survival through prenatal investment on which we do not have data. The next set of rows presents infant mortalities. Each of the infant mortality varaibles takes on the value one if a birth dies in a certain period of time and 0 otherwise. The infant mortality rate is about

7 deaths within 28 days of birth (aka. neontal infant mortality) per 1,000 births. Roughly 80% of the neonatal infant deaths occur within 7 days of birth and around 40% within 24 hours. In addition, the post-neontal mortality rate (infant death within 28 days to 1 year) is around 3 deaths per 1,000 neontal surviors.

Panel B of Table 1 presents summary information for the subsample with postnatal parental investment variables. Because questions on parental inputs are asked only for children born after June 1987, the sample size is reduced accordingly. The vaccination variable is an indicator variable for whether the child received any of the standard childhood vaccines against BCG, IPV, DPTa and measles. The vaccination rate in China is fairly low, ranges from 16% - 25% depending on the type of vaccine. In contrast, over 97% of children were ever breastfed. This suggests that breastfeeding was widespread in China, compared to childhood vaccination. The mean duration of breastfeeding is 14.9 months. Lastly, around 85% of the children were being taken care of by their mothers.

Table 2 presents the summary statistics for the sibling subsample. This subsample contains live births with at least one other sibling identified within the cohorts 1975 to 1992. The means and standard deviations for most of the observable characteristics of the sibling sample are very similar to those from the entire sample. The only exception is that there is a lower percentage of the siblings "exposed" to ultrasound. This is possibly because the children born in the later part of our sampling window are more likely to be "exposed" to ultrasound, and are at the same time less likely to have siblings due to the tightening One Child Policy under way.

6 Results

Table 3 shows the effect of ultrasound on infant mortality. The subsequent tables presenting results with different outcome variables have a similar structure. The first column displays the coefficients on the female indicator, ultrasound indicator and their interaction term. These results are from the linear model for whether an infant died in a certain period of time regressed on the female indicator, ultrasound indicator and their interaction, plus controls for birth order indicators, ethnicity, mother's age and age squared, mother's education, county fixed effects, year fixed effects and county-specific linear time trends. The second column shows the same regression, but for the subsample of births with at least one other sibling identified. In the third column, the coefficients displayed correspond to the regression model that now includes mother fixed effects. County fixed effects are dropped accordingly. For all regressions in our study, standard errors are adjusted for serial correlation by clustering at the county level.

The top panel in Table 3 shows the results from estimating equation (1) using infant mortality within 24 hours as the dependent variable. For all specifications, the coefficients on the female indicator are always small in magnitude and statistically indistinguishable from zero, suggesting no systematic difference in infant mortality within 24 hours between boys and girls before ultrasound is available. The full sample results suggest that the availability of ultrasound has a positive relationship with the probability of death within 24 hours for male infants. When we use only the sibling sample in column (2), this relationship more than doubles and is also highly significant. The positive association between ultrasound availability and infant death is somewhat surprising since the introduction of diagnostic sound is normally considered an improvement in the technology of prenatal care. One plausible explanation would be that the availability of better medical technology might have induced more disadvantaged women to bear children that are more likely to die young, and if this compositional effect dominates the health benefits of ultrasound, one could observe an increase in the overall infant mortality rate. In column (3), after adding mother fixed effect in the sibling sample, the coefficient on ultrasound becomes negative and is no longer significant at conventional levels. The mother fixed effect estimate implies that the introduction of ultrasound may in fact improve the health of newborn male infants, and the between-estimator of ultrasound might be biased due to selection. For the interaction term, both the full sample and sibling sample using OLS produce positive and statistically significant coefficients with the similar magnitude. However, after including mother fixed effects, the estimate almost doubles, suggesting an impact of 0.19 percentage point increase in the one-day mortality for girls relative to boys with the introduction of ultrasound.

The bottom panel in Table 3 presents the results for infant mortality within 7 days of life. Once again, the coefficients on the female indicator from all three specifications are small in magnitude and statistically indistinguishable from zero, which indicates no systematic difference in infant mortality within 7 days between boys and girls before ultrasound. Interestingly, the same contrast in results across specification arises when we compare the coefficients on ultrasound using the entire sample and the sibling sample with and without mother fixed effects. The full sample results suggest that the availability of ultrasound is associated with a 0.14 percentage point increase in the probability of death within 7 days for male infants. When we use only the sibling sample, this relationship more than doubles. However, after including mother fixed effect in the sibling sample, the coefficient on ultrasound becomes negative and is significant at the 1% level, suggesting a 0.28 percentage point decrease in one-week mortality for boys after the introduction of ultrasound. A similar pattern for the coefficients on the interaction term is also found for one-week mortality as for the one-day mortality. Both the full sample and sibling sample using OLS give positive and statistically significant coefficients with the similar magnitude and adding mother fixed effects doubles the estimates. The implied effect of ultrasound is a 0.25 percentage point increase in the one-week mortality for girls relative to boys.

The top panel in Table 4 displays the results from estimating equation (1) using infant mortality within 28 days as the outcome variable. Recall that roughly 80% of the neonatal infant deaths occur within 7 days of life. Not surprisingly, the results are very similar to the 7-days results, which suggest that the introduction of ultrasound has a positive impact on the neonatal mortality for girls relative to boys.

The bottom panel in Table 4 shows the results for infant mortality within 28 days to 1 year as the outcome variable, conditional on survival until 28 days of age. For all three specifications, the coefficients on the girl indicator are always small in magnitude and statistically insignificant, indicating no systematic difference in post-neonatal mortality between boys and girls before ultrasound. The least-squares results without mother fixed effect indicate a positive relationship between ultrasound availability and infant death within 28 days to 1 year. The point estimate increases substantially from using only the sibling sample. Once again, the estimate becomes negative, although no longer significant. Unlike the case with neonatal mortalities, the coefficients on the interaction term between ultrasound and girl indicators are small in size and statistically insignificant. Furthermore, the point estimate gravitates towards zero after including mother fixed effects. Our results suggest that ultrasound access has no further effect on the difference in survival between boys and girls once the child survived the neonatal stage.

The infant mortality results presented thus far suggest that the availability of ultrasound has a disproportionate impact on the probability of death soon after birth for girls relative to boys. The estimates imply that about 70% of the effect of ultrasound on the girl-boy difference in neonatal mortality is due to increase in the difference in infant death within 24 hours of birth. By contrast, ultrasound does not seem to have any effect on relative mortality if the child has survived the first month of life. Taken together, these results show that the effect of ultrasound on relative mortality of girls is concentrated soon after birth, which suggest that the knowledge of fetal gender might cause parents to withhold prenatal investment in female fetuses, which decreases the probability of survival of girls relative to boys during the neonatal period.

Tables 5 and 6 explore the relationship between ultrasound availability and gender imbalance in childhood vaccination. Specifically, an indicator variable for whether the child is vaccinated is regressed on the gender indicator, ultrasound indicator and their interaction term. The same sets of control variables are included as in the previous analysis of infant mortality. We observe vaccination receipt information for four types of vaccines, namely vaccines against BCG, IPV, DTPa and measles.

The top panel in Table 5 shows the estimated effects of ultrasound on the probability of receiving vaccine type 1, i.e. the vaccine against BCG. The cross-section results using either the entire sample or the sibling sample reveal no significant gender difference in vaccination before ultrasound. However the sibling fixed effects analysis in column (3) indicates a non-intuitive female advantage in receipt of vaccination and the point estimate is significant at the 10% level. For all three specifications, the coefficients on the ultrasound indicator and the girl-ultrasound interaction are always statistically insignificant, which provide little evidence of any impact of ultrasound on receiving vaccination type 1 for both genders.

The bottom panel in Table 5 shows the analysis for vaccine type 2, i.e. the vaccine against IPV. Interestingly, the coefficients on the girl indicator are uniformly positive in all three columns and statistically significant at least at the 10% level, which indicates a clear female advantage in receipt of vaccination type 2. The least-squares estimates for the ultrasound effect are small and statistically insignificant. The mother fixed effect estimate of ultrasound, however, is negative and significant at the 10% level, which indicate that the introduction of ultrasound is associated with a 1.7 percentage points decrease in receipt of IPV vaccination for boys. For all three specifications, the coefficients on the girl-ultrasound interaction are never statistically significant at conventional levels, which provide little evidence of any effect of ultrasound on receiving vaccination type 2 for girls relative to boys.

The top panel in Table 6 shows the results for vaccine type 3, i.e. the vaccine against DTPa. We find some evidence of female advantage of getting this particular type of vaccine. The coefficient from full-sample on the female indicator is positive and significant at the 10% level. The coefficient remains virtually unchanged once we use the sibling sample with or without mother fixed effects, although the effect is less precisely measured. For all three specifications, the coefficients on the ultrasound indicator and the girl-ultrasound interaction are always statistically insignificant, which reveals little evidence of the effect of ultrasound on receiving vaccination type 3 for both genders.

The bottom panel in Table 6 shows the results for vaccine type 4, i.e. the vaccine against measles. We find a substantial female advantage of getting this particular type of vaccine. The estimate of the gender difference barely changes across specifications and is always statistically significant. Once again, we find no substantial difference in receipt of vaccine type 4 for boys after the introduction of ultrasound. Moreover, estimates of the interaction effect of gender and ultrasound from different specification are not suggestive of any effect of ultrasound on receiving vaccination type 4 for girls relative to boys.

Table 7 shows the effect of ultrasound on postnatal investments. The top panel presents the analysis of breastfeeding. The outcome of interest is an indicator for whether the child has ever been breastfed by the mother. The estimates for the female indicator from all the specifications reveal no significant difference in the rate of breastfeeding across genders. The introduction of ultrasound does not seem to have a significant effect on the probability of breastfeeding for boys. The least-squares estimates for the interaction effect are small and statistically insignificant. The mother fixed effect estimate of the interaction effect, however, is negative and significant at the 1% level, and its magnitude implies that the introduction of ultrasound is associated with a 1.3 percentage points decrease in breastfeeding for girls relative to boys.

The next panel in Table 7 reports the results for the duration of breastfeeding. The dependent variable is the duration of breastfeeding in months. The cross-section results suggest that breastfeeding duration are longer for boys before ultrasound and this relationship holds even after adding in mother fixed effect. The within-mother estimate indicates that before ultrasound daughters receive 0.7 month less of breastfeeding relative to sons. The between-mother estimates using the whole sample and the sibling sample indicate that the introduction of ultrasound is associated with a roughly 0.2 month increase in the breastfeeding duration for male children. Including mother fixed effect hardly changes the size of the coefficient, although it is measured less precisely. Moreover, none of the estimates of the interaction effect of gender and ultrasound from different specification is suggestive of any impact of ultrasound on the length of breastfeeding for girls relative to boys.

Finally, the bottom panel in Table 7 displays the results for whether the child was taken care of by his or her mother. We implicitly assumes that the mother has the natural comparative advantage of taking care of her children and the child should be better off being taken care of by his or her mother. The estimates for the female indicator from all the specifications reveal no significant difference in the probability of being taken care of by mother across genders. The introduction of ultrasound does not seem to have a significant effect on the probability of being taken care of by mother for boys. Moreover, none of the estimates of the interaction effect of gender and ultrasound from different specification is suggestive of any impact of ultrasound on the probability of being taken care of by mother for girls relative to boys.

7 Conclusion

This paper addresses the question of whether parental investment decisions change when they are able to know child gender during pregnancy in China. It does this by using both time and cross-section variation in local access to prenatal sex determination caused by the differential introduction of diagnostic ultrasound into Chinese counties during the 1980s. Furthermore, we include maternal fixed effects to control for unobserved time-invariant characteristics of the mother. We find little evidence of any change in postnatal investments as a result of preference-sorting caused by the access to ultrasound. Nevertheless, we estimate a sizable increase in female neonatal mortality relative to male neonatal mortality after ultrasound was introduced. Further, our empirical analysis reveals no significant effects for post-neonatal mortality measures, which implies that the effect of the availability of ultrasound on child health are concentrated soon after birth. Taken together, our results for infant mortality measure indicate that parent withheld investment in female fetuses relative to males after ultrasound became available.

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Table 1: Summary statistics (samples with ultrasound information)

Variables	Observations	Mean	Standard Deviation
Panel A			
Subsample with mortality measures			
Girl	284728	0.468	0.499
Ultrasound	284728	0.360	0.480
Death within 24 hours of birth	284728	0.003	0.056
Death within 7 days of birth	284728	0.006	0.075
Death within 28 days of birth	284728	0.007	0.084
Death within 28 days to 1 year	282711	0.003	0.055
Panel B			
Subsample with postnatal measures			
Girl	93967	0.458	0.498
Ultrasound	93967	0.361	0.480
Vaccine 1 (BCG)	93601	0.159	0.366
Vaccine 2 (IPV)	93600	0.157	0.363
Vaccine 3 (DTPa)	93600	0.192	0.394
Vaccine 4 (Measles)	93600	0.254	0.435
Breastfeeding	93968	0.971	0.167
Duration of breastfeeding (months)	91263	14.842	7.843
Taken care of by mother	93967	0.846	0.361

Notes:
The samples are taken from the Chinese Children Survey.
Information on ultrasound access is collected by the authors.

Table 2: Summary statistics (sibling sample with ultrasound information)

Variables	Observations	Mean	Standard Deviation
Panel A			
Subsample with mortality measures			
Girl	243482	0.468	0.499
Ultrasound	243482	0.307	0.461
Death within 24 hours of birth	243482	0.003	0.059
Death within 7 days of birth	243482	0.006	0.080
Death within 28 days of birth	243482	0.008	0.089
Death within 28 days to 1 year	241557	0.003	0.058
Panel B			
Subsample with postnatal measures			
Girl	80121	0.458	0.498
Ultrasound	80121	0.308	0.462
Vaccine 1 (BCG)	79926	0.163	0.369
Vaccine 2 (IPV)	79926	0.159	0.365
Vaccine 3 (DTPa)	79926	0.195	0.396
Vaccine 4 (Measles)	79926	0.257	0.437
Breastfeeding	80122	0.971	0.168
Duration of breastfeeding (months)	77806	14.852	7.868
Taken care of by mother	80121	0.846	0.361

Notes:
The samples are taken from the Chinese Children Survey.
Information on ultrasound access is collected by the authors.

Table 3 : The effect of ultrasound on mortality: with and without mother fixed effects

	Full sample (1)	Sibling sample No mother FE (2)	Sibling sample With mother FE (3)
		Death within 24 hours of birth	
Girl	0.0002	0.0002	0.0002
	(0.0003)	(0.0003)	(0.0003)
Ultrasound	0.0007**	0.0016***	-0.0009
	(0.0003)	(0.0004)	(0.0006)
Ultrasound × Girl	0.0009**	0.0010*	0.0019***
	(0.0004)	(0.0005)	(0.0007)
Observations	284254	243132	243132
R-squared	0.0033	0.0037	0.0033
		Death within 7 days of birth	
Girl	-0.0002	-0.0002	-0.0003
	(0.0003)	(0.0004)	(0.0005)
Ultrasound	0.0014***	0.0031***	-0.0028***
	(0.0004)	(0.0006)	(0.0009)
Ultrasound × Girl	0.0014**	0.0013*	0.0025***
	(0.0006)	(0.0007)	(0.0010)
Observations	284254	243132	243132
R-squared	0.0035	0.0043	0.0038
County fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
County time trends	Yes	Yes	Yes

Notes: Individual controls include birth order indicators, mother's ethnicity, education, maternal age at conception and its squared term. Standard errors clustered at the county level are reported in parentheses; *denotes statistical significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table 4 : The effect of ultrasound on mortality: with and without mother fixed effects (continued)

	Full sample	Sibling sample No mother FE	Sibling sample With mother FE
	(1)	(2)	(3)
		Death within 28 days of birth	
Girl	-0.0002	-0.0001	-0.0002
	(0.0004)	(0.0004)	(0.0005)
Ultrasound	0.0020***	0.0042***	-0.0033***
	(0.0005)	(0.0006)	(0.0010)
Ultrasound × Girl	0.0013**	0.0011	0.0026**
	(0.0007)	(0.0008)	(0.0011)
Observations	284254	243132	243132
R-squared	0.0037	0.0047	0.0041
		Death within 28 days to 1 year†	
Girl	-0.0001	-0.0001	-0.0001
	(0.0003)	(0.0003)	(0.0003)
Ultrasound	0.0008**	0.0018***	-0.0007
	(0.0003)	(0.0004)	(0.0006)
Ultrasound × Girl	0.0006	0.0005	-0.0001
	(0.0005)	(0.0005)	(0.0007)
Observations	282240	241210	241210
R-squared	0.0035	0.0041	0.0036
County fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
County time trends	Yes	Yes	Yes

Notes: Individual controls include birth order indicators, mother's ethnicity, education, maternal age at conception and its squared term. Standard errors clustered at the county level are reported in parentheses; *denotes statistical significance at the 10% level, ** at the 5% level, *** at the 1% level; analysis of infant death within 28 days to 1 year are conducted for neonatal survivors.

Table 5 : The effect of ultrasound on vaccination: with and without mother fixed effects

	Full sample (1)	Sibling sample No mother FE (2)	Sibling sample With mother FE (3)
		Vaccine 1	
Girl	0.0032	0.0030	0.0068*
	(0.0027)	(0.0028)	(0.0041)
Ultrasound	0.0009	-0.0002	-0.0132
	(0.0041)	(0.0046)	(0.0099)
Ultrasound × Girl	0.0017	0.0007	0.0079
	(0.0045)	(0.0048)	(0.0084)
Observations	93454	79816	79816
R-squared	0.1769	0.1812	0.0276
		Vaccine 2	
Girl	0.0061**	0.0057**	0.0082*
	(0.0027)	(0.0029)	(0.0044)
Ultrasound	0.0023	-0.0009	-0.0165*
	(0.0043)	(0.0049)	(0.0097)
Ultrasound × Girl	-0.0040	-0.0002	0.0030
	(0.0046)	(0.0051)	(0.0083)
Observations	93453	79816	79816
R-squared	0.1261	0.1288	0.0373
County fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
County time trends	Yes	Yes	Yes

Notes: Individual controls include birth order indicators, mother's ethnicity, education, maternal age at conception and its squared term. Standard errors clustered at the county level are reported in parentheses; *denotes statistical significance at the 10% level, ** at the 5% level, *** at the 1% level.

Table 6 : The effect of ultrasound on vaccination: with and without mother fixed effects (continued)

	Full sample (1)	Sibling sample No mother FE (2)	Sibling sample With mother FE (3)
		Vaccine 3	
Girl	0.0050*	0.0044	0.0044
	(0.0028)	(0.0030)	(0.0047)
Ultrasound	0.0005	-0.0025	-0.0123
	(0.0045)	(0.0053)	(0.0099)
Ultrasound × Girl	0.0010	0.0040	0.0065
	(0.0049)	(0.0057)	(0.0091)
Observations	93453	79816	79816
R-squared	0.1488	0.1518	0.0416
		Vaccine 4	
Girl	0.0116***	0.0111***	0.0114**
	(0.0032)	(0.0034)	(0.0051)
Ultrasound	0.0039	0.0046	-0.0026
	(0.0046)	(0.0053)	(0.0107)
Ultrasound × Girl	-0.0087	-0.0065	-0.0132
	(0.0054)	(0.0062)	(0.0102)
Observations	93453	79816	79816
R-squared	0.1531	0.1527	0.0803
County fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
County time trends	Yes	Yes	Yes

Notes: Individual controls include birth order indicators, mother's ethnicity, education, maternal age at conception and its squared term. Standard errors clustered at the county level are reported in parentheses; *denotes statistical significance at the 10% level, ** at the 5% level, *** at the 1% level.

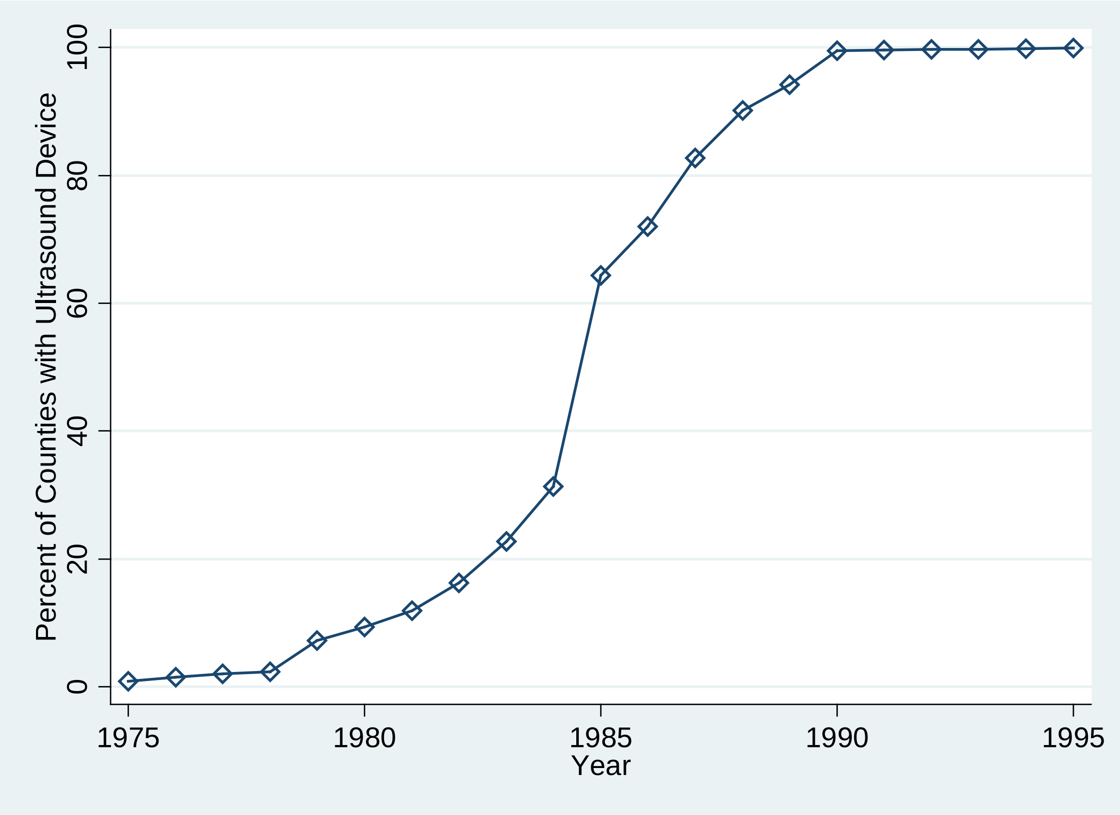
Table 7 : The effect of ultrasound on care: with and without mother fixed effects

	Full sample (1)	Sibling sample No mother FE (2)	Sibling sample With mother FE (3)
		Breastfeeding	
Girl	-0.0020	-0.0019	-0.0020
	(0.0014)	(0.0014)	(0.0022)
Ultrasound	0.0028	0.0019	0.0020
	(0.0017)	(0.0020)	(0.0043)
Ultrasound × Girl	-0.0027	-0.0027	-0.0125***
	(0.0023)	(0.0026)	(0.0043)
Observations	93831	80025	80025
R-squared	0.0384	0.0407	0.0128
		Duration of breastfeeding	
Girl	-0.6988***	-0.6698***	-0.5756***
	(0.0606)	(0.0632)	(0.0969)
Ultrasound	0.1983***	0.2286***	0.2616
	(0.0751)	(0.0848)	(0.1818)
Ultrasound × Girl	0.0447	0.0042	-0.0925
	(0.0977)	(0.1129)	(0.1867)
Observations	91136	77715	77715
R-squared	0.3440	0.3458	0.3124
		Taken care of by mother	
Girl	-0.0032	-0.0028	-0.0054
	(0.0024)	(0.0025)	(0.0041)
Ultrasound	-0.0001	0.0022	-0.0072
	(0.0034)	(0.0040)	(0.0078)
Ultrasound × Girl	0.0017	0.0010	0.0049
	(0.0042)	(0.0051)	(0.0079)
Observations	93830	80024	80024
R-squared	0.1403	0.1428	0.0288
County fixed effects	Yes	Yes	No
Year fixed effects	Yes	Yes	Yes
County time trends	Yes	Yes	Yes

Notes: Individual controls include birth order indicators, mother's ethnicity, education, maternal age at conception and its squared term. Standard errors clustered at the county level are reported in parentheses; *denotes statistical significance at the 10% level, ** at the 5% level, *** at the 1% level.

Figure 1: The spread of ultrasound technology across Chinese counties

Figure 2: Percent of Chinese counties with ultrasound, 1975-1995



Notes: Tabulations of the authors' own dataset.