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RESEARCH PAPER

Son preference and low birth weight for girls

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Abstract

While previous studies have confirmed the negative effects of son preference on the prenatal care received by girls, few have examined its effect on birth outcomes. This study contributes to the literature on son preference by examining this relationship. The degree of son preference is measured by the sex ratio at birth, and the data were obtained from the birth registry of South Korea, which has a long history of strong son preference. We find that girls are more likely to be born with low birth weight when son preference is stronger. In addition, when son preference is stronger, girls are more likely to be born outside hospitals, which implies that mothers conceiving girls make fewer prenatal visits to the hospital when their son preference is stronger.

Key words: Low birth weight; non-hospital birth; prenatal care; sex ratio at birth; son preference

JEL Classifications: I1; J1; O1

1. Introduction

The literature has shown that girls in countries with strong son preferences, including China and India, are discriminated against, prenatally. For example, when a fetus is found to be a girl in India, mothers receive less prenatal care [Bharadwaj and Lakdawala (2013)], and a female fetus is more likely to be aborted than a male fetus in both countries [Ebenstein (2010), Chen *et al.* (2013), González (2018), Bhalotra *et al.* (2020)].[1] When son preference, as shown in the literature, leads to discriminatory behavior against the female fetus, the birth outcomes of newborn girls are not likely to be as good as those of boys, because prenatal care has a significant impact on the birth outcomes of newborns [Gajate-Garrido (2013), Sonchak (2015)]. However, only a few studies have examined this relationship.

We analyzed the relationship between son preference and birth weight in girls.[2] The data cover the period between 2000 and 2015 from South Korea, which has a long history of strong son preference. Recently, however, a decline in son preference has become apparent. The proportion of married women who answered that they wanted

[1]González (2018) examined Indian immigrants in Spain.

[2]Although birth weight is popularly used for measuring neonatal health, one recent study by Conti et al. (2020) reported that health in utero and at birth is multidimensional and cannot be easily represented by one measure.

to have a son was 18.0% in 2000 but fell to 5.7% in 2015 [Oh *et al.* (2016)]. In addition, married women who were not concerned about not having a son accounted for 38.2% in 2000, but this number increased to 65.3% in 2015 [Oh *et al.* (2016)]. The persistence of son preference, followed by its weakening is rarely observed; thus, the South Korean situation is appropriate for analysis.[3]

The degree of son preference is measured by the sex ratio at birth (SRB), which is the number of newborn boys per 100 newborn girls. Since almost all pregnant women underwent ultrasound tests in South Korea before 2000 and abortion has been allowed in practice, the SRB can reflect son preference. Accordingly, other studies have used SRB as a measure of South Korea's son preference [e.g., Chung and Gupta (2007), Den Boer and Hudson (2017), Choi and Hwang (2020)]. If the SRB reflects son preference, a stronger son preference translates to a larger SRB. In other words, parents with a son preference who are likely to follow the son-stopping rule (continuing childbearing until they have the desired number of sons) when they do not have access to ultrasound technology and abortion could tend to abort the female fetus when they do, which leads to a larger SRB.

As shown in Figure 1, the SRB in 2000 for first- or second-born children was in the normal range at 106.3 and 107.4,[4] respectively; whereas, the SRB of third- or later-born children in the early 2000s, which was as high as 144.2 in 2000 [National Statistical Office (2020)], was not. Therefore, we focus our analysis on the children of parents that were considered to have a son preference, that is, third- or later-born children, and first- and second-born children are used for the placebo tests.

SRB is also affected by other factors. For example, malnutrition is a factor that increases the rate of girls being born [Anderson and Bergström (1998), Almond *et al.* (2010)], and natural disasters such as earthquakes increase the proportion of girls [Fukuda *et al.* (1998)].[5] However, malnutrition and earthquakes are not considered serious problems in South Korea. Furthermore, based on the Trivers-Willard hypothesis, Korean women's increased education level and age at birth over time, may have decreased and increased the proportion of girls, respectively. However, as Figure 1 shows, the sex ratio for first- and second-born children is stable over time, indicating that these variables are not likely to have affected the ratio in the country.

Our study relates to the literature that analyzes discriminatory behavior against girls arising from son preference. In addition to studies on prenatal discrimination in prenatal hospital visits and abortions, postnatal discrimination has also been reported. These studies have shown that girls are discriminated against for immunizations, breastfeeding, mortality, childcare time, child labor, and education

[3]For more information on the decline of son preference in South Korea, see Choe (2007), Gendercide (2010), Den Boer and Hudson (2017), and How South Korea Learned to Love Baby Girls (2017).

[4]The SRB of 105–107 is considered to be a normal range. The low numbers for these two birth orders could be caused by either parents' lack of son preference or the son-stopping rule that the parents might follow. Among the two, the lack of son preference is more likely, because ultrasound tests were available in the entire country before 2000, and abortion was practically allowed, thus being effective in preventing parents from following the rule. Moreover, the total fertility rate was only 1.5 in 2000, which is hard to achieve when parents continue childbearing until they have the desired number of boys.

[5]According to the Trivers-Willard hypothesis, women terminate weaker or male fetuses, when experiencing poor conditions [Trivers and Willard (1973)]. Other studies that examined this hypothesis include Almond et al. (2009), Sanders and Stoecker (2015), Valente (2015), Dagnelie et al. (2018), Wu (2021).

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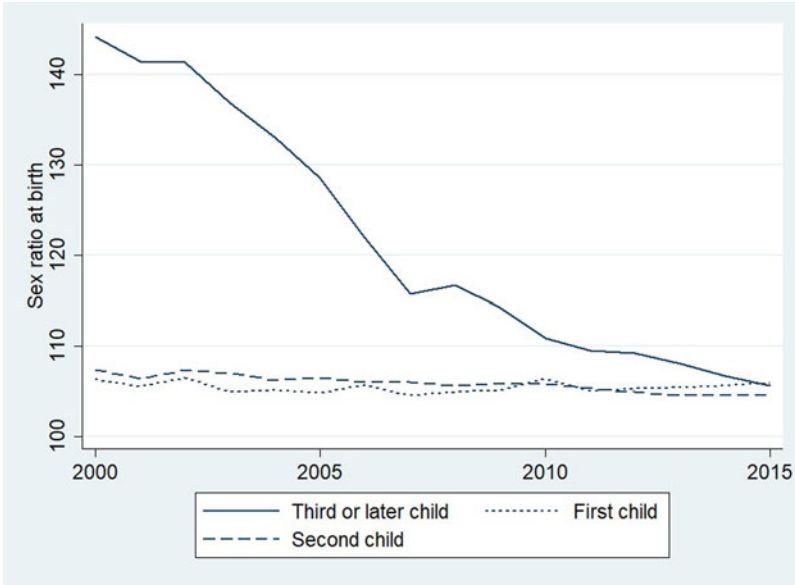

Figure 1. SRB based on birth order.
This figure shows SRB over time based on birth order.

[Oster (2009), Jayachandran and Kuziemko (2011), Kumar (2013), Barcellos *et al.* (2014), Guilmoto (2015), Hafeez and Quintana-Domeque (2018), Kaul (2018), Choi and Hwang (2020)]. For example, Choi and Hwang (2020) reported that in South Korea, boys spend less time on household chores, while their mothers work fewer hours in labor markets. Studies on the effect of discriminatory behavior against girls on birth outcomes are rare. A related study was conducted by Lhila and Simon (2008), who analyzed the data of first-generation Chinese and Indian mothers living in the United States and found that knowing the gender of the fetus had no significant effect on girls' weight at birth.[6]

Our study also relates to the literature on factors associated with birth weight. These factors include the gender and birth order of the child [Goisis *et al.* (2019)] and maternal characteristics such as age [Restrepo-Méndez *et al.* (2014)], income [Conley and Bennett (2001)], and educational attainment [Ahsan and Maharaj (2018)]. These factors also include maternal stress during pregnancy, possibly from natural disasters or economic conditions [Currie and Rossin-Slater (2013), Bozzoli and Quintana-Domeque (2014), de Oliveira *et al.* (forthcoming)] and health behaviors such as prenatal care [Gajate-Garrido (2013), Sonchak (2015)].

This study contributes to the literature in the following ways. First, as described above, many studies have analyzed discriminatory behavior against girls, but very few have analyzed its effect on birth outcomes. As birth outcomes affect later health and school outcomes [Figlio *et al.* (2014), Bharadwaj *et al.* (2018), McGovern (2019)], they represent an essential factor in determining the level of human capital. For

[6]They also examined the impact on prenatal care including prenatal care visits and alcohol and tobacco use during pregnancy but found no significant effect.

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example, Bharadwaj *et al.* (2018) reported that low birth weight (that is, weighing less than 2,500 grams at birth; LBW) decreases math test scores by 0.1 standard deviations, and McGovern (2019) found that LBW is associated with a six percentage point increase in mortality risk.[7] Second, we used SRB to measure the degree of son preference, which is possible because the rate has declined in South Korea with the availability of abortion and ultrasound technology throughout the country. China and India have seen a recent rise; however, this increase should be interpreted as a rise in the prevalence of ultrasound technology [Ebenstein (2010), Bhalotra and Cochrane (2010), Hu and Schlosser (2015)], not as a change in son preference. Instead, this ratio has been used for other purposes. For example, Hu and Schlosser (2015) examined the effect of sex-selective abortion in India on girls' well-being and used state-level SRB to measure how common abortions are in each state. The use of state-level SRB was possible because of significant differences in prenatal sex selection technology over time and across states in the country, which implies that not every state had the technology during the period examined in the study: the early 1980s to the mid-2000s. In this context, although Jayachandran and Kuziemko (2011) used SRB to measure son preference in Indian states, Hu and Schlosser (2015) caution against the use of the ratio to measure son preference in India, as their findings indicate that there were Indian states with strong son preference but with no trend of increases in SRB.

The results of this study are as follows. Girls are more likely to be born with LBW when son preference is stronger. Specifically, if the ratio increases by one, the probability of LBW among girls increases by 0.0156 percentage points. Because SRB for third- or later-born children decreased by 38.6 from 144.2 in 2000 to 105.6 in 2015, the decline in SRB was associated with a reduction in the probability of LBW among girls by 0.6 percentage points ($= 0.0156\%p \times 38.6$). In addition, when the ratio is higher, girls are more likely to be born outside hospitals, implying that mothers conceiving girls make fewer prenatal visits to the hospital when the son preference is stronger.

The remainder of this paper is organized as follows. Section 2 describes the background, followed by description of the data in Section 3. Section 4 describes the empirical strategy. Section 5 presents the estimation results, and Section 6 concludes the paper.

2. Background

2.1 Son preference in South Korea

South Korea, along with China and India, has been a country with strong son preference; this is rooted in the patriarchal family system introduced during the Choson dynasty, which reigned from 1392 to 1910. Under their patriarchal family system, the son (or the eldest son) becomes head of the family, and inheritance occurs through the male line, leading to a strong son-preferring culture [Larsen *et al.* (1998), Chung and Gupta (2007)].

Son preference has declined and almost disappeared in recent times. As described in Section 1, in 2015 only 5.7% of married women thought that they wanted to have a son, compared to 18.0% in 2000. Furthermore, according to the Korean General Social Survey

[7]One recent study by Clarke et al. (2021) finds that individuals are willing to pay $1.47 for each additional gram of birth weight when the value of birth weight is estimated linearly.

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(KGSS), in 2004, more people, in the case of having only one child, preferred to have a son rather than a daughter, accounting for 36.2% and 31.9%, respectively. However, in 2015, 43.1% preferred having a daughter, whereas 35.6% preferred to have a son.[8]

Figure 2 shows the SRB for third- or later-born children during 2000–2015 for 16 regions in South Korea; there is a decline in the ratio in all the regions.[9] Larger declines occurred in the southeastern region, which has a strong tradition of son preference, including Busan, Daegu, and Ulsan. For example, Daegu had the largest decline, from 192.1 in 2000 to 106.2 in 2015; the ratio in Seoul, which had a relatively weak son preference, dropped from 137.9 to 104.2 during the same period.

The improved socioeconomic status of women is one reason why son preference has declined in South Korea [Chung and Gupta (2007), Edlund and Lee (2013)]. Women's participation in economic activities has increased, as has their educational attainment. Girls perform better than boys on standardized tests and are more likely to attend college. As reported in the literature, discrimination against women decreases when their economic conditions improve. According to Qian (2008), when the prices of female-grown agricultural products and women's income rise, girls are less likely to die and women's educational level increases. Jensen (2012) showed that as the number of female-labor intensive jobs increases, girls receive more education.

2.2 Abortion and ultrasound technology

Although abortion is illegal in South Korea except for in certain cases, it is widely performed. In 2005, there were approximately 340,000 abortions and in 2010, 170,000 [Sohn *et al.* (2011)].[10] Nevertheless, only few people have been indicted; for example, in 2006, only five cases led to the indictment [Korean Women's Association United (2011)]. This means that abortion has been allowed in practice in the country.

According to Hong *et al.* (1994), 97.6% of pregnant women underwent an ultrasound test in 1994, which implies that a pregnancy ultrasound test was available in every region of the country in the years prior to 2000, and the abnormally high SRB for third- or later-born children was caused by sex-selective abortion of girls enabled by the test.

It is worth noting that as abortion is allowed in practice, the estimates found in this study are likely to be smaller than those estimated when abortion is not allowed. We consider that mothers who tend to abort the female fetus when abortion is allowed, are more likely to treat the baby improperly (e.g., abandonment) when abortion is not allowed than mothers who do not abort and carry the pregnancy of a girl to term when it is allowed. Thus, girls who would have been born to mothers who intend to carry out an abortion when it is prohibited, are likely to have worse birth outcomes than girls who are born when it is allowed. This implies that gender differences in birth outcomes would have been larger when abortion was not allowed.

2.3 Fertility

Although other son-preferring countries have seen an increase in SRB as fertility declined [Ebenstein (2010), Jayachandran (2017)], South Korea has seen declines in

[8]The KGSS data can be downloaded from https://www.icpsr.umich.edu/icpsrweb/ICPSR/series/288

[9]Figure A1 presents a map of South Korea.

[10]The numbers of babies born in both years are 470,000 and 440,000 respectively.

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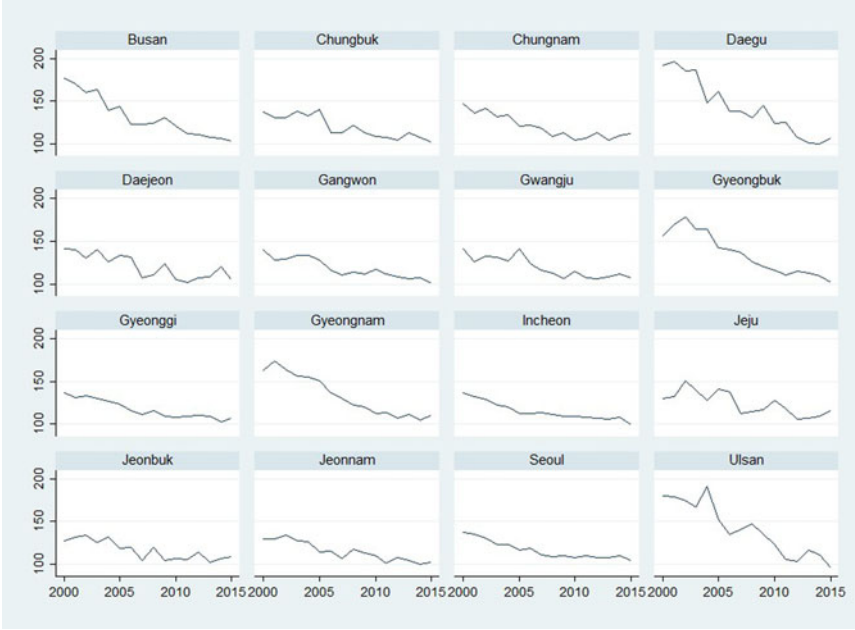

Figure 2. Regional SRB of third- or later-born children.
These graphs are the ratios of third- or later-born children for 16 regions in South Korea.

both SRB and fertility simultaneously: it currently has one of the lowest fertility rates in the world. The total fertility rate was 2.8 in 1980 but declined to 1.5 in 2000 and to 1.2 in 2015 [National Statistical Office (2017)]. This low fertility rate, combined with the abnormally high SRB for third- or later-born children, indicates that son preference is limited to parents with three or more children.

3. Data

Data from 2000 to 2015 were obtained from the birth registry maintained by the National Statistical Office. The data contain information on each baby's gender, birth year/month, region, birth weight, birth order, and birthplace (e.g., hospital, home, etc.). The data also contain parental information including age and educational attainment. The birth regions comprise the seven largest cities, including Seoul and nine provinces consisting of several small or mid-sized cities.

The analysis sample was approximately 760,000 third- or later-born children born between 2000 and 2015. Approximately 66,000 of them were born in 2000, the year with the highest number of births, and approximately 43,000 were born in 2015, which recorded the lowest number of births. Gyeonggi, a province surrounding Seoul, had the largest number of babies (approximately 180,000), followed by Seoul, which had approximately 110,000 births (median = 38,000). Table 1 presents the descriptive statistics. In column (1) for third- or later-born children, girls accounted for 45.2% of the total, and 5.5% had LBW. In addition, the proportion of mothers with college degrees was 41.6%. This number increased from 23.3% in 2000 to 62.7%

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Table 1. Descriptive statistics

	Third- or later-born children (1)	First-born children (2)	Second-born children (3)
Girl (%)	45.2	48.7	48.6
Birth weight (gram)	3,258 (497)	3,228 (452)	3,240 (455)
Low birth weight (%)	5.5	4.6	4.6
Non-hospital birth (%)	2.2	1.6	1.3
Maternal education – a college degree (%)	41.6	63.7	57.3
Maternal age	33.2 (4.0)	29.0 (4.0)	30.8 (3.7)
Maximum number of observations	758,524	3,859,627	2,989,453

Standard deviations are in parentheses. Low birth weight means weighing less than 2,500 g at birth.

in 2015, reflecting the gradual socioeconomic improvements in women's lives. Columns (2) and (3) of the table indicate that girls account relatively more for other birth orders, that is, 48.7% and 48.6% for first- and second-born children, respectively.

4. Empirical strategy

We estimated the following regression equation using ordinary least squares and examined whether son preference affects birth outcomes for girls. The subscripts i, r, and t represent newborn baby, region, and year, respectively.

$$O_{irt} = \beta_0 + \beta_1 girl_i + \beta_2 SRB_{rt} + \beta_3 girl_i \times SRB_{rt} + \boldsymbol{X}_i \mathbf{B}_4 + \boldsymbol{I}_{rt} \mathbf{B}_5 + \gamma_r + \delta_t + \varepsilon_{irt} \quad (1)$$

The dependent variable includes birth weight and a dummy variable indicating LBW. The independent variables include the variable *girl*, a dummy variable indicating whether a baby is a girl, and *SRB* representing SRB at the region/year level. $Girl \times SRB$ is the interaction of the two variables, and the coefficient for this variable shows how birth outcomes for girls change relative to birth outcomes for boys as SRB changes. The coefficient sign is expected to be negative when the dependent variable is birth weight and son preference leads to less prenatal care for girls. If the dependent variable is a dummy variable that indicates LBW, it is expected to be positive. Vector $\boldsymbol{X}$ includes the mother's age, its square, and a dummy variable indicating whether the mother is a college graduate. The vector also includes the interactions of these variables with the variable *girl*. Vector $\boldsymbol{I}$ includes regional income, namely, individual income per capita[11] and its interaction with the variable *girl*. In the equation, γ, δ, and ε are the region, year fixed effect, and error term, respectively. Finally, standard errors are clustered at the region/year level. We also

[11]The regional income data are taken from the following National Statistical Office website. https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1C86&conn_path=I2 (published in Korean).

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Table 2. Effect of son preference on girls' birth outcomes

	Dependent variable =	
	Birth weight	Low birth weight
	(1)	(2)
SRB	0.0232 (0.1038)	−0.0079* (0.0034)
Girl × SRB	−0.2311* (0.0969)	0.0156* (0.0046)
Dep. Var. Mean	3,258	0.055
Adjusted R^2	0.020	0.003
Number of observations	758,299	758,299

Standard errors are in parentheses. They are clustered at the region/year level. These regressions also include a constant, two dummy variables indicating a girl and whether a mother has a college degree, maternal age, age squared, regional income, their interactions with a girl, region fixed effect, and year fixed effect. The coefficients and their standard errors in column (2) are multiplied by 100.
*: $p < 0.05$.

calculated standard errors clustering at the region level using the method suggested by Cameron *et al.* (2008), but the results did not change.

Among the factors for birth weight described in Section 1, we did not control for prenatal care and maternal stress. Prenatal care should not be controlled because SRB is likely to affect prenatal care and controlling for it could lead to an over-control problem. Not controlling for maternal stress is problematic when it affects SRB and birth outcomes differently based on gender. As a robustness check, we controlled for the interaction of region and year fixed effects to check whether stress-inducing events possibly occurring in a particular region/year confounds the estimate.[12]

5. Results

5.1 The effect of son preference on girls' birth outcomes

Table 2 presents the estimation results for equation (1). The coefficients and their standard errors in column (2) were multiplied by 100. Therefore, if a coefficient is 0.02, it can be interpreted as 0.02 percentage points rather than two percentage points. Focusing on LBW in column (2), the coefficient of the interaction between SRB and the dummy variable *girl* is 0.0156, meaning that if the ratio increases by one, the probability of LBW among girls increases by 0.0156 percentage points relative to the probability for boys.[13] As the SRB for third- or later-born children

[12]We did not include the interaction of region and girl in the equation, which controls for regional factors that differentially affect both genders. Such factors are likely to include son preference, and hence the control may cause an over-control problem. The interaction of year and girl has not been included for the same reason.

[13]Excluding maternal age, its square, education level, regional income, and their interactions with the dummy variable *girl* in the regression leaves the result unchanged. The coefficient is 0.0134.

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Table 3. Results for other children (placebo tests)

	First-born children		Second-born children	
	Dependent variable =			
	Birth weight	Low birth weight	Birth weight	Low birth weight
	(1)	(2)	(3)	(4)
SRB	−0.0000	−0.0027	−0.0001	0.0023
	(0.0003)	(0.0085)	(0.0003)	(0.0085)
Girl × SRB	−0.0003	0.0127	−0.0000	−0.0051
	(0.0003)	(0.0110)	(0.0003)	(0.0118)
Dep. Var. Mean	3,228	0.046	3,240	0.046
Adjusted R^2	0.016	0.004	0.017	0.003
Number of observations	3,858,644	3,858,644	2,988,860	2,988,860

Standard errors are in parentheses. They are clustered at the region/year level. Other independent variables are the same as in Table 2. The coefficients and their standard errors in columns (2) and (4) are multiplied by 100.

decreased from 144.2 in 2000 to 105.6 in 2015, with a decrease of 38.6, the decline in SRB was related to a reduction in the probability of LBW among girls by 0.60 percentage points (= 0.0156%p × 38.6). Furthermore, because the ratio of newborns with LBW was 5.6% (Table 1), 0.60 percentage points was equivalent to 10.7% (= 0.0060/0.056). In other words, during 2000–2015, a decrease in SRB was related to a 10.7% reduction in the probability of LBW among girls. Finally, one can see in Table 2 that a one-unit increase in SRB is related to a decline in the probability of LBW among boys by 0.0079 percentage points and an increase in the probability among girls by 0.0077 (= − 0.0079 + 0.0156) percentage points, implying that the reduced probability of LBW among girls by 10.7% over the period is related to an increase in the probability among boys and a decrease in the probability among girls.

5.2 Results for other children (placebo tests)

We conducted the same analysis reported in Table 2 for first- and second-born children as placebo tests. Considering that son preference did not exist for these children, their birth outcomes should be unaffected. In Table 3, columns (1) and (2) are for first-born children, and columns (3) and (4) are for second-born children. As the table shows, no coefficients for *girl* × *SRB* were statistically significant, reflecting that the parents of first- and second-born children had no son preference.

5.3 Mechanism of the effect

The literature shows that son preference leads to less prenatal care for girls. To examine whether less prenatal care or less frequent hospital visits are related to the results in Table 2, we examined whether son preference is related to an increase in the

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Table 4. Mechanism analysis

	Third- or later-born children	First-born children	Second-born children
	Dependent variable = Non-hospital birth		
	(1)	(2)	(3)
SRB	−0.0059 (0.0030)	−0.0062* (0.0017)	−0.0031* (0.0014)
Girl × SRB	0.0075* (0.0028)	0.0017 (0.0012)	−0.0001 (0.0009)
Dep. Var. Mean	0.022	0.016	0.013
Adjusted R^2	0.021	0.011	0.003
Number of observations	758,080	3,857,736	2,988,222

Standard errors are in parentheses. They are clustered at the region/year level. Other independent variables are the same as in Table 2. The coefficients and their standard errors are multiplied by 100.
*: $p < 0.05$.

incidence of non-hospital births for girls. This is because non-hospital births are likely to reflect fewer hospital visits. For the analysis, we estimated regression equation (1) with a dummy dependent variable indicating whether a baby was born outside a hospital. The results are presented in column (1) of Table 4, and the coefficients and their standard errors are multiplied by 100. This column shows that if the ratio increases by one, the probability of a girl being born outside the hospital increases by 0.0075 percentage points relative to the probability for boys. As the SRB of third- or later-born children decreased by 38.6 during the period 2000 to 2015, the decline in the son preference was related to a reduction in the probability of a girl being born outside a hospital by 0.29 percentage points (= 0.0075%p × 38.6), which is equivalent to 13.2% (= 0.0029/0.022) because the proportion of non-hospital-born children during 2000–2015 is 2.2%, as shown in Table 1. This result implies that mothers with female fetuses are likely to make fewer prenatal hospital visits when the son preference is stronger, which could be an important reason why son preference leads to low birth weight for girls. Finally, we conducted the same analysis on first- and second-born children. As presented in columns (2) and (3) of Table 4, the coefficient of the interaction term is insignificant, indicating that girls of these birth orders did not go through prenatal discrimination.

5.4 Robustness checks

We conducted two robustness checks for the results presented in Table 2. First, we controlled for the interaction of region and year fixed effects to check whether an event occurring in a particular region/year confounds the estimate. It is noteworthy that when conducting this analysis, SRB and regional income were dropped because these variables were at the region/year level. As shown in panel A of Table 5, the inclusion of the interaction changes the result little. The coefficient for *girl* × *SRB* in

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Table 5. Robustness checks

	Dependent variable =		
	Birth weight	Low birth weight	Non-hospital birth
	(1)	(2)	(3)
Panel A: Adds control for the interaction of region and year fixed effects			
Girl × SRB	−0.2359* (0.0960)	0.0158* (0.0046)	0.0077* (0.0029)
Adjusted R^2	0.020	0.003	0.022
Number of observations	758,299	758,299	758,302
Panel B: Uses two-year moving average			
Girl × SRB	−0.2854* (0.0964)	0.0169* (0.0046)	0.0081* (0.0028)
Adjusted R^2	0.020	0.003	0.021
Number of observations	758,299	758,299	758,302
Panel C: Uses three-year moving average			
Girl × SRB	−0.2834* (0.0917)	0.0173* (0.0044)	0.0075* (0.0027)
Adjusted R^2	0.020	0.003	0.021
Number of observations	758,299	758,299	758,302

Standard errors are in parentheses. They are clustered at the region/year level. Other independent variables are the same as in Table 2, although the analysis in panel A does not control for SRB and regional income because these variables are at the region/year level. The coefficients and their standard errors in columns (2) and (3) are multiplied by 100.
*: $p < 0.05$.

column (2) is 0.0162, while the corresponding coefficient in Table 2 is 0.0156. Second, we used two- and three-year moving averages for SRB instead of the current year SRB, because babies born at the beginning of a year are conceived a year before and are not likely to be affected by the son preference of the year in which they were born. Panels B and C of Table 5 indicate that the results do not differ from those in Table 2. In summary, the results in Table 2 are robust to the different specifications. Finally, we conducted the same analysis reported in Table 2, excluding southeastern regions with a strong son preference (one region at a time), to examine whether a particular region drove the result in Table 2. We conducted the same analysis excluding Gyeonggi and Seoul, the two largest regions. In Table 6, focusing on LBW in column (2), all estimates are significant, ranging from 0.0110 to 0.0176, implying that the results in Table 2 are robust to the sample.

5.5 Heterogeneity analysis

This subsection examines the effects based on the period. As presented in Figure 1, the SRB of third- or later-born children decreased faster in the period 2000–2007 than in 2008–2015, which implies that the effect is likely to be more significant in the former

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Table 6. Effect of son preference on girls' birth outcomes and birthplace excluding one region at a time

	Dependent variable =		
	Birth weight	Low birth weight	Non-hospital birth
	(1)	(2)	(3)
Panel A: Excludes Busan			
Girl × SRB	−0.2566*	0.0169*	0.0090*
	(0.0982)	(0.0050)	(0.0029)
Adjusted R^2	0.020	0.003	0.021
Number of observations	722,030	722,030	722,032
Panel B: Excludes Daegu			
Girl × SRB	−0.1448	0.0110*	0.0085*
	(0.9629)	(0.0050)	(0.0033)
Adjusted R^2	0.020	0.003	0.021
Number of observations	727,562	727,562	727,552
Panel C: Excludes Gyeongbuk			
Girl × SRB	−0.2342*	0.0160*	0.0076*
	(0.1061)	(0.0049)	(0.0029)
Adjusted R^2	0.020	0.003	0.021
Number of observations	717,383	717,383	717,391
Panel D: Excludes Gyeongnam			
Girl × SRB	−0.2758*	0.0152*	0.0065*
	(0.1021)	(0.0047)	(0.0030)
Adjusted R^2	0.020	0.003	0.021
Number of observations	704,251	704,251	704,262
Panel E: Excludes Ulsan			
Girl × SRB	−0.2292*	0.0176*	0.0068*
	(0.1097)	(0.0049)	(0.0031)
Adjusted R^2	0.020	0.003	0.021
Number of observations	741,572	741,572	741,571
Panel F: Excludes Gyeonggi			
Girl × SRB	−0.2352*	0.0153*	0.0092*
	(0.0999)	(0.0047)	(0.0030)
Adjusted R^2	0.020	0.003	0.021
Number of observations	577,525	577,525	577,525
Panel G: Excludes Seoul			
Girl × SRB	−0.2528*	0.0174*	0.0075*
	(0.0987)	(0.0047)	(0.0029)

(*Continued*)

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Table 6. (*Continued.*)

	Dependent variable =		
	Birth weight	Low birth weight	Non-hospital birth
	(1)	(2)	(3)
Adjusted R^2	0.021	0.003	0.021
Number of observations	651,530	651,530	651,509

Standard errors are in parentheses. They are clustered at the region/year level. Other independent variables are the same as in Table 2. Panel A excludes Busan, and so on. The coefficients and their standard errors in columns (2) and (3) are multiplied by 100.
*: $p < 0.05$.

Table 7. Analysis based on the period

	2000–2007		2008–2015	
	Dependent variable =			
	Birth weight	Low birth weight	Birth weight	Low birth weight
	(1)	(2)	(3)	(4)
SRB	−0.0355 (0.1525)	−0.0142* (0.0054)	0.3945 (0.2179)	−0.0189* (0.0089)
Girl × SRB	−0.2447* (0.1144)	0.0174* (0.0055)	−0.0320 (0.2322)	0.0156 (0.0110)
Dep. Var. Mean	3,286	0.049	3,228	0.062
Adjusted R^2	0.019	0.003	0.016	0.002
Number of observations	390,028	390,028	368,271	368,271

Standard errors are in parentheses. They are clustered at the region/year level. Other independent variables are the same as in Table 2. The coefficients and their standard errors in columns (2) and (4) are multiplied by 100.
*: $p < 0.05$.

period than in the latter. Table 7 shows that the relationship is significant only between 2000 and 2007. The coefficient for the interaction term is −0.2447 in column (1) and 0.0174 in column (2).

6. Conclusions

Research has shown that there is discrimination against the female fetus when the son preference is strong. Girls of parents with strong son preference are less likely to receive prenatal care and more likely to be aborted. As prenatal care is an important factor in determining a baby's birth outcomes, those for girls are likely to be worse when the son preference is strong. However, only a few studies have examined this topic.

To analyze this topic, we measured the degree of son preference using SRB, which was possible because the rate declined in South Korea with the availability of

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abortion and ultrasound technology throughout the entire country. We found that girls were more likely to be born with LBW when son preference was stronger. In addition, we present evidence that girls are more likely to be born outside hospitals in these cases, which implies that girls are discriminated against prenatally. In summary, over the period 2000–2015, the decline in SRB for third- or later-born children by 38.6 reduced the probability of a girl being born outside hospitals by 13.2%, while the probability of LBW for them decreased by 10.7%.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/dem.2022.13.

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References

Ahsan, M. N. and R. Maharaj (2018) Parental human capital and child health at birth in India. *Economics & Human Biology* 30, 130–149.

Almond, D., L. Edlund, H. Li and J. Zhang (2010) Long-term effects of early-life development: evidence from the 1959 to 1961 China famine. In T. Ito and A. Rose (eds.), *The Economic Consequences of Demographic Change in East Asia, NBER-EASE Volume 19*, pp. 321–345. Chicago: University of Chicago Press.

Almond, D., L. Edlund and M. Palme (2009) Chernobyl's subclinical legacy: prenatal exposure to radioactive fallout and school outcomes in Sweden. *Quarterly Journal of Economics* 124(4), 1729–1772.

Anderson, R. and S. Bergström (1998) Is maternal malnutrition associated with a low sex ratio at birth? *Human Biology* 70(6), 1101–1106.

Barcellos, S. H., L. S. Carvalho and A. Lleras-Muney (2014) Child gender and parental investments in India: are boys and girls treated differently? *American Economic Journal: Applied Economics* 6(1), 157–189.

Bhalotra, S., R. Brulé and S. Roy (2020) Women's inheritance rights reform and the preference for sons in India. *Journal of Development Economics* 146, 102275.

Bhalotra, S. and T. Cochrane (2010). Where have all the young girls gone? Identification of sex selection in India. IZA Discussion Paper No. 5381.

Bharadwaj, P., J. P. Eberhard and C. A. Neilson (2018) Health at birth, parental investments, and academic outcomes. *Journal of Labor Economics* 36(2), 349–394.

Bharadwaj, P. and L. K. Lakdawala (2013) Discrimination begins in the womb: evidence of sex-selective prenatal investments. *Journal of Human Resources* 48(1), 71–113.

Bozzoli, C. and C. Quintana-Domeque (2014) The weight of the crisis: evidence from newborns in Argentina. *Review of Economics and Statistics* 96(3), 550–562.

Cameron, A. C., J. B. Gelbach and D. L. Miller (2008) Bootstrap-based improvements for inference with clustered errors. *Review of Economics and Statistics* 90(3), 414–427.

Chen, Y., H. Li and L. Meng (2013) Prenatal sex selection and missing girls in China: evidence from the diffusion of diagnostic ultrasound. *Journal of Human Resources* 48(1), 36–70.

Choe, S.-H. (2007). South Koreans rethink preference for sons. New York Times, 28 November. Retrieved from https://www.nytimes.com/2007/11/28/world/asia/28iht-sex.1.8509372.html?_r=1&.

Choi, E. J. and J. Hwang (2020) Transition of son preference: evidence from South Korea. *Demography* 57, 627–652.

Chung, W. and M. D. Gupta (2007) The decline of son preference in South Korea: the roles of development and public policy. *Population and Development Review* 33(4), 757–783.

Clarke, D., S. Oreffice and C. Quintana-Domeque (2021) On the value of birth weight. *Oxford Bulletin of Economics and Statistics* 83(5), 0305–9049.

Conley, D. and N. G. Bennett (2001) Birth weight and income: interactions across generations. *Journal of Health and Social Behavior* 42(4), 450–465.

Conti, G., M. Hanson, H. Inskip, S. Crozier, C. Cooper and K. M. Godfrey (2020). Beyond birthweight: The origins of human capital. IZA Discussion Paper No. 13296.
Currie, J. and M. Rossin-Slater (2013) Weathering the storm: hurricanes and birth outcomes. *Journal of Health Economics* 32(3), 487–503.
Dagnelie, O., G. D. De Luca and J. F. Maystadt (2018) Violence, selection and infant mortality in Congo. *Journal of Health Economics* 59, 153–177.
Den Boer, A. and V. Hudson (2017) Patrilineality, son preference, and sex selection in South Korea and Vietnam. *Population and Development Review* 43(1), 119–147.
de Oliveira, V. H., I. Lee and C. Quintana-Domeque (forthcoming). Natural disasters and early human development: Hurricane Catarina and infant health in Brazil. *Journal of Human Resources*, 0816-8144R1.
Ebenstein, A. (2010) The "missing girls" of China and the unintended consequences of the one child policy. *Journal of Human Resources* 45(1), 87–115.
Edlund, L. and Lee, C. (2013). Son preference, sex selection and economic development: The case of South Korea (No. w18679). National Bureau of Economic Research.
Figlio, D., J. Guryan, K. Karbownik and J. Roth (2014) The effects of poor neonatal health on children's cognitive development. *American Economic Review* 104(12), 3921–3955.
Fukuda, M., K. Fukuda, T. Shimizu and H. Møller (1998) Decline in sex ratio at birth after Kobe earthquake. *Human Reproduction* 13(8), 2321–2322.
Gajate-Garrido, G. (2013) The impact of adequate prenatal care on urban birth outcomes: an analysis in a developing country context. *Economic Development and Cultural Change* 62(1), 95–130.
Gendercide (2010). The Economist. Retrieved from http://www.economist.com/node/15606229.
Goisis, A., H. Remes, P. Martikainen, R. Klemetti and M. Myrskylä (2019) Medically assisted reproduction and birth outcomes: a within-family analysis using Finnish population registers. *The Lancet* 393(10177), 1225–1232.
González, L. (2018) Sex selection and health at birth among Indian immigrants. *Economics & Human Biology* 29, 64–75.
Guilmoto, C. Z. (2015) Mapping the diversity of gender preferences and sex imbalances in Indonesia in 2010. *Population Studies* 69(3), 299–315.
Hafeez, N. and C. Quintana-Domeque (2018) Son preference and gender-biased breastfeeding in Pakistan. *Economic Development and Cultural Change* 66(2), 179–215.
Hong, M., S. Lee, Y. Chang, Y. Oh and H. Kye (1994) The 1994 National fertility and family health survey. Korea Institute for Health and Social Affairs Working paper.
How South Korea learned to love baby girls (2017). The Economist. Retrieved from https://www.economist.com/news/international/21714982-aborting-girls-simply-because-they-are-girls-has-become-unthinkable-how-south-korea-learned.
Hu, L. and A. Schlosser (2015) Prenatal sex selection and girls' well-being: evidence from India. *Economic Journal* 125(587), 1227–1261.
Jayachandran, S. (2017) Fertility decline and missing women. *American Economic Journal: Applied Economics* 9(1), 118–139.
Jayachandran, S. and I. Kuziemko (2011) Why do mothers breastfeed girls less than boys? Evidence and implications for child health in India. *Quarterly Journal of Economics* 126(3), 1485–1538.
Jensen, R. (2012) Do labor market opportunities affect young women's work and family decisions? Experimental evidence from India. *Quarterly Journal of Economics* 127(2), 753–792.
Kaul, T. (2018) Intra-household allocation of educational expenses: gender discrimination and investing in the future. *World Development* 104, 336–343.
Korean Women's Association United. (2011). NGO shadow report: Republic of Korea, http://www2.ohchr.org/english/bodies/cedaw/docs/ngos/KWAU_RepublicKorea49.pdf.
Kumar, A. (2013) Preference based vs. market based discrimination: implications for gender differentials in child labor and schooling. *Journal of Development Economics* 105, 64–68.
Larsen, U., W. Chung and M. D. Gupta (1998) Fertility and son preference in Korea. *Population Studies* 52(3), 317–325.
Lhila, A. and K. I. Simon (2008) Prenatal health investment decisions: does the child's sex matter? *Demography* 45(4), 885–905.

https://doi.org/10.1017/dem.2022.13 Published online by Cambridge University Press

McGovern, M. E. (2019) How much does birth weight matter for child health in developing countries? Estimates from siblings and twins. *Health Economics* 28(1), 3–22.
National Statistical Office. (2017). 2016 Vital statistics (written in Korean) https://kostat.go.kr/portal/korea/kor_nw/1/1/index.board?bmode=read&aSeq=359243.
National Statistical Office. (2020). Sex ratio at birth. http://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B81A19&conn_path=I2&language=en.
Oh, Y., K. Kim, C. Shin and H. Bae (2016) A study of fertility changes in Korea: Based on national fertility and family health survey (1974–2012). Korea Institute for Health and Social Affairs. Working paper 2016–21.
Oster, E. (2009) Proximate causes of population gender imbalance in India. *Demography* 46(2), 325–339.
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(3), 1251–1285.
Restrepo-Méndez, M. C., D. A. Lawlor, B. L. Horta, A. Matijasevich, I. S. Santos, A. Menezes, F. C. Barros and C. Victora (2014) The association of maternal age with birthweight and gestational age: a cross-cohort comparison. *Paediatric and Perinatal Epidemiology* 29, 31–40.
Sanders, N. J. and C. Stoecker (2015) Where have all the young men gone? Using sex ratios to measure fetal death rates. *Journal of Health Economics* 41, 30–45.
Sohn, M., M. Kang, S. Chang, H. Kim, K. Park, J. Nam, D. Kang, *et al.* (2011) National survey on trends of induced abortion. Ministry of Health and Welfare. No.11-1352000-000522-01.
Sonchak, L. (2015) Medicaid reimbursement, prenatal care and infant health. *Journal of Health Economics* 44, 10–24.
Trivers, R. L. and D. E. Willard (1973) Natural selection of parental ability to vary the sex ratio of offspring. *Science* 179(4068), 90–92.
Valente, C. (2015) Civil conflict, gender-specific fetal loss, and selection: a new test of the Trivers–Willard hypothesis. *Journal of Health Economics* 39, 31–50.
Wu, H. (2021) Maternal stress and sex ratio at birth in Sweden over two and a half centuries: a retest of the Trivers–Willard hypothesis. *Human Reproduction* 36(10), 2782–2792.

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