# The Effect of Sex Selection on Female Education Outcomes in Taiwan*

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The practice of sex selection, in the form of aborting female fetuses, theoretically should increase investments and the level of care provided for girls who are not initially aborted. This research presents evidence that the legalization of abortion in Taiwan improved educational outcomes for girls born at the most sex selective birth orders. Consistent with the substitution hypothesis that prenatal discrimination against girls and postnatal discrimination against girls are substitutes, I find that girls born at the most sex selective birth orders after the legalization of abortion experience an improvement in their college attainment by approximately 3.5 percentage points. Moreover, a similar improvement in college attainment for higher birth order boys is not found. These findings are highly robust to several different specifications and tests. (*JEL* J13, A22)

## 1 Introduction

While the natural sex ratio at birth (henceforth SRB) is 105-106 boys per 100 girls, sex selective countries have a SRB that is much higher. For example, a SRB as high as 110 has been observed in Taiwan (Chu and Yu (2010)). Sex selection occurs prenatally when there are gender based abortions or postnatally when poor care for infants of the undesired

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gender results in unusually high death rates for those children. Sex selection is known to be the cause of unusually high male to female sex ratios in many Asian countries. Families of these societies prefer male children over female children for two reasons: One, they have a desire to preserve the family name; And two, parents are culturally more likely to be financially supported by their sons than by their daughters (Lin et al. (2003)). Nations with particularly high sex ratios have expressed concerns and, although often not strictly enforced, some have placed legal bans on the practice of sex selection. India, for example, banned sex detection tests in 1994 and similar policies are in place in China and South Korea (Vogel (2012)). While there are obvious inefficiencies from high sex ratios (for example marriage markets do not clear), there are potential benefits from sex selection that are not as obvious. Studies have found that health outcomes improved for girls born after families are able to make endogenous gender based abortion decisions (Lin et al. (2003) and Dasgupta (2010)). Before a complete ban is placed on sex detection in all sex selective nations, it is important to understand the extent of positive outcomes in terms of better care for the girls born after sex selection.

I investigate whether the ability to sex select in a society with a male preference improves investments in female children. The substitution hypothesis, first outlined in 1996 by Daniel Goodkind, posits that increasing prenatal discrimination results in decreased postnatal discrimination, or that postnatal and prenatal discrimination are substitutes. The substitution hypothesis suggests that sex selective abortion shifts the composition of families who have girls towards those who value them more, and hence towards those who also take better care of them. I focus on college attendance in Taiwan as a form of investment. Since college tuition is a cost often borne by parents, college attendance signals high investments in a child.[1] Moreover, raising a child who is ready for college signals early life investments in a child, perhaps in the form of private schooling or in the form of additional time spent with a child. This study contributes to the literature by looking at later life economic outcomes instead of early life health outcomes, which has been the focus of the existing literature.

I follow Lin et al. (2008) and exploit the legalization of abortion in Taiwan as a policy that exogenously increased sex selection at the highest birth orders in Taiwan. I explore whether the probability of ever attending college increases for female children born at higher birth orders as sex selection is allowed. Similar to Lin et al. (2008), I exploit both the

[1] Costs of university tuition for 2003-2004 were $NT 58,714 for public universities and $NT 107,360 for private universities. Source: http://english.moe.gov.tw

variation in sex selection across birth order as well as the variation over time (before and after the legalization of abortion). I estimate a difference-in-difference model to determine whether girls born at higher birth orders after abortion are differentially more likely to go to college than girls born at the first birth order. I find that abortion legalization in Taiwan increased the probability of attending college for a second and higher birth order girl by about 3.5 percentage points, while no such increase is observed for a second or higher birth order boy.

Although, beyond the scope of this study, the causal effect of female education on sex selection is also worth investigating carefully by future studies. It could be the case that college attainment causes females to better realize their own economic worth and be less discriminatory towards the female sex.[2] If such a causal link is found, then it is possible that sex selection would decline without implementing additional policies that ban the practice. Nonetheless, the findings of this study present new and well identified evidence supporting the substitution hypothesis. The remainder of the paper is organized as follows: Section 2 discusses the substitution hypothesis within the context of sex selection in detail and explains how gender specific investments are expected to change once sex selection is introduced, section 3 presents the literature, section 4 presents the methodologies, section 5 presents the results, section 6 provides robustness checks and finally section 7 concludes.

## 2 The Substitution Hypothesis

In any society, there are three types of potential parents: Those who prefer a male child, those who prefer a female child and finally those who are indifferent between a male or a female child. In a society with male preference, there are by definition more families that prefer male children to female children. Then also by definition without sex selection, a girl is on average born in a family that has low preference for her. After abortion is made legal given sex detection technology is already present, families that have a low preference for girls are able to stop a female birth by choosing to abort the female fetus. Since many families who have low preferences for a girl will no longer have a girl, an average girl will be born into a family who has a stronger desire for her in comparison to an average girl born before abortion was made legal. Although fewer in number, girls theoretically are on

[2] A commonly cited fact is that more educated and rich families are the most sex selective; This assertion, however, is purely a correlation. Since abortions and ultrasounds are costly, the rich and the educated are best able to afford to sex select.

average born into families with higher preference for them after abortion is made legal.

Analogously, because the society under consideration prefers a male child, an average boy born into a family, even before sex selection is allowed, is born into a family that has a high preference for him. After abortion is made legal, the families who prefer a female child (few in number) are able to abort a male fetus. Theoretically, abortion yields a similar composition shift of families who have a child of either gender; both boys and girls are born into families that, in comparison to families they are born into prior to the legalization abortion, prefer them more. However, since there are many more families who prefer a boy to a girl and many more families abort a female fetus than those who abort a male fetus, the compositional shift in favor of girls is much greater.

As can be imagined in this simple example of how the composition of families having a child of either gender could change after sex selection is introduced in a society with a male preference, potential gains from sex selection are larger for girls born after sex selection than for boys born after sex selection. An additional reasonable postulation is that a family with higher preference for a particular child also take better care of that child. Then after abortion is made legal, it is predicted that investments in girls will increase, while investments in boys may or may not increase. However because the predicted shift in family composition is greater in favor of girls than the shift in favor of boys, the gains in investments for girls are expected to be greater than those for boys. Although some evidence exists that girls born after sex selection are given better health care in their early life (see Dasgupta (2010) and Lin et al. (2008)), this is the first research investigating whether increased sex selection translates into better later life outcomes for female children. Finding positive effects of abortion legalization on education outcomes would suggest that families continue to provide better care throughout a daughter's life when a she is born after an endogenous gender choice decision. The following section introduces the existing literature.

## 3 The Literature

An extensive literature shows that cultural preferences for boys increases sex selection (in the form of sex selective abortion or female infant mortality) and yields high sex ratios for societies with these preferences (Anderson and Ray (2010); Das Gupta (1987); Goodkind (1996); Lin et al. (2008); Qian (2008)). Another related and large literature is one

that examines how fertility decisions affect economic outcomes. Becker (1970) argues that children can be thought of as durable goods, and that, similar to durable goods, income elasticity of children with respect to quality of children is far greater than the income elasticity for quantity of children. Becker and Lewis (1973) take this notion a step further and formalize a quantity-quality tradeoff. They theorize the idea that when families have fewer children, they invest more in them. The quantity-quality framework, that ignores gender preferences, would predict that having fewer children, perhaps because fewer children are needed to get to the ideal number of sons, would increase overall quality for all children, boys and girls alike.

For the most part, the literature has ignored the effect of sex selection on gender specific investments. Exceptions are Lin et al. (2008) and Dasgupta (2010). Dasgupta (2010) finds evidence that the gender gap for the duration of breastfeeding closes as ultrasound technology, or sex selection, is introduced in India over time. While she also investigates the effects of sex selection on vaccine provision and postnatal mortality, Dasgupta finds no evidence supporting the closure of the gender gap for these two variables. Dasgupta (2010) is an important contribution to the literature on the subject, but it does not investigate the effect of sex selection on later life economic outcomes of females such as schooling.

Another study that finds evidence of the substitution hypothesis, and one that I follow closely is Lin et al. (2008). Lin, Qian and Liu find that abortion increased SRB in Taiwan and that the increase in SRB for births at the third or higher birth order was the largest.[3] Perhaps a more interesting result is that the authors find evidence of decreased female infant mortality after abortion is made legal. An important contribution of Lin et al. (2008) is the data itself, since it covers the universe of birth and death registries, and that it does not suffer from recall bias.

Dasgupta (2010) and Lin et al. (2008) have already suggested that sex selection improves outcomes for female children who are not initially aborted. I add to their findings by investigating family investment decisions in education for female children after abortion is legalized in Taiwan. If found that investments in girls increase after the legalization of abortion, an important and less negative side of sex selection will be revealed. The next section describes the methodologies used to uncover the effect of sex selection on gender

[3]Chu (2001) and Ebenstein (2007) also report that sex selection is greatest for larger birth orders. Das Gupta (1987) provides evidence that higher order girls are more discriminated against in rural Punjab, India. Moreover, Das Gupta finds that differential treatment against higher order girls worsens as fertility declines.

specific investments.

# 4 Methodologies

## 4.1 The Natural Experiment

Taiwan made abortion legal on January 1st of 1985 under the *Eugenic Health Law* in response to a feminist movement which demanded the legalization of safe abortions (Lin et al. (2008)). The law legalized abortion for fetal, maternal, or social reasons for the first 6 months of gestation (Chiang (2005)). At the time, contraception use was high, and fertility rates were at a decline. In 1965, an extensive and highly effective family planning program under the Taiwan Provincial Institute of Family Planning was introduced, and by 1985, 95% of all married women in Taiwan had used some form of contraception (Chu and Yu (2010)). Also, ultrasound technology was spreading worldwide in the early 1980s and has been present in Taiwan since its introduction (Lin et al. (2008)). The cost of abortion during the 1980s was on average 1% of an average household's income (Lin et al. (2008)). Since abortion was only legal up to 6 months of gestation, only those born after the first 4 months of 1985 could be sex selectively aborted, and 1986 was the first full year in which children born in all 12 months of the year could have been sex selected. The methodologies used in this analysis define the years 1985 and after as the "post" treatment (legalization of abortion) period, but robustness checks show that the results are robust to using the years 1986 and after as the "post" period as well.

Since abortion, combined with ultrasound technology, allows termination of pregnancy based on gender preferences, the legalization of abortion in Taiwan presents an exogenous shift in families' sex selection ability. I exploit the variation created by the legalization of abortion to explain the causal effect of sex selection on investment decisions in education for female children. The next section discusses the data.

## 4.2 The Data

The data come from Taiwan family income/expenditure survey and consist of randomly selected registered households in Taiwan. The analysis uses survey years 1996-2010 and focuses on children who are college age and are born between 1978-1992. Approximately 13,000-15,000 households are surveyed each year. Although some households are repeated in different survey years, the survey does not provide a unique identifier for households;

hence the analysis treats the data as a cross-section over time. A household is defined to consist of individuals who share a home. Additionally, members who do not live in the home, but contribute at least 50% of their income to the household and those with at least 50% of their expenditures paid for by the family are included. Hence, for example college students who are financially supported by their families but no longer live at home are included, and children who are independents and do not live with the family are not included. The data include detailed income and expenditure information for each household. Furthermore for each member of the household, I observe age, sex, the relationship to the head of the household, and the highest level of education completed. Using the year of survey and age of individual, I deduce year of birth for each individual. Also using age of individual and relationship to the head, I deduce the birth order of child. Due to the fact that some of the children are not observed in the sample, birth order is sometimes misspecified.

It is important to discuss the limitations of these data, since the nature of birth order misspecification affects the research design. Children who have left home and do not either rely on financial support from the family or contribute to the family financially are not included in the data, and as a result birth order of child may be misspecified. Since most children who are not included in the survey are likely older because they may be independents themselves, the assigned birth order will likely be a downward estimate of actual birth order (a child assigned second order in the analysis may actually be third order and so forth). Moreover since the survey only consists of live children, any children who have died are not accounted for. If children's deaths are not due to systematic postnatal sex selection, then both girls and boys will be assigned a smaller than their actual birth order. If however, deaths are systematic and occur because of sex selection in the form of female infant mortality, then boys will be more likely than girls to be incorrectly assigned a smaller than actual birth order. However, it has been found that infanticide is not a major source of high SRB in Taiwan (Ebenstein (2007)). I find that the birth order misspecification in the sample is substantial and that within 18-24 year old children, the ratio of children assigned birth order 3 or greater using the sample is 17-27 percentage points smaller than what it should be. The appendix provides synthetic panel analysis for children with birth years 1983-1987, which compares the same birth year cohort overtime to empirically show this misspecification of birth order. Since the data are imperfect in assigning birth order and the assigned birth order is often smaller than the actual birth order, I do not investigate the

effect for third or greater birth orders (like Lin et al. (2008)), but instead exploit a more aggregate variation and investigate the effect for second or greater birth order children.

The main analysis is limited to birth cohorts born within a 14 year window around the legalization of abortion in 1985. The sample is also limited to children between the ages of 18-24; this restriction is based on the fact that most of the children in the data (72% of them) who have ever attended college are between the ages of 18 to 24. Table 1 provides summary statistics at the household level for children in the sample. The table is split for children born "pre" (1978-1984) and "post" (1985-1992) abortion periods. I also report average fertility in Taiwan. These data come from the National Statistics of Republic of China's website.[4] The "pre" period reports the average fertility in Taiwan from the years 1981-1984 and the "post" period's fertility is the nation's average for the years 1985-1992.[5] Of the children in the sample, those who are born after abortion come from households with younger and fewer children, fewer number of household members, slightly older mothers, higher household income per capita, a larger proportion of household heads who also went to college and fewer of them have a male head of household. Fertility is also much lower for the years 1985-1992. Since 2010 is the last survey year in the analysis, all of the children in the sample who are born in 1992 are only 18 years old and only observed only in the 2010 survey. Following similar logic for other birth years and survey year restrictions, children born after abortion in the sample are mechanically a little younger than those born before the legalization of abortion. To account for fertility differences, the main analysis adds additional controls for number of children. I also add controls for the mother's age to help control for how "young" the family is.

Since overall fertility is declining, families who have a higher order child may be very different from families who have a higher order child prior to the legalization of abortion. For example, if at a time of lower fertility having more children is a luxury good, then higher investments in a higher birth order child could be independent of increased sex selection. In that case, however, the effect of abortion on higher order children would be independent of the gender of child.

Table 2 provides birth order and gender specific ratio of children in the sample who have ever attended college and previews the difference-in-difference results. It can be seen that if born prior to the legalization of abortion, girls and boys had similar college attendance rates in Taiwan. However, girls and boys born after the legalization of abortion

[4] http://eng.stat.gov.tw

[5] 1981 is the first year the National Statistics of Republic of China's website provides the fertility rate.

**Table 1:** Summary statistics at the household level for children in the sample

| Birth Years | | 1978-1984 | | | 1985-1992 | | |
|---|---|---|---|---|---|---|---|
| Variable | Obs | Mean | Std. Dev. | Obs | Mean | Std. Dev. | Diff |
| Mean age of children | 29,251 | 13.73 | 2.39 | 18,298 | 13.17 | 2.31 | -0.55*** |
| | | | | | | | (0.02) |
| No. of children | 29,251 | 2.46 | 0.91 | 18,298 | 2.30 | 0.82 | -0.16*** |
| | | | | | | | (0.01) |
| No. of people | 29,251 | 4.61 | 1.25 | 18,298 | 4.42 | 1.14 | -0.20*** |
| | | | | | | | (0.01) |
| Mother's age | 28,222 | 46.21 | 4.35 | 17,540 | 46.82 | 4.43 | 0.62*** |
| | | | | | | | (0.04) |
| Income per capita $NT | 29,251 | 306,095 | 183,757 | 18,298 | 318,256 | 184,823 | 12,161*** |
| | | | | | | | (1,736) |
| Head went to college | 29,251 | 0.09 | 0.29 | 18,298 | 0.13 | 0.33 | 0.03*** |
| | | | | | | | (0.00) |
| Head is male | 29,251 | 0.83 | 0.37 | 18,298 | 0.80 | 0.40 | -0.03*** |
| | | | | | | | (0.00) |
| Average Fertility Rate | | 2.25 | | | 1.76 | | |

Standard errors in parentheses. Sample restricted to children between the ages 18-24 born between 1978-1992. Average fertility statistics are from National Statistics: Republic of China (Taiwan)'s website. Since 1981 is the first year with reported fertility, only years 1981-1984 are used to estimate the pre abortion average fertility. Post abortion fertility is the average fertility in Taiwan from 1985-1992.

*** $p<0.01$

** $p<0.05$

* $p<0.1$

have different trends. Girls born after abortion are more educated than boys born after abortion. Moreover, the increase in college enrollment rates over time for higher birth order girls born after the legalization of abortion is larger than the increase in college enrollment rates over time for girls at the first birth order born after the legalization of abortion. The difference-in-difference estimate suggests that second and higher birth order girls born after abortion have an increase in educational attainment of 4.4 percentage points beyond that of the female trend at the time. The increase in educational attainment for the first birth order girls born after abortion helps capture the general trend in education for all girls; since sex selection in Taiwan does not occur at the first birth order. Analogously for boys, the difference-in-difference estimate suggests that higher birth order boys born after the legalization of abortion have an increase of 1.6 percentage points in the likelihood of attending college beyond the male trend. However the estimate for boys is statistically insignificant.

**Table 2:** Gender specific ratio of college attendance by birth order and birth years

| | Girls | | | Boys | | |
|---|---|---|---|---|---|---|
| Birth Order | 2 + | 1 | Difference | 2+ | 1 | Difference |
| Birth Years 1985-1992 | 0.666 | 0.688 | -0.022** | 0.624 | 0.664 | -0.040*** |
| | (0.0075) | (0.0066) | (0.0100) | (0.0076) | (0.0065) | (0.0100) |
| Birth Years 1978-1984 | 0.394 | 0.460 | -0.066*** | 0.394 | 0.450 | -0.056*** |
| | (0.0061) | (0.0055) | (0.0083) | (0.0061) | (0.0055) | (0.0082) |
| Difference | 0.272*** | 0.228*** | 0.044*** | 0.230*** | 0.213*** | 0.016 |
| | (0.0098) | (0.0087) | (0.0131) | (0.0097) | (0.0086) | (0.0130) |

Standard errors in parentheses. Sample restricted to girls and boys of ages 18-24 born between 1978-1992.

*** p<0.01

** p<0.05

* p<0.1

### 4.3 Estimating Equation

Equation 1 is the main difference-in-difference model and I estimate it for boys and girls separately. Trends in schooling for men and women are different and female college enrollments have increased at a much higher rate in Taiwan; hence estimating the regressions separately for boys and girls is appropriate. National gender specific enrollment data of

Taiwan show that college enrollment for 18-21 years old for males and females in 1985-1986 were 14.2% and 13.5% respectively and had increased to 64% and 71% for males and females respectively by school years 2010-2011.[6]

A similar difference-in-difference specification as equation 1 is used in Lin et al. (2008). Like their specification, equation 1 exploits the fact that sex selection increased most dramatically at higher birth orders. $Y_{ijty}$ is a dummy variable for whether child $i$, of birth order $j$, born pre or post abortion period $t$, has ever attended college in survey year $y$. $Ord_{2plus}$ is a dummy for whether a child is of birth order 2 or greater and $Post$ is a dummy variable that equals 1 if the child is born in 1985 or after and is 0 otherwise. Also in the equation are fixed effects for the survey year of observation, the birth year of child, controls for per capita household income and the age of the mother. Survey year fixed effects help capture overall trends in schooling that are increasing over time. Birth year fixed effects capture birth year cohort effects, and in combination with survey year fixed effects control for age of child. Since birth year fixed effects are perfectly collinear with "post", the main effect of "post" drops out of the model when birth year fixed effects are added.

$$\begin{aligned} Y_{ijty} = \beta_2(Ord_{2plus} \times Post) + Ord_{2plus} + Income_i + Mother's\_Age_i + Survey\_Year_y \\ + Birth\_Year_t + (NChildren_i \times SurveyYear_y) + \epsilon_{ijty} \end{aligned} \quad (1)$$

Fertility in Taiwan has been declining sharply over time and the observed children at first birth order are increasingly those who are also only children. When families have only one child, they are able to invest heavily into that one child, hence it will be important to control for the number of children in the family. To deal with this, the full specification adds survey year specific number of children fixed effects. I use survey year specific number of children fixed effects instead of just fixed effects for number of children because of declining fertility in Taiwan. It is likely that a family that has 3 children before the legalization of abortion in the time of higher fertility is different from a family that has 3 children after the legalization of abortion in a time of much lower fertility; and survey year specific number of children fixed effects help control for this.

In the regression, birth order 1 represents the counterfactual and $\beta_{2plus}$ is the parameter of interest and its estimate is given by equation 2. $\hat{\beta_{2plus}}$ is estimated by differencing out the mean effect of abortion policy for girls (boys) born at first order births from the mean

[6] http://english.moe.gov.tw

effect of abortion policy on girls (boys) at second or greater order births. A positive value of $\hat{\beta_{2plus}}$ indicates an improvement in the rate of college attendance for the second or higher birth order child beyond the improvement seen for the first birth order child. Since sex selection is shown to not increase for the first birth order, differencing out the effect of abortion for the first birth order child from the effect of abortion for the higher birth order child removes any general trends in education that are common between the first and higher order births.

$$\hat{\beta_{2plus}} = (\bar{Y_{Ord2+,post}} - \bar{Y_{Ord2+,pre}}) - (\bar{Y_{Ord1,post}} - \bar{Y_{Ord1,pre}}) \tag{2}$$

Causal interpretation of the effect relies on the assumption that without increased sex selection from the legalization of abortion, trends in education would remain identical for the first and higher order births.

# 5 Results

The dependent variable in all specifications is a dummy variable for whether a girl (boy) has ever attended college. The college dummy is equal to 1 if the highest level of education attainment is university or graduate school. Table 3 presents the results from estimating equation 1 for girls. Column 1 is a basic difference-in-difference regression (as seen in table 2) and does not account for important time trends, birth year effects, household income and number of children effects. Results in column 1 imply that a second and higher birth order girl born after the legalization of abortion is more likely to attend college by about 4.35 percentage points. Column 2 adds survey year fixed effects and the estimate for the second order girl is robust to the accounting of linear time trends. Since education outcomes are generally trending upwards in Taiwan, it is important to take time trends into account, and as we find here, omitting time trends biases the estimate upward in column 1. Column 3 adds birth year fixed effects and the coefficient for girls born at the second or greater birth order after abortion is robust to accounting for birth year fixed effects. Since richer families can afford tuition for college more readily and because families in the more recent survey years are younger, column 4 adds important controls for income and mother's age, and the effect is robust to accounting for these important variables. Number of children limit a family's ability to afford college for a particular child, and column 5 adds survey year specific number of children fixed effects. The estimate for the effect of abortion legalization

on the likelihood of ever attending college for a second or greater order girl remains a 3.54 percentage point increase for the most preferred specification in column 5.

**Table 3:** Effect of abortion on the likelihood of female college attendance

| Dependent variable: Ever attend college? [0,1] | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $Ord_{2plus} \times Post$ | 0.0435*** | 0.0351*** | 0.0392*** | 0.0421*** | 0.0354*** |
| | (0.0130) | (0.0126) | (0.0124) | (0.0125) | (0.0130) |
| $Ord_{2plus}$ | -0.0655*** | -0.0508*** | -0.0476*** | -0.0745*** | -0.0877*** |
| | (0.00826) | (0.00786) | (0.00786) | (0.00799) | (0.00859) |
| $Income/10,000$ | — | — | — | 0.00321*** | 0.00329*** |
| | | | | (0.000199) | (0.000206) |
| $Mother's\_Age$ | — | — | — | 0.0134*** | 0.0147*** |
| | | | | (0.000822) | (0.000854) |
| $Post$ | 0.228*** | -0.0714*** | — | — | — |
| | (0.00859) | (0.0121) | | | |
| Survey year FE | no | yes | yes | yes | yes |
| Birth year FE | no | no | yes | yes | yes |
| No. of children×survey yr FE | no | no | no | no | yes |
| Observations | 23,369 | 23,369 | 23,369 | 22,551 | 22,551 |

Robust standard errors in parentheses. Sample restricted to girls of ages 18-24 born between 1978-1992

*** p<0.01

** p<0.05

* p<0.1

Table 4 is analogous to table 3, but the data is now limited to just boys. In all of the specifications, the coefficient on birth order 2 and greater post abortion is statistically insignificant. Moreover, all estimated effects for birth order 2 and greater are smaller in magnitude for boys than their respective estimates for girls. In all but in specification 1, we can reject the equivalence of the effect for boy and girls at the 10% or lower significance level. Overall, these estimates suggest that abortion did not improve educational outcomes for higher birth order boys, while it increased the likelihood that second or greater birth order girls ever attend college by approximately 3.54 percentage points. This effect amounts to an 8% increase in college attendance for higher birth order girls. The following section establishes that the findings of tables 3 and 4 are highly robust to various tests and

alternative specifications.

**Table 4:** Effect of abortion on the likelihood of male college attendance

| Dependent variable: | | | | | |
|---|---|---|---|---|---|
| Ever attend college? [0,1] | (1) | (2) | (3) | (4) | (5) |
| $Ord_{2plus} \times Post$ | 0.0164 | 0.000260 | 0.00894 | 0.00713 | -1.90e-05 |
| | (0.0129) | (0.0125) | (0.0125) | (0.0126) | (0.0132) |
| $Ord_{2plus}$ | -0.0563*** | -0.0361*** | -0.0342*** | -0.0653*** | -0.0864*** |
| | (0.00816) | (0.00784) | (0.00784) | (0.00799) | (0.00875) |
| $Income/10,000$ | — | — | — | 0.00285*** | 0.00286*** |
| | | | | (0.000366) | (0.000368) |
| $Mother's\_Age$ | — | — | — | 0.0157*** | 0.0175*** |
| | | | | (0.000822) | (0.000841) |
| $Post$ | 0.213*** | -0.0587*** | — | — | — |
| | (0.00847) | (0.0118) | | | |
| Survey year FE | no | yes | yes | yes | yes |
| Birth year FE | no | no | yes | yes | yes |
| No. of children×survey yr FE | no | no | no | no | yes |
| Observations | 24,180 | 24,180 | 24,180 | 23,211 | 23,211 |

Robust standard errors in parentheses. Sample restricted to boys of ages 18-24 born between 1978-1992.
*** p<0.01
** p<0.05
* p<0.1

# 6 Robustness Checks

Perhaps the most convincing way to determine that factors other than increased sex selective abortion are not underlying the effect is to look within a very small window around the legalization of abortion to test whether an effect still exists. When investigating the effect of abortion around the birth year window of 1978-1992 for 18-24 year old children, there could be several factors that change over time which are difficult to control for. To deal with this, I estimate equation 1 for a sample of girls born within a very small window of birth years just around the legalization of abortion. Column 1 in table 5 presents the results from the most preferred specification, which includes all of the fixed effects of table 3, for girls born in the 5 year window of 1983-1987. The estimated effect for this narrow

window of birth years is nearly identical to its analogous effect in column 5 of table 3 and suggests that higher birth order girls born immediately after the legalization of abortion are 3.58 percentage points more likely to attend college. This effect is statistically significant at the 10% level.

One may be concerned that it is not the number of children a family has that matters, but the composition of children a family has. For example, a family with several college age children may find it difficult to afford tuition for all of the children, while a family with young children and a college age child may find it easier to afford tuition for the one child who is of college age. Column 2 of table 5 reports the estimates of equation 1 with all of the fixed effects and controls but replaces survey year specific number of children fixed effects with detailed survey year specific family composition fixed effects. For each survey year, the specification adds fixed effects for number of daughters under the age of 18, number of sons under the age of 18, number of college age daughters between the ages of 18-24, number of college age sons between the ages of 18-24, number of daughters over 24, and number of sons over 24. The coefficient for girls at the second or greater order remains around 3.6 percentage points and highly statistically significant.

Additionally, girls and boys may have different opportunity costs of attending college in Taiwan and may enter college at different ages. One way to deal with differing opportunity costs of time after high school or equivalent secondary schooling completion is to limit the sample to older children so that they have been given a better chance to be observed attending college. Column 3 presents the results from limiting the sample to older girls that are between 20-24 years old. The effect for older girls is larger in magnitude and still highly statistically significant. Within older girls between the ages 20-24, higher birth order girls born after the legalization of abortion are 4.3 percentage points more likely to attend a university. Column 4 presents the effect for older girls born within the much smaller birth year window of 1983-1987. The effect for this group of girls is even larger in magnitude, at an improvement in college attendance by 5.4 percentage points, and it is statistically significant at the 5% level.

It was discussed earlier that not all of the children that are born in 1985 are born after the legalization of abortion, then an argument for using either 1985 or 1986 as the "post" period could be made. Specification in column 5 presents the results from choosing 1986 as the "post" period instead of 1985. Redefining the "post" variable in such a way does not yield a different result and the magnitude reported is only slightly smaller and still highly

statistically significant.

Although limiting the sample to those born just around the legalization of abortion establishes that an effect does indeed exist at the time of abortion, it does not rule out the possibility that there existed a trend such that higher order children were catching up with first order children over time regardless of sex selection. One way to test whether a general trend of improving educational levels for higher birth order girls existed in Taiwan is to investigate whether an effect exists in a time period before the legalization of abortion. In column 6 of table 5, I limit the sample to girls born before the legalization of abortion in the years 1978-1984. I define 1981 as the year that the pseudo "treatment" occurs. This choice is made simply because 1981 evenly splits the sample of children born between 1978-1984. The reported magnitude of the effect of the pseudo treatment is -0.01 for higher birth order girls. It is not only statistically indistinguishable from zero, it is also negative in magnitude. The lack of an effect at a time we do not expect an effect further validates that the effect found in this study is a true improvement in educational attainment for high birth order girls caused by increases sex selection and is not simply capturing a trend of improving educational attainment of higher birth order girls in the nation.

Table 6 reports analogous results to table 5 but restricts the sample to boys. It can be observed in the first specification in column 1 of table 6, that there is no effect of increased educational attainment for higher birth order boys even when the sample is limited to boys born within a small window around the legalization of abortion. In fact, the magnitude of the effect is even negative. Also in column 2 when controls for number of children are switched with survey year specific family composition fixed effects, no statistically significant effect is found. Specification 3 limits the sample to older boys between the ages of 20-24 and no effect is found even when boys are given a better chance to be observed attending college. Column 4 limits the sample to a very small window of birth years around the legalization of abortion and also limits the sample to older boys, and the effect remains indistinguishable from zero. Column 5 redefines the "post" variable to 1986 and after instead of 1985 and after and there continues to be no effect for boys. Finally column 6 reports the effect of the pseudo treatment at 1981 while limiting the sample to only boys born before the legalization of abortion. Consistent with a lack of a general trend in improving educational outcomes for higher birth order boys, no effect is found for this "pseudo" treatment.

I find that the main results reported in Tables 3 and 4 are robust to limiting the

**Table 5:** Robustness Checks: Effect of abortion on the likelihood of female college attendance

| Dependent variable: Ever attend college? [0,1] | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $Ord_{2plus} \times Post$ | 0.0358* | 0.0363*** | 0.0434*** | 0.0537** | 0.0333** | — |
| | (0.0207) | (0.0127) | (0.0167) | (0.0250) | (0.0136) | |
| $Ord_{2plus} \times Post$ $(Pseudo)$ | — | — | — | — | — | -0.00771 |
| | | | | | | (0.0161) |
| $Ord_{2plus}$ | -0.0864*** | -0.0778*** | -0.106*** | -0.103*** | -0.0845*** | -0.0894*** |
| | (0.0165) | (0.00808) | (0.0112) | (0.0202) | (0.00816) | (0.0123) |
| $Income/10,000$ | 0.00296*** | 0.00324*** | 0.00296*** | 0.00254*** | 0.00329*** | 0.00387*** |
| | (0.000293) | (0.000199) | (0.000245) | (0.000342) | (0.000206) | (0.000295) |
| $Mother's\_Age$ | 0.0141*** | 0.0138*** | 0.0160*** | 0.0136*** | 0.0147*** | 0.0161*** |
| | (0.00143) | (0.000826) | (0.00112) | (0.00170) | (0.000854) | (0.00111) |
| Survey Year FE | yes | yes | yes | yes | yes | yes |
| Birth Year FE | yes | yes | yes | yes | yes | yes |
| No. of children×survey yr FE | yes | no | yes | yes | yes | yes |
| Comp. of Children×survey yr FE | no | yes | no | no | no | no |
| Sample Restrictions | | | | | | |
| Age Group | 18-24 | 18-24 | 20-24 | 20-24 | 18-24 | 18-24 |
| Birth years | 1983-1987 | 1978-1992 | 1978-1992 | 1983-1987 | 1978-1992 | 1978-1984 |
| Observations | 8,304 | 22,551 | 13,541 | 5,509 | 22,551 | 13,988 |

Robust Standard errors in parentheses.
*** p<0.01
** p<0.05
* p<0.1

**Table 6:** Robustness Checks: Effect of abortion on the likelihood of male college attendance

| Dependent variable: Ever attend college? [0,1] | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| $Ord_{2plus} \times Post$ | -0.0167 | 0.00192 | -0.000963 | 0.00113 | 0.00865 | — |
| | (0.0205) | (0.0127) | (0.0173) | (0.0254) | (0.0139) | |
| $Ord_{2plus} \times Post$ $(Pseudo)$ | — | — | — | — | — | 0.00939 |
| | | | | | | (0.0162) |
| $Ord_{2plus}$ | -0.0919*** | -0.0715*** | -0.115*** | -0.119*** | -0.0891*** | -0.0977*** |
| | (0.0162) | (0.00807) | (0.0116) | (0.0203) | (0.00831) | (0.0126) |
| $Income/10,000$ | 0.00221*** | 0.00289*** | 0.00292*** | 0.00219*** | 0.00286*** | 0.00316*** |
| | (0.000515) | (0.000370) | (0.000224) | (0.000302) | (0.000368) | (0.000629) |
| $Mother's\_Age$ | 0.0186*** | 0.0162*** | 0.0184*** | 0.0181*** | 0.0175*** | 0.0190*** |
| | (0.00137) | (0.000824) | (0.00110) | (0.00166) | (0.000841) | (0.00112) |
| Survey Year FE | yes | yes | yes | yes | yes | yes |
| Birth Year FE | yes | yes | yes | yes | yes | yes |
| No. of children×survey yr FE FE | yes | no | yes | yes | yes | yes |
| Comp. of Children × survey yr FE | no | yes | no | no | no | no |
| Sample Restrictions | | | | | | |
| Age Group | 18-24 | 18-24 | 20-24 | 20-24 | 18-24 | 18-24 |
| Birth years | 1983-1987 | 1978-1992 | 1978-1992 | 1983-1987 | 1978-1992 | 1978-1984 |
| Observations | 8,781 | 23,211 | 13,158 | 5,539 | 23,211 | 14,234 |

Robust Standard errors in parentheses.
*** p<0.01
** p<0.05
* p<0.1

sample to a much smaller window of births right around the policy change, adding family composition fixed effects, defining the treatment at 1986 instead of 1985, and to limiting the sample to consist of older children who have had a longer opportunity to have attended college in their lifetime. Moreover no effect of increased educational attainment for girls or boys at higher birth orders is found prior to the legalization of abortion. These findings verify that after abortion was made legal in Taiwan, college attainment of girls at the most sex selective birth orders increased while no evidence is found that such an effect also exists for boys.

# 7 Conclusion

I find results consistent with the prior that sex selection improves investments in females. Because families with a strong preference for a boy at a higher birth order (or strong distaste for a girl at a higher birth order) abort the female fetus to help ensure a male birth, girls born at a higher birth order after abortion is made legal are born into families with, on average, higher preferences for girls. I find results consistent with this compositional change, and girls born at the second or greater birth order after abortion legalization are found to be on average 3.5 percentage points more likely to attend college. Consistent with no compositional shift in preferences of families having a higher birth order boy post the legalization of abortion, I find that boys at the second or greater birth order, born after abortion are not significantly more likely to attend a university. These results are consistent with the substitution hypothesis that prenatal gender discrimination reduces postnatal gender discrimination and have an important policy implication. Results form this study recommend that policy makers interested in banning sex selective abortion take these findings and other related works that verify the substitution hypothesis into account, as together these works shine a slightly less negative light on the practice of sex selection in societies with male preference.

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# Appendix

I estimate a simple regression of equation 3 to test whether older children's birth order is more likely to be underestimated within the sample.

$$Order3\_or\_Greater_{ij} = \sum_{j=1}^{24} \gamma_j \times Age_j + \epsilon_{ij} \tag{3}$$

A cohort of children born in a specific year is observed in different survey years at different ages. Then within the entire sample, I observe a particular birth year cohort as it gets older. The dependent variable in equation 3 is whether a child is of third or greater birth order and it is regressed on dummies for ages 1-24. Children of age less than 1 are omitted. Then holding a birth year constant, if there are no deaths or attrition from leaving home, $\gamma_j$ should equal 0 at any $Age > 1$ for all children in the same birth year cohort; that is because the sample is representative, the ratio of a cohort that is birth order three or greater should not change as the cohort of children born in the same birth year gets older. I present results of this simple regression for birth cohorts 1983-1987 in table A-1.[7] Table A-1 is evidence that there is some obvious birth order misspecification within the sample, and 18-24 year old children born within their birth year are anywhere from 17-27 percentage points less likely to be assigned birth order 3 or greater than when they were under 1 year of age. In an effort to report a smaller table, the coefficient for younger ages' fixed effects are not reported, but in general when the birth year cohort is observed at much younger ages, the birth order misspecification is much smaller and sometimes indistinguishable from 0. Table A-1 is evidence that some birth order misspecification occurs in this analysis, and that it is particularly worse for older children.

[7] I am unable to do this exercise for all of the birth years, because I do not observe children at all ages from 0-24 for all of the birth years (1978-1992) in the sample.

**Table A-1:** Birth Order Misspecification

| Dependent variable: | | | | | |
|---|---|---|---|---|---|
| Child is Birth Order 3+? [0,1] | (1) | (2) | (3) | (4) | (5) |
| Birth Year | 1983 | 1984 | 1985 | 1986 | 1987 |
| Age_17 | -0.160*** | -0.179*** | -0.172*** | -0.164*** | -0.185*** |
| | (0.0200) | (0.0199) | (0.0201) | (0.0211) | (0.0207) |
| Age_18 | -0.185*** | -0.208*** | -0.171*** | -0.168*** | -0.172*** |
| | (0.0207) | (0.0202) | (0.0209) | (0.0216) | (0.0216) |
| Age_19 | -0.223*** | -0.184*** | -0.177*** | -0.193*** | -0.228*** |
| | (0.0205) | (0.0202) | (0.0214) | (0.0222) | (0.0212) |
| Age_20 | -0.231*** | -0.215*** | -0.177*** | -0.198*** | -0.195*** |
| | (0.0217) | (0.0214) | (0.0215) | (0.0228) | (0.0223) |
| Age_21 | -0.228*** | -0.245*** | -0.214*** | -0.195*** | -0.209*** |
| | (0.0219) | (0.0219) | (0.0220) | (0.0229) | (0.0227) |
| Age_22 | -0.235*** | -0.253*** | -0.225*** | -0.215*** | -0.245*** |
| | (0.0221) | (0.0219) | (0.0228) | (0.0230) | (0.0227) |
| Age_23 | -0.268*** | -0.235*** | -0.208*** | -0.218*** | -0.250*** |
| | (0.0235) | (0.0233) | (0.0240) | (0.0250) | (0.0234) |
| Age_24 | -0.274*** | -0.228*** | -0.214*** | -0.209*** | — |
| | (0.0247) | (0.0236) | (0.0258) | (0.0251) | |
| Constant | 0.339*** | 0.318*** | 0.297*** | 0.280*** | 0.295*** |
| | (0.0132) | (0.0130) | (0.0137) | (0.0143) | (0.0140) |
| Observations | 24,468 | 22,980 | 20,829 | 17,666 | 17,401 |

Robust standard errors in parentheses. All specification include fixed effects for ages 1-24 and children under the age 1 are the omitted category.
*** p<0.01
** p<0.05
* p<0.1