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The Impact of Sibling Sex Composition on Women's Educational Achievements: A Unique Natural Experiment by Twins Gender Shocks

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Abstract

In a pro-male biased society, brothers may reduce the parental investment received by female siblings, if parents face time or financial constraints. But brothers may also cause positive externalities. Using more than 12,000 firstborn twins from a highly sex-imbalanced economy, Taiwan, we test if women have fewer opportunities to attend college if they have a brother rather than a sister. To minimize the problem of sex selection, we exploit the fact that twin sex is random given the sex of the other twin, once we limit the data to time periods in which abortion was illegal and technology was unavailable to abort one of the two twins. We show that the birth of a male sibling, relative to a female, has almost no impact on women's or men's college enrollments on the average. If there is any effect, it is small and imprecise. Our results point to the importance of accounting for positive externalities (e.g., decreasing family size) created by a son's birth, in studies on sibling rivalry.

Keywords: education, son preference, sibling rivalry, sibling spillover, sex selective abortion, within-family allocation of resources

1 Introduction

Highly imbalanced sex ratios in Asia have led many observers to worry about the social consequences of sex-selective abortions. Strong son preference of Asian families in fertility behavior perhaps implies a higher risk of female infanticide, and worse treatment for surviving daughters.[1] On the one hand, parents may divert family resources from daughters to sons, due to time or financial constraints, especially in economies with a centuries-long tradition of pro-male bias, such as China, India, and Taiwan. Consequently, the daughters in these economies may have had lower educational attainments if they had a brother, instead of a sister.[2] On the other hand, the birth of a son may create positive externalities, such as reducing family size, stabilizing parents' marriage or relationships, increasing fathers' labor supply, or increasing parenting time spent by mothers,[3] all of which may benefit daughters as well. Both rivalry and spillover effects of male siblings, on women's educational achievements appear to coexist; and hence they may cancel out

[1]See El-Badry (1969), Ben-Porath and Welch (1972), Ram Gupta (1975), Hammoud (1977), Chen, Huq, and D'Souza (1981), Rosenzweig and Schultz (1982), Sen (1990, 1992), Goodkind (1996), Qian (2008), and Lin, Liu, and Qian (2008). Besides preference for sons, other possible explanations for imbalanced sex-ratios are either biological or genetic. See discussions by Oster (2005, 2006), Das Gupta (2005, 2006), and Lin and Luoh (2008).

[2]Das Gupta (1987), Muhuri and Preston (1991), Parish and Willis (1993), Lillard and Willis (1994), Powell and Steelman (1989), and Hauser and Kuo (1998) suggested that children do better, in terms of health status or educational outcomes, if they have all sisters, rather than all brothers.

[3]Butcher and Case (1994) suggest that girls raised only with brothers have higher educational achievements than those raised only with sister, conditional on family size. Jensen (1999) provides evidence showing that girls have more siblings than boys. Lundberg and Rose (2003) find that the birth of a son is associated with a faster transition into marriage, when the child is born before the mother's first marriage. Dahl and Moretti (2008) suggest that a first-born daughter is significantly less likely to be living with her father, compared to a first-born son. Lundberg and Rose (2002) show that fathers work more, subsequent to a son's birth, than after a daughter's birth. Using a sample of rural Indian households, Rose (2000) finds that women work less after the birth of a son, relative to that of a daughter.

each other.

Identifying the overall effect of sibling rivalry and spillovers is challenging, particularly in countries with highly imbalanced sex ratios. Pro-male bias, where parents may choose child gender by resorting to sex-selective abortions, as manifestated in the phenomenon of millions of "Missing Women" (Sen 1990, 1992). In this paper, we use the randomness of firstborn twins' sex composition as a natural experiment for studying the causal impact of changes in sibling sex composition. Our goal is to ensure that the estimated impact of a change in sibling gender on education is not confounded by sex-selective abortions. This goal is achieved by taking advantage of the fact that the sex composition of firstborn twins is virtually random (as shown in Table 1a), once we restrict our data to time periods in which abortion was illegal and technology to abort one of the two twins was not available. During the sample period, our twins data exhibits balanced sex ratios, with 100.76 girls for every 100 boys on average. Thus, the impact of having a twin brother, relative to a twin sister, on women's education simply equals the difference in the outcomes between mixed-sex and same-sex twins.

To derive an accurate measure of sibling sex composition, we trace all births by each mother, for at least 15 years. We further derive precise information about college enrollments by linking the birth registry records of all firstborns with the administrative data of college entrance tests records. This unique data set provides a simple, accurate, and powerful method for assessing the role of sibling sex composition in determining women's educational achievements.

A key limitation is that firstborn twins cannot represent the general population. Average firstborn twins have more siblings, lower birth weights, and older and more educated parents than firstborn singletons. However, perhaps surprisingly, the twins' college enrollment rates are very similar to the enrollment of rates of the singletons with the same birth weights. Furthermore, if having a brother might adversely affect a female sibling, due to resources constraints of the family, it would be most likely to arise among twins because of no spacing between the two. The birth of mixed-sex twins in a son-preferring family not only increases the family size, but also makes the girl twin faces an immediate rival competing for family resources. Arguably the estimated effects for twins represent an upper bound of the net rivalry effects that could be realized in the general population. Documenting the size of such effects is important not only for analyzing mechanisms of within-household allocation of resources, but also for understanding female inequality in other segments of populations.

The results of our twins' study provide limited evidence of rivalry effects of male siblings that echoes the literature on sibling rivalry (e.g., Parish and Willis 1993; Garg and Morduch 1998; Morduch 2000).[4] Given that only 14.6 percent of firstborn twins attended college, 0.98 to 1.58 percent of reduction in female college enrollment, caused by having a twin brother relative to a sister, are seemingly sizable but they are statistically insignificant (with standard errors about 1.4 percent). We also find that the detrimental effect of having a twin brother approximately doubles among those who were born in rural areas, and it almost tripples among those whose mother have a high school diploma or above. However, these estimates are imprecise. Our earlier results based on the entire population of firstborn singletons show nearly zero detrimental effects and very small standard errors (Chen, Chen, and Liu 2008). Our finding suggests that positive externalities caused by a son's birth cannot be ignored in the studies on sibling rivalry.

The paper unfolds as follows. Section 2 provides a description of matched administrative population data from one of the most sex-imbalanced economies, Taiwan. Section 3 documents qualitative and quantitative evidences of strong son preference in fertility behavior of Taiwanese families, especially those with firstborn twins, during the late 1970s

[4]Important findings by Butcher and Case (1994) suggest that boys' masculine traits may help their sisters to develop positive attitudes toward greater educational achievement. In contrast, Kaestner (1997) uses the same data set but finds little correlation between sibling sex composition and educational attainments of children, especially in case of later cohorts.

and early 1980s. Section 4 lays out our methodology, and Section 5 reports the estimated effect of sibling sex composition on college enrollments. We also report results by alternative approaches. Section 6 discusses several potential interpretations. Section 7 concludes.

2 Data

Our analysis is based primarily on the national birth registry records of Taiwan, which cover virtually all newborns since 1978, the initial year of the digitalization of birth registry data. This data provides detailed information about each newborn's birth date, order, place, weight, and parental age, education, and residential location. We focus on the subpopulation of firstborn twins, born between 1978 and 1984, i.e., before the legalization of abortion.[5] During this period, sex-selective abortion of one of the two twins was not only illegal but also technically impossible. In fact, the technology for aborting one of the two twins was initially developed in laboratories only in 1988 (see Cunningham *et al.* 2005), a few years after the analyzed period. Although prenatal sex determination methods, such as ultrasound, were available since early 1980s, it was only after 1986/7 that the technology for sex-selective abortion became widely available but limited to singletons (Lin, Liu, and Qian 2008); technologies for aborting one of the twins became available a few years after that.

Our data of sex composition and completed family size appear to be quite accurate. We trace all births by each mother of firstborn twins using their Unique Identification Numbers, over an extended period, i.e. from 1978 to 1999. Because of the quality of the administrative data, we were able to match 100 percent of our data. It is noteworthy that no mother in our data had another child after 1997, suggesting that the constructed

[5]Taiwanese abortion laws (i.e. the *Eugenics Protection Law*) were enacted in 1984, and were enforced from 1 January 1985 onwards.

measures of sibling sex composition and completed family size are reliable. Furthermore, we exclude children whose mothers were unwed, older than 50, or younger than 15 at the time of birth. Inclusion of children born to single mothers, who account for less than 1 percent of the data, does not impact our results.

As statistics in Table 1a show, sex composition of firstborn twins is virtually random in our data. The probability of having a boy twin almost equals the probability of having a girl twin, irrespective of the sex of the other twin. The sex ratio in the population of firstborn twins is nearly unity, which is the natural rate for twins documented in medical literature (James 1980; Derom *et al.* 1988; see discussions in Machin 1996).[6] Thus, the sex composition of the first-born twins appears to represent a truly exogenous event that can be used to identify the effects of a change in sibling sex composition on children's educational outcomes.

By contrast, sibling sex composition of firstborn singletons during the same pre-abortion period does not seem to be random. As Table 1b shows, the subsequent sibling of a first-born female singleton is 2.07 percentage points more likely to be male than female. This is because some of the second-born children in our data were born after 1986, when technology for sex-selective abortion became widespread. Consequently, the probability of having two boys at the first two births is 2.6 percentage points higher than the probability of having two girls (p-value< 0.01) at the first two births.

In this paper, we measure educational achievements by college attendance. To derive reliable information about college enrollments, we match firstborn children to the College Entrance Test records, when they turned 18 during the academic years 1996 to 2003. This matched administrative data covers all Taiwanese teens who were born between 1978 and 1984 and were the age of high school seniors during the academic years. Children who died or emigrated overseas during those years are considered non-attendants in our analysis.

[6]According to this literature, the ratio of boys to girls for MZ and DZ twins is around 0.96 and 1.04, respectively, based on the US data for the early 1980s and late 1970s.

Table 2a provides descriptive statistics of firstborn twins, with variables that we study below. To measure the extent to which twins and singletons share similar demographics and backgrounds, we also report data on firstborn singletons for comparison purposes. Compared with most of the previous studies of twins, our sample size is much larger and the data is more comprehensive. The matched data contains 11,998 firstborn twins, and includes important information such as their birth weights and parental age and education. According to our data, parents of these children were born mostly during the 1950s. About 65 percent of them completed secondary education, and 13 to 17 percent completed post-secondary education.

Relative to firstborn singletons, firstborn twins tend to have more siblings and lower birth weights, which is a direct consequence of twin births. Because the frequency of twin births rises with maternal age, parents of firstborn twins in our data are more educated than parents of firstborn singletons. In addition, we also find that firstborn twins were more likely than firstborn singletons to have been born in urban areas. This might have resulted from the fact that older mothers are more likely to have taken fertility-inducing drugs, which are more available in urban than rural areas, and are known to increase the incidence of multiple pregnancies (Chitkara and Berkowitz 2002).

Table 2b compares statistics of firstborn twins and singletons, by sex composition of their siblings. It shows that a female first-born, either twin or singleton, has 0.43 to 0.47 more siblings if her twin or subsequent sibling is female, instead of male. This increase in family size caused by a change in sibling sex is substantial since it accounts for 17 percent of the average family size. Given that having a brother considerably lowers family size, a firstborn girl might actually receive more family resources if her subsequent sibling is male, not female. Therefore, a large portion of a rivalry effect of a brother on women's education may be overcome by a benefit of having fewer siblings because of a brother's birth. Indeed, Row (2) of Table 2b suggests that a boy twin or singleton at the second birth is associated with more opportunities for the firstborn female to attend college.

The higher incidence of mixed-sex twins among older mothers in Table 2b might look puzzling. The mothers of mixed-sex twins are about 0.8 to 0.9 years older than mothers of same-sex twins, at the time when the twins are born. The medical literature, summarized by Chitkara and Berkowitz (2002), provides one explanation. Infertile women who take fertility-inducing drugs (such as menopausal urinary gonadotropins or clomiphene citrate), or adopt an in-vitro fertilization technology, generally have a considerably higher probability of having DZ births, compared with those who conceive without medical treatment. Given that infertility rises significantly with age and that mixed-sex twins are mostly dizygotic, mixed-sex twins are more likely, than same-sex twins, to be born to older mothers. The medical literature shows that the probability of DZ twins increases from 0.3 percent to 1.4 percent, when the age of the mother rises from under age 20 to 35-40 years. In contrast, the frequency of MZ twining remains constant at around 0.4 percent, irrespective of maternal age.

Since age and education are positively associated, as expected, Table 2b and A1 also show that parents having mixed-sex twins are more educated than those having same-sex twins. In addition, parents living in urban areas are more likely to have mixed-sex twins, probably because of better access to fertility-inducing technologies in urban than in rural areas.

One concern is the large gap in maternal age between mixed-sex twins and girl twins, as Table 2b shows. Mothers of mixed-sex twins are 0.9 years older than mothers of girl twins (with p-value< 0.001). Ebenstein (2007) has noted that the delay in a son's birth may be a sign of sex-selective abortion because aborting female fetus delay the birth. Closer exploration of our data, however, indicates otherwise. Table A1 shows that mothers of mixed-sex twins are also 0.8 years older than those having boy twins (with p-value< 0.001) also, besides being older than those of girl twins. In fact, during the analyzed period of 1978 to 1984, technologies for sex-selective abortions were not yet widely available, and aborting one of the two twins was still technically impossible. This suggests that sex-selective abortions cannot dominate other causes, such as fertility-inducing treatments, for the excess of mixed-sex twins among older mothers.

3 Documenting the demand for sons

3.1 Quantitative evidence

By the ratio of men to women among Asian countries, Taiwan is next only to China, India, and South Korea (see the CIA World Fact Book 2007). The sex ratio at birth is 1.081 for all children born between 1978 to 1999, which amounts roughly to more than 218,000 "missing women," or the number of additional females required to have a sex-balanced population, taking 1.05 as the benchmark ratio.[7]

On average, Taiwanese couples tend to continue having children until they have a son. The demand for sons in Taiwan is much stronger than estimates in most other countries. Taiwanese parents with two daughters are nearly 30 percentage points more likely to have a third child than those with two sons. In contrast, similar estimates from the U.S. or Israeli Censuses are less than two percentage points (see Ben-Porath and Welch 1976; Angrist and Evans 1998; Angrist, Lavy, and Schlosser 2006).

In Taiwan, family size depends largely on sibling sex composition, in a distinct manner from other countries. Unlike American or Israeli families, which significantly favor mixed-sex over same-sex composition, Taiwanese parents strongly prefer two boys to a mixed-sex composition. Panel (B) of Table 3 shows that families with a boy and a girl singletons at the first two births have 0.1 more children than those with two boys (s.e.=0.002). In addition, families having two girls at the first two births have 0.53 more children than those having two boy singletons (s.e.=0.023). Given that the average family size is about 2.8 among families with at least two children, these estimates indicate a very strong pro-

[7] See Lin, Liu, and Qian (2007) for more statistics on "missing women" in Taiwan.

male bias. In addition, Panel (A) of Table 3 indicates that the impact of a change in twin sex composition on family size seems stronger than that for singletons. Compared with families with boy twins at the first birth, having girl twins increases family size by at least 0.45 (s.e.=0.023), and having a pair of mixed-sex twins also increases family size by 0.048 (s.e.=0.029).

3.2 Qualitative evidence

The strong Taiwanese preference for sons is rooted in the millennia-old Confucian tradition. The Confucian thought and discipline that systematically justifies the preference for male offsprings over females, such as *Analects* (ca 479 BCE), has been at the core of the educational curriculum in imperial China for more than two thousand years, since the Hang Dynasty. In accordance with Confucian doctrines, inheritance of family wealth and titles moves strictly from father to son, and the responsibility of old-age security of parents is traditionally assumed by the son and his wife.[8] Old-age citizens in Taiwan have traditionally relied on family support. Public-funded old-age security programs were initially established in 2002, targeting only farmers, who account for only a small portion of population.

By Taiwanese customs, the oldest grandson of the family also inherits part of his grandparents' properties, possibly as much as his father does. Therefore, raising a son is not only to secure old-age care and to ensure perpetuation of the family lineage, but also to gain power and wealth in the extended family. In contrast, raising a daughter is costly because they traditionally require expensive dowries from the parents at the time of marriage, and are assumed to be responsible for taking care of their husbands' parents in their old-age, not of their own parents. Raising daughters, thus, is considered

[8]If the family has no son but still wants to keep the family name, a conventional solution is giving the family name to one of daughters' son, or adopting a boy from a relative's family. The the named or adopted son assumes the old-age care of the parents.

less worthwhile than raising a son. A Chinese poem, "Si Gan" from *Book of Songs* (also called *Shi-Jing*), dated centuries before Confucius and believed to be compiled by him has advised parents to allocate family resources unevenly between sons and daughters:

When a son is born
Let him sleep on the bed
Dress him with fine ropes
And give him jade to play...
When a daughter is born
Let her sleep on the ground
Cover her in usual wrappings
And give her tiles for playing....

With the prevalent system of patrilinear inheritance, it is not surprising that more educated parents have a stronger son preference, because they are more likely to come from wealthier families and because having a son can increase the probability of retaining the family wealth within the family. Edlund (1999) advanced a similar argument to explain why the ratio of boys to girls may increase with parental socio-economic status, although the effect of the patrilinear inheritance system is not the focus of her model. In addition, because of better access to information about sex-selective abortion, relatively more educated parents and those who live in urban areas tend to have stronger preference for sons. Our statistics (not shown here) indicate that starting in 1987, sex ratios at birth for third-born children became imbalanced among third-born children who were born in urban or to a mother who had a high school diploma or above. Before 1987, there were no clear evidence that shows the practices of prenatal sex selection.

4 Identifying sibling gender effects

With highly imbalanced sex ratios and strong preference for sons, we need to overcome the problem of endogenous child gender. We address this by exploiting the fact that given the sex of one twin, the sex of the other twin is exogenous. Indeed, during the pre-abortion period, firstborn twins' sex ratio is balanced, and their sex composition is virtually random, as Table 1a has shown. In practice, we compare the education of girls who have twin brothers, with the education of girls who have twin sisters. The effect of changes in sibling sex composition is measured simply by the difference between college enrollment rates in the treatment and comparison groups (i.e. samples of mixed-sex and same-sex twins).

Formally, we denote by y_i the college attendance dummy of the i-th girl in the sample of firstborn twins; we denote by X_i her observed covariates and by B_i an indicator for having a brother. We consider a parsimonious model of girl i's college attendance as follows:

$$y_i = X_i'\alpha + \beta B_i + \varepsilon_i, \tag{1}$$

where α includes a constant and a set of covariates, and β is the parameter of interest, the effect of a twin brother, as opposed to a twin sister, on women's college enrollment. Because sex composition of the twins is random in our data, we assume that the error term ε_i is uncorrelated with sibling sex B_i, conditional on X_i. For comparisons, we also use the data of firstborn sons in the twins population to estimate the effect of having a twin brother, as opposed to having a twin sister, on men's education. In all models, we estimate standard errors that allow for potential correlations between the error terms within family clusters.

The covariates include individual and family demographics, including a full set of dummies for child i's birth year and place, parents' birth years, mother's age at the first birth, and the academic year in which the child graduated from high school. In some specifications, we also include children's and their siblings' birth weights, family size, and parental education. We find that adding some or all of these additional controls does not change our results, as discussed below. In addition, estimation results based on a Probit model are virtually identical to those based on the linear probability model in (1).

One important merit of the twins' methodology is that we can control for the time intervals separating the births of siblings. Consequently, we are able to isolate the impact of a change in sibling gender from accompanying effects of a change in age-spacing, which arise only in case of singleton siblings. Wider spacing between an older brother and a younger sister, for example, may lower the degree of sibling rivalry for the girl, because it permits parents to time to recoup the financial expenses before the next child is born (e.g., Powell and Steelman 1993). Closer spacing, however, may provide "economies of scale" for the family, by reducing the total cost of toys and clothes that siblings can share (e.g., Kidwell 1981). Moreover, a longer interval between the birth of a son and the preceding birth, than in case of a daughter's birth, might signal the use of sex-selective abortion, since aborting a female fetus until a male is born delays the birth of the male (Ebenstein 2007). The twins' methodology allows us to set aside the disagreements on the relationship among spacing, sex composition, and children's outcomes.

Our main finding, presented below, is built on the reduced-form model (1). As in Dahl and Moretti (2008), we exclude family size from our specification because family size is endogenous. Thus, our results may reflect any indirect effect of having a brother that can be operated through decreasing family size. In this sense, we understate the pure rivalry effect of male siblings on educational outcomes of girls. In our earlier work (Chen et al. 2008), we included and instrumented for family size, so the main effect of family size on child outcomes was also identified. Consistent with other studies (Black et al. 2005; Angrist et al. 2006), the estimated family size effect is nearly zero, with small standard errors.

5 Results

Using the large-scale administrative population data sets, which cover virtually all newborns in Taiwan over an extensive period of time, our estimates indicate that the overall effect of male siblings on women's college attendance is small and insignificant. Based on estimates of the 6,022 firstborn twin girls, Column (1) of Table 4 shows that on average, the overall rivalry effect of male siblings is about 1.4 percentage points (s.e.=0.014), which is approximately one tenth of the average enrollment rate for firstborn twins.

In Panel (B) of Table 4, we further show a parallel analysis of the 5,976 firstborn twin boys, using the specifications in panel (A). The results suggest that the effect on men is less than 0.5 percentage points (s.e.=0.013-0.014), even smaller than the effect on women. Overall, our estimates strongly suggest that the causal effect of having a male sibling on his twin brother's or sister's opportunity to attend college is small in magnitude and insignificant in statistics.

As a robustness check, we examine our results by including a full set of dummies for levels of parental education. As Column (2) of Table 4 shows, the coefficient of the brother indicator changes little and the estimate remains insignificant. Interacting the brother indicator with parental education also does not affect our result; all coefficients of the cross terms are insignificant at the 5 percent level (not shown in the table). F-test statistics cannot reject the hypothesis that all interactions have no effect on firstborn twin girls' college attainment.

5.1 Controlling for Birth Weights

While both dizygotic (DZ) and monozygotic (MZ) twins are included in the regression analysis, we do not observe zygosity in our data. Given that MZ twins must be same-sex, our identification, essentially based on comparisons between mixed-sex and same-sex twins, could in part reflect a genetic difference between DZ and MZ twins.

We address this issue by including twins' birth weights. This strategy is motivated by previous studies that show twins' birthweights are highly correlated with their educational attainment and other outcomes (e.g., Currie and Hyson 1999; Conley and Bennett 2000; Behrman and Rosenzweig 2004) and by the medical literature that uses birth weight as a major indicator for a twin's health status (e.g., Cunningham *et al.* 2005). DZ and MZ twins differ considerably in patterns of birth weights: MZ twins on average are lighter than DZ twins, and within-pair size discordance arises more often, and is more remarkable, in MZ than in DZ twins.[9]

To see how this strategy works, define by $\overline{y}_b(z, w)$ the mean of college enrollment of twin girls who have a twin brother or sister, $b = 1$ or 0; z_i is girl i's observed characteristics, and w_i indicates her birthweight and her twin sibling's birthweight. Given (z, w), the parameter of interest is $\beta = \overline{y}_1(z, w) - \overline{y}_0(z, w)$. If birthweights are omitted, the estimated effect of sibling rivalry is a weighted average of the between-pairs differences across DZ-MZ and DZ-DZ pairs, and they are weighed by the fractions of MZ and DZ twins (denoted by ϕ and $(1 - \phi)$):

$$\begin{aligned} & \phi[\overline{y}_1(z, w_{dz}) - \overline{y}_0(z, w_{mz})] + (1 - \phi)[\overline{y}_1(z, w_{dz}) - \overline{y}_0(z, w_{dz})] \\ = \quad & [\overline{y}_1(z, w_{dz}) - \overline{y}_0(z, w_{dz})] + \phi[\overline{y}_0(z, w_{dz}) - \overline{y}_0(z, w_{mz})] \end{aligned} \tag{2}$$

where w_{dz} and w_{mz} denote the birthweights of DZ and MZ pairs, and γ is the coefficient of birthweights. The second term, $\phi[\overline{y}_0(z, w_{dz}) - \overline{y}_0(z, w_{mz})]$, is a bias term due to unobserved differences between DZ and MZ twin pairs. Adding birthweights in regression (1) removes this bias term and yields unbiased estimates, since $w_{dz} = w_{dz}$. If birthweights were omitted, the twins' estimates would understate the net rivalry effect, since on average, DZ twins are generally heavier than MZ twins ($w_{dz} > w_{mz}$). Column (3) of Table 4 shows that

[9] Coefficients of correlations between MZ twins are about 0.91 to 0.93 for birth weights and heights, while the same coefficients range between 0.48 and 0.58 for DZ twins (e.g., Mittler 1971; Plomin, DeFries, and McClearn 1990, Tables 12.6).

the understatement caused by omitting birthweights is small and insignificant, and that the standard error is nearly unchanged even after including birthweights (see comparisons between Columns (2) and (3)).

Although there may be other differences in initial endowments between DZ and MZ twins, birthweight is viewed as one of the most important proxies for a child's initial endowment. Evidence of the strong association between a child's birthweight and outcomes, such as schooling, wage, or health, can be seen in Bonjour *et. al.* (2003), Behrman and Rosenzweig (2004), Almond, Chay, and Lee (2005), and Lin, Liu and Chou (2007).

5.2 External Validity

We have used differences in education across firstborn twin pairs to identify the causal effect of a change in sibling gender on education. However, the question of generalization of the results to the general population remains.

Twins differ from singletons in many ways. Twins are known to have shorter gestation and higher mortality rates than singletons. In particular, twins are more likely to be characterized by low birthweight than singletons, due mostly to restricted fetal growth and premature delivery (Buekens and Wilcox, 1993). Although twins account for only 1.33 per 100 first-born children in our data, they account for 12.9 percent of low-birthweight (less than 2,500 grams) newborns. As Table (2a) shows, in contrast to the average weight of less than 2,500 grams in case of firstborn twins, firstborn singletons have an average weight of 3,211 grams.

Twins, on average, have less schooling than singletons. The difference in college enrollment rates is about 2 percentage points, as Table 2a shows. When one compares twins and singletons with the same birthwieght, however, their college enrollment rates are surprisingly similar. Figures 3 and 4 show the differences in college enrollment rates by birthweight, between firstborn twins and singletons. The differences in college enrollment rates are nearly zero between female twins and singletons with the same birthweights of over 1500 grams. Male twins with birthweights of over 1750 grams are more likely to enroll in college than male singletons with the same birthweights, though the differences in enrollment rates are insignificant at conventional levels. Lower educational outcomes of twins are found only among boys with very low birthweights. In addition, conditional on the birthweights of both of the twins, our identification in equation (2) is based primarily on the difference in educational outcomes across DZ pairs. In the sense that the incidence of low birthweight is less likely to be found among DZ twins, than among MZ twins, the estimates conditional on birthweights of firstborn twins may be generalized to the entire population of firstborn singletons. This generalization is supported by our earlier findings (see Section 5.4) of no effect of a change in sibling sex at the second birth on firstborn daughters' college attainment.

Some evidence has shown that twins may still differ from singletons, aside from low weights at birth. For example, Duflo (1998) and Pettersson-Lidbom and Thoursie (2007) suggest that shorter spacing between siblings has a negative impact on children's outcomes, because spacing children closer imposes additional strain on family resources, besides increasing family size. This suggests that rivalry effects, if any, should be stronger on twins than on singletons. In this sense, it is actually conservative to generalize the twins' results to the rest of the population.

5.3 Heterogeneous Effects of Sibling Sex Composition

As we have shown earlier, since 1987, sex ratios after the second birth became more imbalanced for children born in families in urban areas, or families having more educated mothers. While this phenomenon may be an outcome of better access to sex-selective abortion facilities or information available to these families, we examine in this section if the net rivalry effects of male siblings can also vary by regions or by maternal education. Irrespective of specifications of regression models, we find no evidence of rivalry effects of male siblings on boys' college attainment. Thus, our report below focuses primarily on heterogeneous effects of a change in sibling sex on girls' college enrollments.

The strongest effect of sibling rivalry in this study appears among twin girls having more educated mothers. As Table 5a shows, if a twin girl's mother has high school diploma or above, having a twin brother may decrease her opportunity to attend college by 3.9 to 5.4 percentage points. This effect is substantial, given that only about 24 percent of twin girls with an educated mother enrolled in college, and accounts for 16 to 24 percent of college enrollments of twin girls, although the estimates are either insignificant or marginally significant. In contrast, in families with less educated mothers, net rivalry effects on twin girls are less than 0.6 percentage points. The standard errors are about 1.5 percentage points. Because our analysis is based on population data comprising a large number of twins, these estimates have reasonably small standard errors.

We also find a considerably strong rivalry effect of male siblings on college attainment of females who were born in rural areas. In contrast, the same effect is not observed in urban areas. As Table 5b shows, twin girls born in rural areas are 2.0 to 3.9 percentage points less likely to enroll in college, if they have a twin brother, rather than a twin sister. This impact is substantial since it constitutes up to 30 percent of college enrollments among twin girls born in rural areas.

It is worth noting that when family size is included, the estimated effect of sibling rivalry, either by regions or by maternal education, is significant at 5 percent level. This suggests that the reduction in family size, which can be viewed as a spillover effect caused by having a brother as opposed to having a sister, may have offset part of the rivalry effect on the sister. This, once again, highlights the importance of taking into account spillover effects while studying sibling rivalry.

It sounds somewhat puzzling that the net rivalry effect of male siblings is stronger in rural areas, while sex ratios after the second birth are more imbalanced in urban areas. This seemingly contradicting result can be explained by the prevalent tradition of patrilinear inheritance. Land-holding families, mostly concentrated in rural areas, may invest more in sons than in daughters, in order to retain the family wealth and titles within the family. As a result, sibling rivalry effects on children's educational outcomes appear to be stronger in rural areas, where land ownership and inheritance issues are more important for families. In contrast, the ratio of boys to girls depends not only on pro-male bias, but also on the accessibility of sex-selective abortion technology. With limited availability of sex-selective abortion facilities, families in rural areas may have to opt for diverting resources to sons from daughters, since they cannot achieve the desired sex-ratio by sex-selective abortions. Some supporting evidence can be seen in Goodkind (1996) and Lin, Liu and Qian (2008).

5.4 Another approach - using firstborn singletons

In an attempt to examine the representativeness of our twins estimates, this subsection compares our estimates with the earlier results in Chen, Chen, and Liu (2008), based on the data of the firstborn singletons population. There, we tested the hypothesis that the sex of the second-born has no effect on the firstborn's college enrollment, using the same data sources and similar specifications as in this paper. We focused on educational achievements of firstborn singletons who were born during the years 1978 to 1984, the same pre-abortion period that has been studied in this paper. As Table 1b has suggested, this population exhibited a seemingly balanced sex ratio, about 104.2 boys to every 100 girls. However, by the time the siblings of this singletons population were born, abortion laws had been legalized and technology for sex-selective abortions had started to be widespread. Consequently, second-born singletons had a less balanced sex ratio, about 106.5 boys to every 100 girls, although the sex ratio of the first-borns seemed balanced. Thus, while the sex of the firstborn child could be taken as a random event, the incident that the second child is a boy might be a consequence of sex-selective abortions. To the extent that parents who would resort to sex-selective abortions are most likely to divert family resources to a son from daughters, our earlier estimates for singletons may have overstated the net rivalry effect of male siblings on women's education.

Nevertheless, the firstborns' results in Table 6, using the same covariates and specifications as of twins in Column (4) of Table 4, resemble twins' results reported in this paper. OLS estimates in Column (1) of Table 6 indicate that the estimated coefficients of the brother indicator are nearly zero. The net rivalry effect on firstborn girls is about 0.34 percentage points, and that for firstborn boys is even smaller. Furthermore, as columns (2) to (6) show in the set of firstborn singletons' results, two-stage least squares estimates that use twinning at the second birth to instrument family size also exhibit similar results. The firstborn singletons data provide precise benchmark results, which suggest that having a brother, as opposed to having a sister, has almost no impact on women's or men's college enrollments. The new evidence based on the twins population in this paper echoes this finding.

6 Concluding Remarks

This paper estimates the causal impact of a change in sibling sex composition on children's educational achievements. Based on a matched administrative data of entire Taiwan, identification is achieved by a unique natural experiment of twins gender shocks, given that the twin sex is random conditional on the sex of the other twin. We focus on the period 1978-1984 when abortions were illegal and sex-selectively aborting one of the two twins was technically impossible. The statistics show that sex composition of firstborn twins was virtually random. The twins' estimates show no evidence of negative effects of having a brother, relative to a sister, on women's or men's college attainment. This result remains robust even if we control for a function of family size and/or birthweights. The finding based on firstborn twins also echoes our earlier estimates based on firstborn singletons.

Although Taiwanese' son preference has been diminishing in recent decades, pro-male bias in fertility choice remains markedly strong. For example, during the years 1996 to 2003, when the analyzed cohorts turned 18, the sex ratio of boys to girls continues to rise, and parents still strongly favor having two boys over mixed-sex children, for the first two births. However, since 1989, share of girls enrolling in college has been higher than of boys, by 2 to 3 percentage points on average, in spite of the strong pro-male bias in fertility choices. Lack of evidence of discrimination against girls in household expenditures – even in economies where a strong pro-male bias is known such as India, Bangladesh and Pakistan – has also been noted by Deaton (1989, 1997), Subramanian and Deaton (1990), Subramanian (1995), Bhalotra and Attfield (1998), Ahmad and Morduch (2002), Case and Deaton (2003), and Kingdon (2005).

While the rationale behind this phenomenon awaits further investigations, recent studies on parents' behavioral responses to a son's birth provide possible interpretations for our findings. For example, some evidence has suggested that a son's birth, relative to a daughter's, motivates the father to earn more, the mother to work less, or the parents to reside together and to have more stable relationships.[10] If the parental response to a son's birth can also benefit daughters, the rivalry and spillover effects of the son on daughters may have canceled out each other in the process of the home production of human capital. Our ongoing research is exploring these possibilities.

[10]See, e.g., Rose (2000), Lundberg and Rose (2002, 2003), Morgan and Pollard (2002), Lundberg (2005), Bedard and Deschenes (2005), Ananat and Michaels (*forthcoming*), and Moretti and Dahl (*forthcoming*); see Lundberg (2005) for some literature reviews.

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Figure 1: College Enrollment Rates of Firstborn Girls by Birthweight

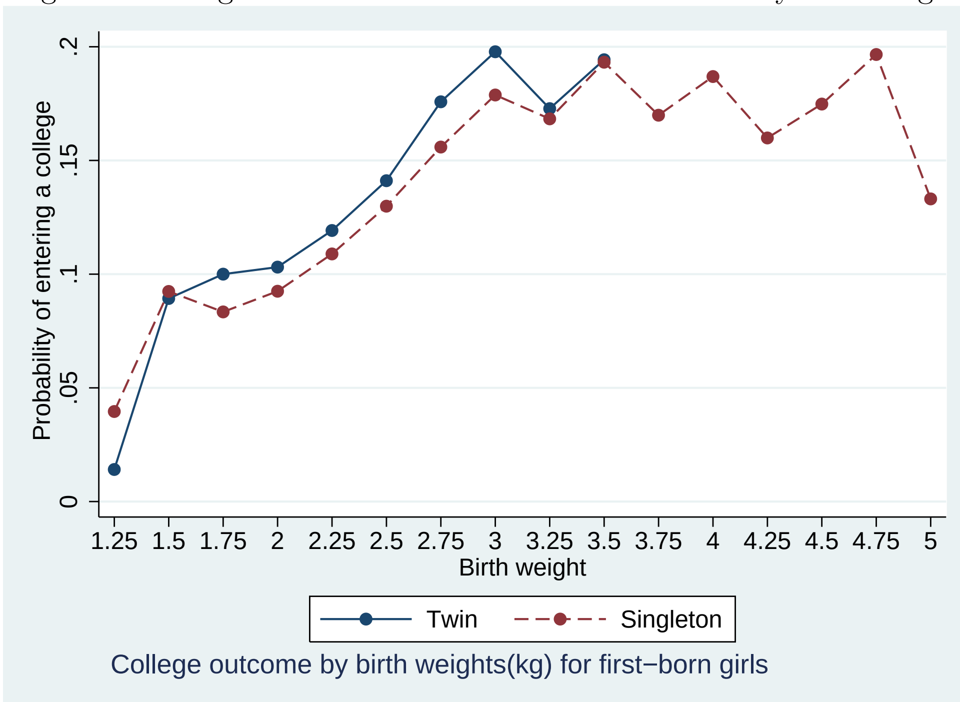

Figure 2: College Enrollment Rates of Firstborn Boys by Birthweight

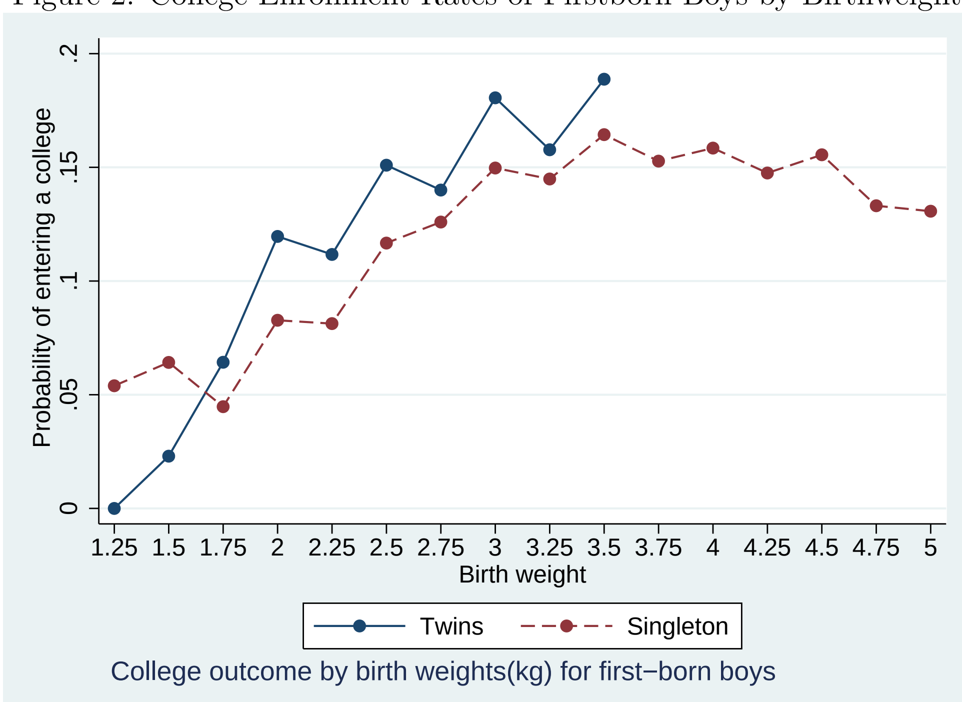

Table 1a. The probability distribution of firstborn twins' sex composition

	Twin 1		
	Female	Male	Marginal distribution
Twin 2			
Female	0.4297	0.0722	0.5019
Male	0.0722	0.4259	0.4981
Marginal distribution	0.5019	0.4981	

Source: Taiwan birth registry records from 1978 to 1984.

Table 1b. The probability distribution of first two singletons' sex composition

	Singletons 1st		
	Female	Male	Marginal distribution
Singleton 2nd			
Female	0.2362	0.2480	0.4842
Male	0.2534	0.2624	0.5158
Marginal distribution	0.4896	0.5104	

Source: The same as Table 1a.

Table 2a: Descriptive Statistics

Variables	Mean (standard deviation in parentheses)	
	Firstborn Twins	**Firstborn Singletons**
Boy-to-girl ratio	0.992	1.042
	(0.500)	(0.500)
Family size	2.837	2.698
	(0.895)	(0.808)
College enrollment rate	0.146	0.165
	(0.352)	(0.371)
Age of mother at birth	24.333	23.448
	(3.642)	(3.336)
Mothers' birth year	1956	1957
	(3.944)	(3.737)
Fathers' birth year	1953	1954
	(5.129)	(4.584)
Mothers' highest grade completed		
College or above	0.037	0.028
	(0.187)	(0.166)
Professional training degree	0.056	0.040
	(0.229)	(0.197)
High School	0.069	0.061
	(0.254)	(0.238)
Vocational HS	0.209	0.187
	(0.406)	(0.389)
Junior HS	0.244	0.259
	(0.429)	(0.438)
Fathers' highest grade completed		
College or above	0.088	0.062
	(0.282)	(0.242)
Professional training degree	0.086	0.072
	(0.279)	(0.259)
High School	0.089	0.091
	(0.284)	(0.288)
Vocational HS	0.177	0.176
	(0.382)	(0.381)
Junior HS	0.214	0.231
	(0.410)	(0.421)
Birth weight (kg)	2.472	3.211
	(0.532)	(0.445)
Born in urban	0.405	0.341
	(0.491)	(0.474)
Sample size	11,998	893,157

Source: The birth registry records from 1978 to 1984, matched with college entranc test records of 1996 to 2003 while children turn 18. Singleton data are drawn from families with at least two children. Urban areas refer to cities of Taipei, Taichung, Kaoshiung, or Taipei county.

Table 2b: Descriptive Statistics of firstborn girls, by sibling sex composition

Variables	Firstborn female twin			Firstborn female singleton		
	with a boy twin	with a girl twin	Diff=(2)-(1)	with a 2nd-born brother	with a 2nd-born sister	Diff=(5)-(4)
	(1)	(2)	(3)	(4)	(5)	(6)
Family size	2.627	3.097	0.470	2.620	3.051	0.431
	(0.784)	(0.962)	[0.000]	(0.751)	(0.921)	[0.000]
College enrollment rate	0.157	0.144	-0.013	0.172	0.169	-0.003
	(0.363)	(0.352)	[0.203]	(0.377)	(0.374)	[0.040]
Age of mother at birth	25.070	24.168	-0.902	23.483	23.444	-0.039
	(3.573)	(3.652)	[0.000]	(03.349)	(3.358)	[0.000]
Mothers' birth year	1956	1956	0.000	1957	1957	0.000
	(3.911)	(3.946)	[0.694]	(3.749)	(3.756)	[0.226]
Fathers' birth year	1953	1953	0.000	1954	1954	0.000
	(5.097)	(5.160)	[0.495]	(4.602)	(4.646)	[0.092]
Mothers' highest grade completed						
College or above	0.051	0.033	-0.018	0.029	0.028	-0.001
	(0.219)	(0.177)	[0.000]	(0.167)	(0.164)	[0.009]
Professional training degree	0.073	0.059	-0.014	0.041	0.040	-0.001
	(0.259)	(0.235)	[0.037]	(0.198)	(0.196)	[0.314]
High School	0.065	0.072	0.007	0.061	0.061	0.000
	(0.246)	(0.257)	[0.329]	(0.239)	(0.239)	[0.999]
Vocational HS	0.219	0.197	-0.022	0.188	0.186	-0.002
	(0.413)	(0.397)	[0.047]	(0.390)	(0.388)	[0.062]
Junior HS	0.228	0.241	0.013	0.258	0.259	0.001
	(0.419)	(0.428)	[0.257]	(0.437)	(0.438)	[0.311]
Fathers' highest grade completed						
College or above	0.105	0.080	-0.025	0.063	0.062	-0.001
	(0.306)	(0.270)	[0.001]	(0.243)	(0.241)	[0.111]
Professional training	0.100	0.086	-0.014	0.073	0.072	-0.001
degree	(0.299)	(0.280)	[0.082]	(0.259)	(0.258)	[0.215]
High School	0.088	0.088	0.000	0.092	0.091	-0.001
	(0.283)	(0.283)	[0.989]	(0.289)	(0.287)	[0.103]
Vocational HS	0.193	0.176	-0.017	0.176	0.175	-0.001
	(0.395)	(0.380)	[0.105]	(0.381)	(0.380)	[0.358]
Junior HS	0.204	0.214	0.010	0.229	0.232	0.003
	(0.403)	(0.410)	[0.400]	(0.420)	(0.422)	[0.027]
Birth weight (kg)	2.503	2.417	-0.086	3.164	3.161	-0.003
	(0.477)	(0.525)	[0.000]	(0.431)	(0.434)	[0.013]
Born in urban	0.430	0.387	0.956	0.344	0.342	0.998
	(0.495)	(0.487)	[0.001]	(0.475)	(0.474)	[0.128]
Sample size	1,732	5,156		226,254	211,077	

Note: Same as Table 2a. Standard deviations in (.); p-values in [.].

Table 3: Son preference -- the effect of sibling sex composition on family size

	All families with at least 2 kids		Non-urban areas	High school graduated mothers
	(1)	(2)	(3)	(4)
A) Firstborn twins				
Two girls	0.456	0.421	0.467	0.328
	(0.023)	(0.023)	(0.032)	(0.031)
Mixed gender	0.048	0.048	0.080	0.040
	(0.029)	(0.031)	(0.044)	(0.038)
Parental education controls	No	Yes	Yes	Yes
R-squared	0.186	0.203	0.187	0.178
Sample size	11,998	11,998	7,133	4,399
B) Firstborn singletons				
Two girls	0.533	0.531	0.581	0.407
	(0.002)	(0.002)	(0.003)	(0.003)
Mixed gender	0.099	0.099	0.113	0.060
	(0.002)	(0.002)	(0.002)	(0.002)
Parental education controls	No	Yes	Yes	Yes
R-squared	0.161	0.186	0.172	0.136
Sample size	893,157	893,157	588,197	280,379

Note: Control variables in all specifications include a full set of dummies for children's birth place an
year, mother's age at first birth parental age. Parental education controls include a full set of dummies for mothers' and fathers' categorical education. Standard errors in (.)

Table 4: The effect of twins' sex composition on college enrollments

	(1)	(2)	(3)
A) Firstborn girls			
B=1 if sibling is boy	-0.0098	-0.0135	-0.0158
	(0.0139)	(0.0136)	(0.0139)
Birthweight (kg) of subject			0.0411
			(0.0103)
Birthweight (kg) of twin sibling			0.0084
			(0.0097)
Parental education	No	Yes	Yes
R-squared	0.0892	0.0935	0.1519
Sample size	6,022	6,022	6,022
B) Firstborn Boys			
B=1 if sibling is boy	-0.0042	-0.0022	-0.0001
	(0.0139)	(0.0134)	(0.0135)
Birthweight (kg) of			0.0458
			(0.0107)
Birthweight (kg) of			-0.0052
			(0.0106)
Parental education	No	Yes	Yes
R-squared	0.0713	0.0774	0.1199
Sample size	5,976	5,976	5,976

Note: All specifications include the same set of covariates as Table 3. The cross terms between sibling sex and parental education, if included, are all insignificant at the 5 percent

Table 5a: The effect of twins' sex composition on college enrollments, by mothers' education

	High school graduated mother			Less educated mother		
	(1)	(2)	(3)	(5)	(6)	(7)
A) Subject=First-born girls						
B=1 if sibling is boy	-0.0393	-0.0420	-0.0462	-0.0025	-0.0024	-0.0037
	(0.0270)	(0.0269)	(0.0272)	(0.0144)	(0.0143)	(0.0147)
Birthweight (kg) of subject			0.0575			0.0246
			(0.0205)			(0.0112)
Birthweight (kg) of twin sibling			0.0337			-0.0057
			0.0202			0.0104
Parental education	No	Yes	Yes	No	Yes	Yes
R-squared	0.1159	0.1188	0.1485	0.0667	0.0839	0.0871
Sample size	2,189	2,189	2,189	3,833	3,833	3,833
B) Subject=First-born boys						
B=1 if sibling is boy	-0.0326	-0.0291	-0.0269	0.0158	0.0155	0.0170
	(0.0269)	(0.0262)	(0.0263)	(0.0141)	(0.0139)	(0.0141)
Birthweight (kg) of subject			0.0922			0.0186
			(0.0224)			(0.0109)
Birthweight (kg) of twin sibling			-0.0007			-0.0087
			0.0225			0.0107
Parental education	No	Yes	Yes	No	Yes	Yes
R-squared	0.0897	0.0964	0.1272	0.0654	0.0692	0.0894
Parental education	No	Yes	Yes	No	Yes	Yes
Sample size	2,210	2,210	2,210	3,766	3,766	3,766

Note: Same as Table 4. The college enrollment rate for firstborn twin girls who bore to a high school graduated mother is 0.2435, while that for those who bore to a less educated mother is 0.1093.

Table 5b: The effect of twins' sex composition on college enrollments, by place of birth

	Born in a rural area			Born in an urban area		
	(1)	(2)	(3)	(5)	(6)	(7)
A) Subject=First-born girls						
B=1 if sibling is boy	-0.0201	-0.0299	-0.0334	0.0104	0.0151	0.0148
	(0.0172)	(0.0170)	(0.0173)	(0.0238)	(0.0231)	(0.0235)
Birthweight (kg) of subject			0.0322			0.0523
			(0.0120)			(0.0189)
Birthweight (kg) of twin sibling			0.0169			-0.0062
			0.0109			0.0187
Parental education	No	Yes	Yes	No	Yes	Yes
R-squared	0.0942	0.0994	0.1497	0.1092	0.1121	0.1788
Sample size	3,656	3,656	3,656	2,366	2,366	2,366
B) Subject=First-born boys						
B=1 if sibling is boy	-0.0095	0.0007	0.0011	0.0008	-0.0057	-0.0027
	(0.0179)	(0.0173)	(0.0177)	(0.0227)	(0.0218)	(0.0217)
Birthweight (kg) of subject			0.0176			0.0869
			(0.0137)			(0.0173)
Birthweight (kg) of twin sibling			-0.0083			0.0017
			(0.0141)			(0.0167)
Parental education	No	Yes	Yes	No	Yes	Yes
Parental education	No	Yes	Yes	No	Yes	Yes
R-squared	0.0736	0.0790	0.1264	0.0854	0.0910	0.1322
Sample size	3,477	3,477	3,477	2,499	2,499	2,499

Note: Same as Table 4. The college enrollment rate for firstborn twin girls born in a rural area is 0.1283, while that for those in a urban area is 0.1741.

Table 6: The effect of sibling sex composition on firstborn singletons' college enrollments

	OLS	2SLS Instrumenting family size with twins at 2nd birth	Birth areas: Non-urban	Birth areas: Urban	Mother's education: HS graduated	Mother's education: Less educated
	(1)	(2)	(3)	(4)	(5)	(6)
A) Subject=First-born Girls						
B=1 if sibling is boy	0.0013	-0.0062	-0.0033	-0.0108	-0.0101	-0.0032
	(0.0011)	(0.0047)	(0.0065)	(0.0066)	(0.0067)	(0.0062)
Birthweight (kg) of subject	0.0198	0.0205	0.0205	0.0204	0.0290	0.0169
	(0.0013)	(0.0013)	(0.0015)	(0.0025)	(0.0030)	(0.0014)
Birthweight (kg) of twin sibling	0.0038	0.0025	0.0046	-0.0008	0.0006	0.0033
	(0.0012)	(0.0014)	(0.0017)	(0.0024)	(0.0030)	(0.0015)
Family size		-0.0180	0.0037	-0.0229	-0.0291	-0.0118
		(0.0107)	(0.0138)	(0.0171)	(0.0180)	(0.0130)
Parental education	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	437,331	437,331	287,284	150,047	137,287	300,044
B) Subject=First-born Boys						
B=1 if sibling is boy	-0.0001	-0.0006	-0.0001	-0.0025	-0.0003	-0.0011
	(0.0010)	(0.0014)	(0.0018)	(0.0022)	(0.0026)	(0.0022)
Birthweight (kg) of subject	0.0186	0.0190	0.0180	0.0209	0.0228	0.0173
	(0.0012)	(0.0012)	(0.0014)	(0.0022)	(0.0028)	(0.0012)
Birthweight (kg) of twin sibling	0.0015	0.0007	0.0011	-0.0001	-0.0015	0.0014
	(0.0012)	(0.0012)	(0.0015)	(0.0022)	(0.0029)	(0.0014)
Family size		-0.0079	-0.0097	-0.0057	-0.0082	-0.0113
		(0.0093)	(0.0120)	(0.0150)	(0.0187)	(0.0169)
Parental education	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	455,826	455,826	300,913	154,913	143,092	312,734

Note: Same as Table 4. The firstborn results are based on Chen, Chen, and Liu (2008). R-squares of the OLS regressions range between 0.09 and 0.12

Table A1: Descriptive Statistics of firstborn twin boys

Variables	Firstborn male twin		
	with a girl twin	with a boy twin	Diff=(2)-(1).
	(1)	(2)	(3)
Family size	2.627	2.646	0.019
	(0.784)	(0.788)	[0.387]
College enrollment rate	0.157	0.134	-0.023
	(0.363)	(0.340)	[0.015]
Age of mother at birth	25.070	24.250	-0.820
	(3.573)	(3.625)	[0.000]
Mothers' birth year	1956	1956	0.000
	(3.911)	(3.939)	[0.129]
Fathers' birth year	1953	1953	0.000
	(5.097)	(5.103)	[0.115]
Mothers' highest grade completed			
College or above	0.051	0.036	-0.015
	(0.219)	(0.185)	[0.005]
Professional training degre	0.073	0.047	-0.026
	(0.259)	(0.212)	[0.000]
High School	0.065	0.069	0.004
	(0.246)	(0.252)	[0.564]
Vocational HS	0.219	0.217	-0.001
	(0.413)	(0.412)	[0.902]
Junior HS	0.228	0.253	0.025
	(0.419)	(0.434)	[0.004]
Fathers' highest grade completed			
College or above	0.105	0.090	-0.014
	(0.306)	(0.286)	[0.078]
Professional training	0.100	0.080	-0.020
degree	(0.299)	(0.271)	[0.011]
High School	0.088	0.090	0.001
	(0.283)	(0.286)	[0.851]
Vocational HS	0.193	0.173	-0.020
	(0.395)	(0.378)	[0.055]
Junior HS	0.204	0.218	0.013
	(0.403)	(0.413)	[0.239]
Birth weight (kg)	2.503	2.516	0.013
	(0.477)	(0.551)	[0.379]
Rural areas	0.570	0.584	0.044
	(0.495)	(0.493)	[0.311]
Sample size	1,732	5,156	

Note: same as Table 2. Standard deviation in (.); and P-values in [.].

Table A2: 2SLS Results for first-born singletons, by area and by mother's education

	Area		Mother's education	
	Rural	Urban	HS graduated or more	Less educated
	(1)	(2)	(3)	(4)
A) Subject=First-born Girls				
B=1 if sibling is boy	-0.0033	-0.0108	-0.0101	-0.0032
	(0.0065)	(0.0066)	(0.0067)	(0.0062)
Family size	0.0037	-0.0229	-0.0291	-0.0118
	(0.0138)	(0.0171)	(0.0180)	(0.0130)
Birthweight (kg) of	0.0205	0.0204	0.0290	0.0169
subject	(0.0015)	(0.0025)	(0.0030)	(0.0014)
Birthweight (kg) of	0.0046	-0.0008	0.0006	0.0033
twin sibling	(0.0017)	(0.0024)	(0.0030)	(0.0015)
Parental education	Yes	Yes	Yes	Yes
Sample size	287,284	150,047	137,287	300,044
B) Subject=First-born Boys				
B=1 if sibling is boy	-0.0001	-0.0025	-0.0003	-0.0011
	(0.0018)	(0.0022)	(0.0026)	(0.0022)
Family size	-0.0097	-0.0057	-0.0082	-0.0113
	(0.0120)	(0.0150)	(0.0187)	(0.0169)
Birthweight (kg) of	0.0180	0.0209	0.0228	0.0173
	(0.0014)	(0.0022)	(0.0028)	(0.0012)
Birthweight (kg) of	0.0011	-0.0001	-0.0015	0.0014
	(0.0015)	(0.0022)	(0.0029)	(0.0014)
Parental education	Yes	Yes	Yes	Yes
Sample size	300,913	154,913	143,092	312,734

Note: Covariates include parental ages, mother's age at first birth, year dummies, and birth place. Parental education includes a full set of dummies for categorical education. If interactions between sibling gender and parental education are included, the coefficients are all insignificant at the 5 percent level. In singletons sample, we use twins at 2nd birth as the instrument for family size.