The Impact of Sibling Sex Composition on Educational Attainment: A Unique Natural Experiment by Twins Gender Shocks

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Abstract

Brothers may reduce the parental attention and investment received by female siblings when parents with a pro-male bias face time or financial constraints. This paper uses exogenous gender shocks of *first-born twins* to estimate the impact of sibling sex composition on college attendance in a highly sex-imbalanced economy, Taiwan. Gender composition of first-born twins – before sex-selective abortion became widely available, and before the technology for aborting one of the twins was initially developed – is nearly random. Their sex ratio almost equals unity. We also took unusual steps to measure sibling sex composition and educational outcomes accurately. We obtain accurate measures of birth order and educational achievement by linking the national birth registry to administrative records of college entrance tests. The estimates show that sibling sex composition has almost no effects on men's or women's college attendance, contrary to what previous estimates have suggested.

1 Introduction

The phenomenon of "Missing Women," a term coined by Amartya Sen (1990) indicating an exceedingly imbalanced sex ratios at birth in Asia and North Africa, is the starkest manifestation of female inequality at home. Unequal allocation of family resources between sons and daughters is a primary reason why surviving women have less access to education than men in developing countries. If son-preferring parents divert family resources from daughters to a son, due to time or financial constraints, the daughters can be less educated than if they had a sister, instead of a brother.

The rivalry effect of male offsprings on the educational outcomes of women or men can be particularly pervasive among *twins.* Some evidence has noted that close spacing of siblings constrains the allocation of family resources, which in turn lowers educational attainments. The consequence of a twin birth is both to increase family size and to adversely affect both twin siblings because of no spacing.

This paper uses the gender shocks of first-born twins to identify the causal effect of sibling sex composition on educational achievement. We use the sample of first-born twins, born before sex-selective abortion became widely available, and before the technology for aborting one of the twins was initially developed. Our goal is to ensure that the estimated impact of sibling sex composition on education is not confounded by sex-selective abortions. This goal is achieved by taking advantage of the fact that sex composition of first-born twins during the pre-abortion period is plausibly exogenous. We use the variation in twins sex composition to identify its impact on college enrollment. For the purpose of this study, we construct a mother-based birth data, by tracing all births by each mother, and match the children to their college entrance test records. This unique data provides a simple, accurate, and powerful method for assessing the role of sibling sex composition in determining college attendance.

The results of our study indicate that the effect of sibling sex composition may have been overstated in the past. We find no impact of sibling sex composition on men's or women's opportunity to enroll in college, irrespective of specifications of regression models. Our previous result, using the sample of *singletons*, also indicates little correlation between sibling sex composition and college attendance. These findings are contrary to earlier estimates suggesting a sizable effect of sibling sex composition on educational outcomes, especially on women's.[1]

We begin this paper with a description of the matched administrative data. We document the degree of Taiwanese preference for sons, by the estimated effect of sibling sex composition on family size. We next report the detailed results of our study of the sibling-gender effects on women's college enrollment. In the final section of the paper, we summarize and provide plausible explanations for our findings.

2 Extraordinarily Strong Preferences for Sons

Taiwanese preference for sons is remarkably strong because in the Confucian tradition, daughters leave the family household at the time of marriage and carry dowry to the husband's family. In contrast, sons inherit family wealth, and are expected to take care of parents in their old age. The Confucian thought and discipline that systematically justifies the preference for male offsprings over females, such as *Analects* (ca 479 BCE), has remained a dominant component of the educational curriculum in Taiwan for centuries.

[1]Ashish Garg and Jonathan Morduch (1998) and Morduch (2000) suggest that males may become rivals of other siblings, competing for family resources. Using Taiwanese data, William Parish and Robert Willis (1993) suggest a stronger rivalry effect of male siblings on girls than on boys. Alternatively, the gender role of sons may affect their female siblings through a non-resource-based channel. Kristin Butcher and Ann Case (1994) find that boys' masculine traits may help their sisters to develop positive attitudes toward greater educational achievement. In contrast, Robert Kaestner (1997) suggests little correlation between sibling gender composition and educational attainments of children in case of later cohorts.

2.1 Matching Administrative Data Sets

Our statistics and estimates are based primarily on the national birth registry records of Taiwan, which cover all of the 7,053,190 children born between 1978 and 1999, and provides detailed information about the birth date, order, place, weight, and parental age and education. For the purpose of this study, we match mothers to children by their Unique Identification Numbers (UIN) and construct a *mother-based sample* by tracing all births by each mother, until 1999. We restrict the sample to children born between 1978 and 1984, before legalization of abortion (that is, the *Eugenics Protection Law*). During this period, the mothers in our sample were 15 to 50 years old.

We use the mother-based sample in order to ensure an accurate measure of completed family size and sibling sex composition of each family. Our data indicate that no mother in our sample had another child after 1997, suggesting that our measurements of completed family size and sibling sex composition are very accurate. We further match the mother-based sample to the national administrative records of college entrance tests between 1997 and 2003, in order to derive precise information about college attendance of all children at the age of 18.

We analyze samples of twins and singletons separately. We focus on those who were the first-borns of the family, because later-born children's gender can be related to the sex composition of their earlier-born siblings. As Table 3 shows, the sex ratio among the first-born twins almost equals the natural rate (p-value=1.0). Sibling sex composition of the twins sample seems random; the probability of having boy twins is virtually equal to the probability of having girl twins (p value=1.0). In contrast, sex composition of first two singletons appears to be non-random; the probability of having two boys is about 3 percentage points higher than the probability of having two girls (p-value¡.01).

Table 1 provides descriptive statistics of the first-born twins, with the variables that we study below. To measure the extent to which the twins and the singletons share similar demographics and backgrounds, we also report data from the first-born singletons for comparison purposes. Two things stand out in the table: first, our sample of twins has larger families, and older and more educated parents, while the twins have slightly lower college enrollment rates than the singletons; second, the maternal age at birth is narrowly distributed around 23.4 and 24.3, with standard deviations ranging from 3.3 to 3.6. In our regressions we control the full sets of parental age, education and maternal age at the first birth.

2.2 Effects of Sibling Sex Composition on Family Size

Differential fertility decisions of parents to achieve a desirable number of sons has been used to measure the degree of son preference, at least since Yoram Ben-Porath and Finis Welch (1976). In our data, Taiwanese families with two daughters are nearly 30 percentage points more likely to have a third child than those with two sons. In contrast, the same estimates of the U.S. or Israeli Censuses are less than two percentage points.[2] Other ways to measure the degree of son preference include the use of direct survey questions and estimation of the impact of child gender on marriage stability, family expenditure on housing, or fathers' labor supply and earnings.[3] While the previous measures of son preference are mostly based on the U.S. data, only a few similar estimates using data from Asia have been documented.

This subsection estimates the degree of son preference by the effect of sibling sex composition on family size. Table 2 suggests that families with both girls at the first and second births have 0.52 more children than those with both boys (s.e.=0.023). Given that the average family size is about 2.8, the estimate indicates an extraordinarily strong

[2]See Ben-Porath and Welch (1976), Joshua Angrist and William Evans (1998), and Angrist, Victor Lavy, and Analia Schlosser (2006).

[3]See Elizabeth Ananat and Guy Michaels (2004), Gordon Dahl and Enrico Moretti (2004), Shelly Lundberg and Elaina Rose (2002, 2003, 2007), and Rose (2000).

pro-male bias, much stronger than available estimates of other regions. The degree of son preference is slightly smaller for families with twins than with singletons. Having girl twins at the first birth increases family size by 0.42, relative to having boy twins (s.e.=0.022). It is noteworthy that unlike American families significantly preferring mixed-sex to same-sex sibling composition, average Taiwanese parents with two or more children strongly prefer two boys to mixed-sex offsprings.

3 Effects of Sibling Gender on Children's Education

3.1 Conceptual Model and Identification Strategy

Given that Taiwanese have a strong preference for sons, the key issue in identifying the impact of sibling sex composition on educational outcome is the endogeneity of child gender. On the one hand, the phenomenon of "missing women," made possible by sex-selective abortions, most likely came from families that would have allocated their resources in favor of sons at the cost of daughters. As a result, the effect of sibling sex composition on female survivors' education may *understate* the true effect; that is, the effect in a society where there were no sex-selective abortions. On the other hand, because a son's birth may be a consequence of sex-selective abortions, a son may receive more of the family's resources, at the cost of existing daughters. In this case, the observed contrast in daughters' education by the gender of her sibling *overstates* the true effect.

We address the endogeneity issues of child gender by taking advantage of the fact that the probability distribution of twins' sex composition at birth is nearly random during the pre-abortion period. As Table 3 shows, the probability of girl twins (0.4297) almost equals the probability of boy twins (0.4259). The sex ratio of first-born twins during this period is 0.9924, approximately equal to the natural twins' sex ratio documented in medical literature (Derom, Vlietinck, Derom, van den Berghe, and Thiery 1988). The sex composition of the twins sample represents truly exogenous events that can be used to identify the causal effect of sibling sex composition on children's education.

Assuming momentarily that all twins in our data are dizygotic, we compare the education of a girl who has a twin brother, with the education of a girl who has a twin sister. Because twins sex composition is exogenous, we can use the difference in their educational outcomes to identify the impact of sibling sex composition on women's educational achievements. Similarly, we contrast the education of a boy who has a twin sister, with the education of a boy who has a twin brother, to identify the impact of sibling sex composition on men's educational outcomes. This approach allows us to estimate the causal effect of interest, using simple statistical methods; that is, the difference between college enrollment rates in the treatment and comparison groups (that is, mixed-sex and same-sex twins).

Formally, we denote by y_i the college attendance dummy of the i-th child in the twins sample. Let M_i and m_i denote the male indicators for child i and his or her twin sibling. We also include child i's own birth weight W_i and sibling's birth weight w_i. Consider a parsimonious model of child i's college attendance:

$$y_i = \alpha + \beta_0 m_i + \beta_1 M_i + \beta_2 m_i M_i + \beta_3 W_i + \beta_4 w_i + \varepsilon_i, \tag{1}$$

where α and β_k, for $k = 1, 2, ..., 4$, are parameters. The cross term $m_i M_i$ is included to allow the effect of sibling sex composition to vary with one's own gender. The error term ε_i is assumed to be uncorrelated with sex composition (m_i, M_i) and birth weights (w_i, W_i). The parameters of interest are (β_0, $\beta_0 + \beta_2$); that is, the treatment effects on females and on males.

Furthermore, we include x_i the set of observed family backgrounds, which contains child i's family size, parental age and education, maternal age at the first birth, test-year dummies (i.e. cohort effects), and residential location. Our results show that the results do not change with inclusion of x_i.

One potential concern around this estimation method is that mixed-sex twins must be dizygotic but dizygotic and monozygotic twins are indistinguishable in our data. Thus, the effect of sibling sex composition suggested by dizygotic twins might differ from the effect of sibling sex composition suggested by a comparison between monozygotic and dizygotic twins. The contrast of college enrollment rates between mixed-sex and same-sex twins may simply be a consequence of heterogeneity between dizygotic and monozygotic twins, not a gender shock.[4] Given some medical evidence that MZ twins have higher mortality rates than DZ twins (see Boklage 1987), our estimates of the impact of sibling sex composition on educational outcome tend to *overstate* the true effect.

Another concern is the representativeness of the twins sample. On the one hand, families with twins are more likely to face liquidity constraints, because of the zero spacing between the two, and because of the exogenous increase in family size. The rivalry effects of male siblings can be more pervasive among twins than among singletons. Thus, our twins estimates tend to *overstate* the rivalry effect of male siblings on women's educational outcome. On the other hand, parents with twins can be more in favor of investing in sons and daughters equally, relative to those with singletons. As a result, other things being equal, a girl who has a twin brother tends to be more educated than a girl who has a singleton brother. Thus, our twins estimates may *understate* the detrimental effect of male siblings on women's education.

Another potential issue is that omitted family backgrounds in equation (1) can be correlated with sibling sex composition and children's educational outcomes simultaneously. One importance source of the simultaneous bias is son preference. Because parents with a pro-male bias tend to have more children to ensure the birth of a male offspring, boys tend to be brought up in a smaller family, which in turn increases parental investment in each sibling. The estimates in Table 2 show that mixed-sex twins have 0.37 fewer siblings

[4]See discussions in Plomin, DeFries, and McClearn (1990) and Goldberger and Kamin (1998) on genetic differences between monozygotic and dizygotic twins.

than girl twins. This suggests that omission of family size may lead to an understatement the rivalry effect of a male sibling on women's education. In contrast, the results of the sibling-gender effect on men's education may not suffer from omission of family size, since family size is about the same for boy twins and mixed-sex twins.

Another possible source of the simultaneous bias is the omission of parental education. More educated parents tend to have a stronger preference for sons. As Edlund (1999) has noted, parents of economically lower status might opt for a daughter because she could marry a man from a wealthier family. Some empirical evidence can be found in our previous work, which shows maternal education is positively associated with son preference for the third child born after 1985. Before 1985, maternal education seems uncorrelated with son preference for the first or second child. In this study, because we use the data from the pre-1985 period and focus on the first- and second- borns, it is most likely that omission of parental education in equation (1) is not an important issue. In fact, we will show that our results do not change with inclusion of parental education or family size.

3.2 Results

Table 4 contains estimated effect of sibling sex composition on college attendance. The impact of having a brother, relative to a sister, on women's education is reported in the first row, i.e. the coefficient of m. The same impact on men's education is represented by the sum of the coefficients of m and $m * M$. The coefficient of M reports the effect of one' own gender on education. As a benchmark, Chen, Chen, and Liu's (2007a) OLS result is reported in column (1), based on the *first-born* children of the entire Taiwanese population during the same period of time (1978-1984). Based on the parsimonious model, our estimate shows a small *positive* association between women's college attendance and the birth of a brother, as opposed to a sister. Omission of family size, however, is the primary reason for this positive association, because a son's birth tends to lower family size and potentially enhance the educational outcome of his siblings. Indeed, after including and instrumenting for family size, column (2) indicates that the correlation becomes significantly *negative*, with a p-value of less than 0.001.

The first-born singletons data provide a set of very precise benchmark estimates. However, subsequent brothers of the first-borns were probably born after 1985, when sex-selective abortion became widely available. The birth of a second-born brother is perhaps a consequence of sex-selective abortions. Thus, the estimate using the first-borns' sample is probably biased toward finding a sizable rivalry effect of male siblings on women's education.

The key results of this paper, in columns (3)-(6) of Table 4, are devoted to address this issue, using the population of *first-born twins*, born during the pre-abortion period (1978-1984). The twins estimates remain very precise and indicate almost no rivalry effects of male siblings on women's college attendance, irrespective of the inclusion of either family size, parental education, or both. The point estimate of the rivalry effect of a male sibling ranges between 0.0042 and 0.0167, with small standard errors of no more than 0.0145. In addition, the twins estimates indicate no impact of sibling sex composition on men's college attendance, similar to our previous finding using the sample of first-born singletons has shown.

We further include the birth weights of the twins in column (6), to take account of individual heterogeneity in initial health conditions. This inclusion captures part of the unobserved heterogeneity between dizygotic and monozygotic twins. This is motivated by the medical evidence that marked size discordance tends to arise in dizygotic than monozygotic twins, because size differences among dizygotic twins reflect different genetic fetal growth potentials, which would not occur in monozygotic twins (Cunningham *et al.* 2005). It is evident that adding the birth weights of the twins has almost no impact on our key result.

4 Concluding Remarks

Even with Taiwanese extraordinarily strong preference for sons, the estimates based on twins show no evidence of negative effects of having a brother (relative to a sister) on women's education. In fact, Taiwanese women have been more likely to enroll in college than men by 2 to 3 percentage points, on average, since 1989, although the sex ratio of boys to girls continues to increase, and remains among the highest in the world.[5]

The findings presented here are important because they show that a strong preference for sons does not necessarily lead to women's education being affected by sibling gender. This indirectly points to a possibility that a son's birth may create external benefits for his female siblings. Chen, Chen, and Liu (2007b) find that Taiwanese mothers work less during the first two years after a son's birth, relative to a daughter's.[6] This suggests that the negative impact of having a brother on daughters' education may be offset by the benefit generated by the increased time spent by the mother on parenting, because of the concern about the son. Moreover, the diminishing (or even reversing) gender gap in the educational wage premium since the late 1990s in Taiwan may be associated with the increasing parental investment in surviving daughters. Our ongoing research is exploring these possibilities.

[5] Similar findings that show little evidence of unequal treatment within the family, even in economies where a strong pro-male bias is well-known, include Deaton (1989, 1997), Subramanian and Deaton (1990), Subramanian (1995), Bhalotra and Attfield (1998), Ahmad and Morduch (2002), and Case and Deaton (2003).

[6] Rose (2000) finds similar results, using data from rural Indian households.

Table 1: Descriptive Statistics

	Mean (standard deviation in parentheses)	
Variables	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 (HS)	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)
HS	0.089	0.091
	(0.284)	(0.288)
Vocational HS	0.177	0.176
	(0.382)	(0.281)
Junior HS	0.214	0.231
	(0.410)	(0.421)
Birth weight	2.472	3.211
	(0.532)	(0.445)
Sample size	11,998	893,157

Source: The birth registry records from 1978 to 1984; singleton births are from family with 2 or more children.

Table 2: Effects of Sex-composition of the first two kids on family size

	Twins at first birth	Singletons at first births
Two girls	0.421	0.524
	(0.022)	(0.023)
Mixed gender	0.047	0.094
	(0.028)	(0.018)
Sample size	11,998	893,157

Note: The reference group is families whose first 2 kids are boys. Control variables include birth place and year; a full set of dummies for parental age and education; and the mother's age at the first birth. Standard errors in (.).

Table 3: The sex distribution of firstborn twins at birth, born between 1978 ad 1984

	Female	Male	Marginal distribution
Female	0.4297	0.0722	0.5019
Male	0.0722	0.4259	0.4981
Marginal distribution	0.5019	0.4981	

Note: Using this table, we can derive $P(M = 1|B = 1) = 0.8551$, $Pr(M = 1|B = 0) = 0.2878$, $Pr(M = 1) = 0.4981$. The sex ratio is 0.9924.

Table 4: Estimates of sibling gender effects on children's college attendance, using first-borns between 1978 to 1984

	Firstborn Singletons		Firstborn Twins			
	(1)	(2)	(3)	(4)	(5)	(6)
m=1 if sibling	0.0032	-0.0215	-0.0042	-0.0165	-0.0167	-0.0161
is boy	(0.0012)	(0.0012)	(0.0145)	(0.0147)	(0.0143)	(0.0144)
M=1 if subject	-0.0191	-0.0435	-0.0069	-0.0191	-0.0197	-0.0241
is boy	(0.0011)	(0.0011)	(0.0147)	(0.0147)	(0.0141)	(0.0137)
m*M	-0.0023	0.0167	0.0021	0.0086	0.0134	0.0146
	(0.0015)	(0.0029)	(0.0232)	(0.0233)	(0.0224)	(0.0224)
Family size	-	-0.0574	-	-0.0321	-0.0196	-0.0171
		(0.0007)		(0.0043)	(0.0042)	(0.0040)
Birthwight (kg)	-	-	-	-	-	0.0420
of subject						(0.0077)
Birthwight (kg)	-	-	-	-	-	-0.0026
of twin sibling						(0.0075)
Parental education	No	Yes	No	No	Yes	Yes
Sample size	893,157	893,157	11,998	11,998	11,998	11,998

Note: Same covariates as Table 2. Columns (1) and (2) are cited from Chen *et al.* (2007a). Column (2) reports the gender effect of the second-born on the first-born's college attendance, using twins at the second birth as an instrument for family size. The other regression results are based GLS.

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