# Effects of Sibship Structure Revisited: Evidence from Intrafamily Resource Transfer in Taiwan

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Numerous studies have consistently found negative effects of sibship size on educational outcomes. Three main explanations of these effects have been offered in the literature: (1) the dilution of family resources, (2) a changing intellectual environment in the family for each succeeding sibling, and (3) unobserved selectivity at the family level. In this article, the authors propose a fourth explanation as an extension of the resource-dilution hypothesis: In a traditional or transitional society where resources from all family members are pooled together, families may sacrifice the educational opportunities of older (female) siblings and use their remittance to compensate the family expenses, particularly when there are younger siblings. With analyses of data from the Panel Study of Family Dynamics (PSFD), the authors found empirical evidence to support this explanation. In particular, they found that the negative effects of sibship size are the strongest for girls with younger brothers and sisters who are spaced apart from them. They interpret this unusual high-order interaction involving sibship size, gender, density, and seniority within the context of Taiwan's patriarchal culture, in which families typically favor boys over girls.



A large body of literature has been devoted to the study of the relationship between the number of siblings—"sibship size"—and educational attainment (see, e.g., Blake 1989; Blau and Duncan 1967; Steelman et al. 2002). A well-accepted finding in the literature is that, at least for the United States and Western Europe, sibship size has been consistently found to be negatively associated with educational attainment. This negative relationship between sibship size and educational attainment is so strong that it has been called "inarguable" (Kuo and Hauser 1997: 73) and "virtually unequivocal" (Steelman et al. 2002: 248).

The interpretation of the causal mechanisms underlying this empirical pattern, however, is still subject to debate. The literature contains three main explanations: (1) the dilution of family resources (e.g., Blake 1981, 1989), (2) a changing intellectual environment for each succeeding sibling (Zajonc and Markus 1975), and (3) unobserved selectivity at the family level (e.g., Guo and VanWey 1999). While the first and third explanations postulate only sibship-size effects but not birth-order effects, the second explanation implies a particular pattern by birth order. All three explanations are silent on the issue of a potential gender asymmetry. The first explanation also suggests that the negative effects of sibship size are particularly acute when siblings are spaced *closely* because the pressure on resources is more severe when several siblings enter schools at about the same time.

In this article, we propose a fourth explanation as an extension of the resource-dilution hypothesis: In a traditional or a transitional society in which resources from all family members are typically pooled together, families may sacrifice the educational outcomes of older, usually female, siblings. These older children join the labor market earlier and remit some of their resources to relax constraints on the family budget, which, in turn, may improve the educational outcomes of younger siblings. Our explanation is based on a combination of three observations. First, family resources are not necessarily fixed and exogenous to the education of children. That is, family resources may include contributions of unmarried children in young adulthood. Second, in some Asian countries with a strong patriarchal culture, family resources may be directed disproportionately toward the education of boys rather than that of girls. Third, for intrafamily transfer of resources to have an impact on the educational outcomes of children in a family, it is necessary that children be spaced *apart,* rather than follow one another in close succession. Thus, contrary to the common wisdom in the literature based on the United States and Western Europe, which describes virtually no birth-order or sex-composition effects (Ernst and Angst 1983; Hauser and Kuo 1998), we postulate high-order interaction effects of the number, gender, density, and seniority of siblings.

The context of our empirical work is post–World War II Taiwan. By analyzing recent data from the Panel Study of Family Dynamics (PSFD), which included roughly 4,000 respondents from cohorts who were born between 1934 and 1976 (inclusive), we found empirical evidence in support of our proposed explanation. In particular, we found that the negative effects of sibship size are the strongest for girls who are spaced apart from their younger siblings, to whom the former could provide potential support. We interpret this unusual high-order interaction involving sibship size, gender, density, and seniority in the context of Taiwan's patriarchal culture, in which families favor boys over girls.



## THEORETICAL ISSUES

### *Explanations for Sibship-Size Effects*

The literature contains three prevailing explanations for the negative association between sibship size and educational outcomes. The dominant explanation is the resource-dilution hypothesis (Blake 1981, 1989). This explanation assumes a fixed total amount of family resources, both emotional and material. Thus, the family resources that are allocated to each child necessarily decrease as an inverse function of the number of children in the family. Only sibship size, not birth order, is assumed to matter.

Downey (1995) showed that some family resources, such as economic resources that are set aside for children's education, follow this predictable decreasing pattern of $1/x$, where $x$ is the number of children. However, other resources, such as the availability of a computer, follow a threshold pattern in which the number of children no longer has a negative effect beyond a certain threshold. If a family's economic resources are diluted because of the need to support multiple children, it follows that the dilution constraint is greater when children are spaced closely than when they are spaced further apart, since children who are spaced closely enter college and need economic support from parents at about the same time. This is exactly what Powell and Steelman (1990, 1993) found. Their work on the particularly acute negative effects of sibship size when siblings are closely spaced lends strong empirical credence to the resource-dilution hypothesis.

Zajonc and Markus (1975) offered a competing hypothesis that they called "confluence" theory. According to this theory, the intellectual environment of the family for a particular child is construed as the averaged combination of parents and all siblings. Parents are assumed to be intellectually superior; the addition of children serves to lower the average intellectual quality, which explains the negative association between sibship size and educational outcomes. This theoretical model is dynamic in that a family's intellectual environment changes when new children are born into the family. As a result, early-born children are less affected by the total sibship size than are late-born children because the former had lived in a family environment with fewer children, which means a higher average intellectual environment, before the later children were born. Clearly, this theory predicts not only sibship-size effects but birth-order effects. Finally, Zajonc and Markus hypothesized that older children benefit from teaching younger children. This teaching function seems to account for two specific findings in their data: (1) only children do worse than first-born children in two-child families, and (2) last-born children seem to be particularly handicapped.

Despite the apparent elegance of confluence theory, it has faced some serious criticisms (e.g., Retherford and Sewell 1991). The most serious problem with the theory is that decades of empirical research do not seem to support the notion that birth order, net of sibship size, affects educational outcomes (Ernst and Angst 1983; Hauser and Sewell 1985). However, it is possible that Zajonc and Markus's (1975) confluence model is too narrowly focused on the intellectual environment. In a traditional or transitional society, such as Taiwan, where children's *economic* resources are pooled together, older siblings may influence the educational outcomes of younger siblings. We discuss the possibility of this type of "confluence" later.

The third prevailing explanation in the literature is simply the possibility that both sibship size and educational outcomes result from unobserved factors at the family level. If this explanation is true, the negative association between sibship size and educational outcomes is spurious but not causal. One possibility, for example, is that parents who do not place a high value on the "quality" of their children's lives may end up having many children *and* not investing much in their education. In this hypothetical scenario, the parents would not necessarily improve the educational outcomes of their children even if they were to have fewer children and thus have extra resources (say, through an extraneous shock, such as infertility). This view is well represented by Guo and VanWey's (1999) study, which tested the hypothesis of family-level unobserved heterogeneity by constructing a fixed-effects model in which the addition of new children was found not to affect the cognitive skills of other children. Critics of Guo and VanWey's study have pointed to (1) its narrow focus on cognitive skills, whereas the literature on sibship size is concerned with the whole range of educational outcomes, and (2) its research design, which necessarily excluded children who were spaced closely—those children who would suffer most according to the resource-dilution model (Downey et al. 1999; Steelman et al. 2002).

## Gender Symmetry versus Asymmetry

With only a few exceptions (e.g., Powell and Steelman 1989), previous studies on the three prevailing explanations have assumed gender symmetry in their discussions of sibship effects on males and females. The main reason for this practice, of course, is that the literature is largely based on data from the United States and Western Europe. In these areas, although women's educational attainment historically lagged behind that of men, this gender gap has now disappeared or even been reversed (Shavit and Blossfeld 1993). Even when women were disadvantaged educationally, this disparity at the societal level did not translate into a sex-composition effect of sibship on one's educational attainment at the family level (Hauser and Kuo 1998). In other words, girls in families with no brothers or with many brothers fared similarly—attaining less education than boys overall. However, in an article that was written specifically to dispel the notion that the sex composition of siblings may affect educational attainment, Hauser and Kuo (1998: 645) explicitly allowed for an exception in East Asian countries, "where there is a strong preference for sons."

How does the preference for sons translate into family practices that generate gender inequality in educational outcomes in East Asia? It is *not* merely a matter of parents spending more material resources on sons' than on daughters' education. As Greenhalgh (1985) forcefully argued and Parish and Willis (1993) convincingly demonstrated, the key to understanding the implications of the preference for sons for gender inequality in a Confucian culture, such as Taiwan, lies in intrafamily resource transfers.

At the risk of oversimplification, let us give a stylized description of the patriarchal family that is typical in East Asian countries under Confucian influence, drawing on the work of Greenhalgh (1985) and Parish and Willis (1993). We realize that a great deal of variability exists in the applicability of this description across individual families and over time (Thornton and Lin 1994). In the traditional Taiwanese family system, sons are permanent members of their natal families and retain lifetime contractual relationships with their parents. They are expected to contribute to their parents' economic well-being throughout their adult lives. Thus, it is "rational," or in their self-interest, for parents to invest in sons because they can reap the benefits of the investment over a long period. In contrast, daughters are only transitory members of their natal families before their marriage, upon which they move to and contribute to the families of their parents-in-law, although daughters are expected to contribute to their natal families before they marry. Thus, the time during which daughters contribute to their natal families is limited, and education, as human capital, takes time both to occur and to yield a return (Mincer 1974). As a result, parents mobilize resources from their daughters, particularly their unmarried older daughters, to improve the family budget, in general, and sometimes to benefit the educational outcomes of their sons. The resources in question are primarily remittances from daughters' market labor but can also be household work, which frees parents to work longer hours. In Greenhalgh's (1985: 276) words, "Put baldly, parents' *key strategy* was to take more from daughters to give more to sons and thus get more for themselves."



## Close Spacing versus Distant Spacing

The family system just depicted for Taiwanese society and other East Asian countries undermines a basic assumption in the classical resource-dilution model, which assumes that family resources that are available to facilitate children's education are entirely downward, from parents to children, and thus are exogenous and fixed with respect to children's educational outcomes. As we described earlier, in a traditional Taiwanese family, unmarried children can directly contribute economic resources to the family by working and thus help fund their family's expenses. Although theoretically both daughters and sons could help support their siblings' education, the daughters' education is usually sacrificed to help the sons' education.

In the classical resource-dilution model, which assumes only the downward flow of resources, resources are highly constrained when children are spaced closely. Indeed, Powell and Steelman's (1990, 1993) finding that the negative sibship-size effects are most pronounced for closely spaced siblings provides strong support for the resource-dilution explanation. However, in the Taiwanese context, we can observe the negative effect of having younger brothers on an older sister's educational attainment only if there is sufficient spacing between the sister and her younger brothers. That is, the economic resources of older sisters can be diverted to help fund the education only of *much* younger brothers. Thus, contrary to Powell and Steelman's claim, we may observe a stronger effect of sibship size when spacing is *far apart,* rather than when it is close. Our consideration of spacing represents an important improvement over prior work by Greenhalgh (1985) and Parish and Willis (1993).

## Seniority Symmetry versus Asymmetry

Given the normative path of education and then work, the transfer of resources among siblings usually flows from older siblings to younger siblings. This seniority asymmetry implies a birth-order effect: Early-born children, particularly daughters, may discontinue their education early to work and to fund the education of their younger siblings. Given the large literature, based on data from the United States and Western Europe, that has refuted the claim that educational outcomes differ by birth order given sibship size (Blake 1989; Ernst and Angst 1983; Hauser and Sewell 1985; Steelman et al. 2002), it may seem odd that we are reintroducing a birth-order effect for the case of Taiwan.

Our reason for reintroducing a birth-order effect is the argument that there is an intrafamily transfer of resources across siblings in Taiwan, in the form of an older sibling supporting a younger sibling. As Parish and Willis (1993) pointed out, such seniority-based transfers among siblings are particularly sensible when there is no external credit market for investing in education against future earnings. One can view this type of intrafamily transfer as a mirror analog of the teaching effect in the confluence model (Zajonc and Markus 1975), which hypothesizes that older siblings benefit from an opportunity to teach younger siblings. However, whereas the teaching effect is assumed to be positive so that the last born is assumed to be the most disadvantaged by the confluence model, our intrafamily transfer model recognizes the disadvantage of the early born in bearing the burden of supporting younger siblings and thus the relatively favorable position of the last-born child.

The preceding discussions concerning gender, spacing, and seniority are all intricately and intrinsically interrelated. They are all based on a special feature of the Chinese family. As Parish and Willis (1993: 866) observed, "One of the best things that can happen to a male, besides being born to rich, well-educated parents, is to have an older sister." In our model, we suggest that the worst scenario that can happen to a female is "to have much younger siblings." Thus, in this article, we treat the influences of gender, spacing, and seniority in sibship as *interactive,* rather than additive, effects on educational outcomes.

## THE TAIWANESE CONTEXT

Our empirical research is situated in contemporary Taiwan. Before we proceed to the data analysis, we provide a brief description of the educational system in Taiwan. The Taiwanese educational system consists of five main tiers of regular schools: elementary (six years), junior high school (three years), high school (three years), college (four years), and graduate school and some supplementary vocational schools. Although various schools used to screen their own students, since 1950 most schools in Taiwan have participated in the Joint Entrance Examinations (JEE) to select students. Nearly all our sampled respondents were subject to the JEE screening. Before 1968, for the entrance from elementary to junior high school, from junior high to high school, or from high school to college, each person needed to go through a respective JEE. The high school-to-college JEE was nationwide, whereas the others were held in separate districts, within which thousands of students would join the competition. After 1968, mandatory education was extended from six to nine years, and, as a result, the JEE from elementary school to junior high school was abolished.



In Taiwan, because the training of teachers of all school tiers was monopolized by national normal colleges, the salary scales of teachers and professors were based on seniority, and the licensure of university professors was uniformly regulated by the Ministry of Education during most relevant periods of our study, there are not many a priori reasons to expect differences in the quality of schoolteachers.[1] Moreover, the upper-bound tuition of private schools regulated by the government also limits improvement in the quality of teachers. Thus, most parents and students in Taiwan prefer less expensive public schools and universities to private institutions. The JEE ranks all examinees according to their JEE scores, and higher-scoring examinees are allowed to choose schools (or departments) to enter before lower-scoring examinees do.[2]

The JEE in Taiwan is basically a written examination, and thus the criterion for moving up the educational ladder is uniform. Given the aforementioned rigid JEE system, whether a student can enter a higher-tier school or college depends on his or her ability, as well as the resources (e.g., after-school tutoring) that his or her parents are able to provide. The quantity of such resources depends on the parents' educational background, ethnicity, sex preferences, and budgetary constraints. For instance, if the parents can afford to send only one child to college, then a child's gender or birth order may play an important role. In short, the rigid structure of Taiwan's educational system allowed us to assess directly the impact of family inputs.

## Data

For this study, we analyzed data from the PSFD in Taiwan, a large survey project that we conducted in collaboration with other researchers. In the study reported here, the respondents were randomly selected on the basis of their birth years. The survey questionnaires were administered via face-to-face interviews. The main respondents were born into three birth cohorts: Cohort 1, who were born between 1934 and 1954; Cohort 2, who were born between 1953 and 1963; and Cohort 3, who were born between 1964 and 1976. These samples were drawn using a stratified three-stage random sampling procedure. In the first stage, the 131 counties of Taiwan were stratified according to urbanization levels, and counties were then randomly selected within each stratum. In the second stage, smaller administrative districts (villages or equivalent districts in urban areas, called *li* in Taiwan) were randomly selected. In the third stage, individuals were randomly drawn.



The three cohorts of respondents were interviewed using the same survey instrument in 1999, 2000, and 2003. In the analysis, we used data from all three of these surveys. The original sample included roughly 4,000 respondents. The questionnaire covered detailed socioeconomic information about the family members of the interviewed individual, as well as their relations with one another. In particular, for each randomly sampled respondent, information on the educational background of almost all the respondent's siblings was also collected. From the information of the respondent and his or her siblings, we constructed a family-siblings data set to estimate the differential educational achievement among siblings. To analyze the completed education of children in families, we confined the sample to families with individual children aged 25 or older.[3] After we deleted observations with missing variables, the final sample consisted of 10,764 children from 2,626 families.

The educational attainment of children was measured by the total number of years of completed education, regardless of the type of schooling. For postgraduate schooling, a master's degree was coded as 18 years of education, and a doctoral degree was coded as 22 years. The average education by sibling size is listed in Appendix Table A1. In this table, one can observe clear evidence that the average educational attainment of male respondents is negatively associated with the number of brothers, and the average educational attainment of female respondents is negatively associated with the number of sisters. However, the effects of cross-sex sibship sizes are much less clear cut. These preliminary results reveal the complexity of cross-gender sibling effects.

Besides child's schooling, other variables used in the empirical analysis are listed in Appendix Table A2. For analytical purposes, sibship size is further distinguished by gender, seniority, and spacing. The operational definition of sibling spacing is based on whether the age difference between siblings is greater than four years. We decomposed the total number of siblings into two additive parts: siblings spaced closely, as measured by the number of siblings aged less than four years of the respondent's age, and siblings "spaced apart," as measured by the number of siblings aged more than four years of the respondent's age.[4]

Father's schooling and mother's schooling were measured in years of completed schooling, just like child's schooling. They were included as control variables in the regression models to reflect parents' socioeconomic status. To understand the effect of mother's working status on the children's educational attainment, we constructed the variable mother ever worked, defined as 1 if the mother ever worked in the past and 0 otherwise.

The father's ethnicity was divided into four categories (Fukkien, Hakka, Mainlander, and Aborigine), with Aborigine as the reference group. Fukkiens and Hakka were early immigrants from Mainland China, whereas Mainlanders immigrated mainly during the Chinese Civil War of 1945–49.

The means and standard deviations of the variables are summarized in Appendix Table A2. The table shows that the average education of the males was greater than that of the females—11.20 versus 10.08 years. Among the respondents' parents, the fathers' average years of schooling exceeded those of the mothers by 2.2 years. Thus, the educational gap by gender had narrowed from the parents' generation to the respondents' generation. Concerning sibship size, the average number of siblings was about 3.68, and the average number of closely spaced siblings was comparable to that of spaced-apart ones.

To highlight our key argument, we provide descriptive statistics in Appendix Tables A3–A5, modeled after Powell and Steelman (1993, Table 1). In this set of tables, we present the mean levels of schooling completed (last panel), as well as the proportions who attained specific levels of education (other panels), by the total number of siblings versus the number of closely spaced siblings. Powell and Steelman (1993) used the format to illustrate the point that for their U.S. data, it is primarily the number of closely spaced siblings (row-wide variation) that exerts a negative impact on educational attainment. Although small sample sizes for some of the cells should make the mean values unstable because of sampling error, the pattern across the cells is surprisingly regular and thus informative. For our Taiwanese data, as the total number of siblings increases, the average educational attainment of the respondents first increases and then decreases. The relationship between sibship size and mean education is thus not monotonic. When we further distinguished sibship size by density, we observed a clear pattern for the female respondents, which is also evident for the total sample as a result of aggregation: As the number of closely spaced siblings increases, their mean education also increases. This pattern is strong and robust across all the panels. For example, female respondents with 5 or more siblings, none of whom is closely spaced, had 6.9 years of schooling, whereas female respondents with 5 or more siblings, all of whom are closely spaced, had 9 years of schooling. This finding directly contradicts the pattern presented in Powell and Steelman's (1993) Table 1, highlighting differences in family culture between Taiwan and the United States.



We believe that the increasing pattern of closely spaced siblings within each row is due not to female respondents benefiting from having closely spaced siblings, but to their not suffering from having spaced-apart siblings. In other words, women's educational attainment is the lowest in the lower-left corner within each panel, since these entries represent women with numerous spaced-apart siblings. This pattern is consistent with our argument that parents sacrifice older daughters' education to relax the constraints on the family budget and possibly to benefit the education of their much younger, particularly male, siblings. We further explore the relationship between educational attainment and sibship by density in the next section.

## METHODS

Children in the same family may be subject to the influence of unobservable family-level characteristics. Thus, the analysis of family-siblings data should take family (siblings) structure into account. In the literature, either a sibling-fixed effects model or a variance-corrected ordinary least-squares (OLS) model was adopted to lessen such problems (see, e.g., Behrman et al. 2005; Sanbonmatsu et al. 2004). Both solutions have associated advantages and disadvantages, and the choice between them is not always clear-cut. On the one hand, as Griliches (1979) pointed out, the use of sibling fixed effects controls family-level characteristics but not necessarily all unobserved selectivity. Another potential problem with the fixed-effects approach is the presence of measurement error. If the fixed-effects model is applied, the bias associated with measurement error may become larger by taking the differences of variables. Furthermore, this approach puts a high demand on data because it requires siblings to have different sibling configurations within a family—a situation that can be true only briefly in years between the birth years of siblings (Downey et al. 1999; Steelman et al. 2002). On the other hand, the variance-corrected OLS may still generate a biased estimator if there are unmeasured family-level attributes that are correlated with sibship variables and affect educational attainment, whereas a fixed-effects model can overcome the problem (for detailed analyses, see Greene 2003; Griliches 1979).

Education is usually completed in early adulthood, in a period when the configuration of siblings no longer changes for most people. Thus, since we included sibship size as one of our independent variables, the effects of sibship size could not be distinguished from the family-specific constant terms because the two are collinear with each other. We use our regression model, presented next, to illustrate this point. For the *j*th sibling in the *i*th family, consider the following model:



$$y_{ij} = \alpha_i + X'_{ij}\beta + Z'_{ij}\gamma + u_{ij},\ i = 1,\ldots,n,\ j = 1,\ldots,n_i, \quad (1)$$

where $y$ is a measure for education, $X$ is a set of sibship-size variables, $Z$ contains other explanatory variables, and $u$ denotes the error term. In our analysis, the $X$ variable takes alternative forms. In the simplest form, only total sibship size is included. In the more complex models, gender, spacing, and seniority of sibship structure are considered sequentially and interactively. The fixed effects are captured by the term $\alpha_i$. For the simplest model ($X$ containing total sibship size only), it can be easily seen that the fixed-effects model is underidentified owing to the perfect collinearity between the family-specific constant terms ($\alpha_i$'s) and the $X$ variable. This situation is not improved with more refined operationalizations of the $X$ variables, as long as the sum of the sibship-size variables is constant within family. Although the fixed-effects model can be identified by arbitrarily deleting one of the sibship variables in a complex operationalization of $X$, it would be difficult to interpret the remaining variables.

For the aforementioned reasons, we chose OLS with Huber-White adjustment. In our data, we assumed that correlations across different individuals are due to within-family resemblance. We further assumed that across-family differences (represented by $\alpha_i$'s in Equation 1) generate within-family clustering but do not systematically correlate with $X$, our key independent variables. Under this condition, OLS estimation of Equation 1 yielded consistent point estimates but wrong standard errors. The Huber-White procedure calculated the correct standard errors that adjust for correlations between siblings.[5]

## RESULTS

### *The Effects of Sibship Size*

In our empirical analysis, we first follow the literature and estimate the effects of overall sibship size on educational attainment. Then we distinguish sibship size sequentially by gender, spacing, and seniority to explore further the influence of sibship structure on education. In our regression models, we use years of schooling as the dependent variable.

In the regression model, we account for the secular improvement in educational opportunity with birth-cohort dummy variables as explanatory variables. The birth-cohort dummy variables contain 11 groups, the range for each group being five years and the youngest cohort (birth year 1980) being the reference group. The results presented in Table 1 show that, overall, the birth-cohort dummy variables are highly significant at the .01 level. For persons who were born before 1965, an earlier date of birth is associated with a severe disadvantage in educational attainment.[6] For later cohorts, the differences among cohorts are small.

In Table 1, two models (Model A and Model A') are distinguished. The difference is that Model A estimates the overall effect of sibship size, while Model A' estimates the effect of sibship size separately for males and females (which is tantamount to interacting gender dummy variables and sibship size). The results of Model A show that sibship size has a negative effect on educational out-

**Table 1. Estimated Effects of Sibship Size on Educational Attainment**

| | Model A | | Model A′ | |
|---|---|---|---|---|
| Explanatory Variables | Coefficient | *t* value | Coefficient | *t* value |
| Constant | 7.471*** | 15.73 | 7.944*** | 16.73 |
| Year at Birth (≥1980 as the reference.) | | | | |
| ≤1934 | -6.004*** | 9.55 | -5.997*** | 9.62 |
| 1935–39 | -5.513*** | 13.98 | -5.557*** | 14.13 |
| 1940–44 | -4.438*** | 13.22 | -4.455*** | 13.31 |
| 1945–49 | -3.257*** | 10.06 | -3.277*** | 10.15 |
| 1950–54 | -2.359*** | 7.60 | -2.385*** | 7.71 |
| 1955–59 | -1.574*** | 5.13 | -1.594*** | 5.21 |
| 1960–64 | -0.859*** | 2.85 | -0.878*** | 2.92 |
| 1965–69 | -0.396 | 1.32 | -0.412 | 1.37 |
| 1970–74 | -0.121 | 0.41 | -0.142 | 0.49 |
| 1975–79 | -0.106 | 0.36 | -0.136 | 0.47 |
| Male | 1.051*** | 15.85 | 0.133 | 0.72 |
| Father's Schooling | 0.284*** | 18.34 | 0.285*** | 18.35 |
| Mother's Schooling | 0.198*** | 11.78 | 0.199*** | 11.83 |
| Mother Ever Worked | -0.361*** | 3.29 | -0.351*** | 3.20 |
| Father's Ethnicity | | | | |
| Fukkien | 2.240*** | 6.65 | 2.271*** | 6.85 |
| Hakka | 2.669*** | 7.47 | 2.696*** | 7.65 |
| Mainlander | 3.052*** | 8.44 | 3.072*** | 8.61 |
| Sibship Size | -0.089** | 2.51 | | |
| Male X Sibship Size | | | 0.032 | 0.75 |
| Female X Sibship Size | | | -0.217*** | 4.91 |
| Joint *F*-test for birth cohort dummy variables, *df* = (10, 2,590) | 82.41*** | | | |
| | 82.42*** | | | |
| *R*-squared | 0.452 | | 0.453 | |
| Number of families | 2,591 | | 2,591 | |
| Number of observations | 10,654 | | 10,654 | |



Note: Coefficients are OLS estimates, and *t* values refer to the null hypothesis of the true coefficient being zero, with robust standard errors. Model A pools the model by gender. Model A′ separates the model by gender.

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

comes, which is consistent with the previous literature. However, the results of Model A′ show that the number of siblings has asymmetric effects on males and females. The effect remains negative for females but is insignificant for males. These preliminary findings offer some weak evidence for our prior conjecture that additional siblings may provide help to brothers, rather than dilute the resources in the family. We return to this topic later.

As to other explanatory variables, one could observe from Model A that males attain higher levels of schooling than do females. Other regressors show consistent signs and magnitudes of coefficients in Models A and A′. Both father's schooling and mother's schooling have positive effects on educational achievement. The effect of father's schooling is greater than mother's, probably because, with the father being the primary breadwinner, father's education may better reflect the economic situation of the family. Relative to the respondents whose mothers never worked, the ones with mothers who worked attained a lower level of education. Mother's work may affect the educational attainment of children in opposing ways. A working mother could bring more economic resources to her family, which may help her children to attain a higher education. However, since child care and work compete for a mother's time, the time and energy that a working mother devotes to her children could be constrained. In addition, a mother may work out of economic necessity, so that her work status may reflect an underlying economic condition. In any event, mother's work status is associated with a lower level of education in our results.[7]

With respect to the dummy variables for ethnicity, relative to Aborigines, the respondents of other ethnic backgrounds tend to have higher educational levels. Among all the groups, the educational attainment of Mainlanders is the highest. As postwar immigrants, Mainlanders are more likely to live in urban areas and to hold nonfarming jobs but are less likely to own land than are early immigrants and Aborigines. On average, Mainlanders have higher levels of educational attainment than do other ethnic groups.

## *Sibship Configuration Refined*

To analyze the effects of sibship size by gender,

**Table 2. Estimated Effects of Sibship Size, by Gender, on Educational Attainment**



| | Model B | | Model B′ | |
|---|---|---|---|---|
| Explanatory Variables | Coefficient | *t* value | Coefficient | *t* value |
| Constant | 7.472*** | 15.73 | 7.924*** | 16.62 |
| Male | 1.052*** | 15.76 | 0.167 | 0.90 |
| Father's Schooling | 0.284*** | 18.34 | 0.285*** | 18.33 |
| Mother's Schooling | 0.198*** | 11.78 | 0.199*** | 11.85 |
| Mother Ever Worked | -0.362*** | 3.30 | -0.353*** | 3.21 |
| Father's Ethnicity | | | | |
| Fukkien | 2.237*** | 6.63 | 2.271*** | 6.82 |
| Hakka | 2.666*** | 7.44 | 2.690*** | 7.60 |
| Mainlander | 3.047*** | 8.40 | 3.070*** | 8.56 |
| Brothers | -0.081* | 1.72 | | |
| Male X Brothers | | | 0.007 | 0.12 |
| Female X Brothers | | | -0.182*** | 3.13 |
| Sisters | -0.093** | 2.33 | | |
| Male X Sisters | | | 0.051 | 1.06 |
| Female X Sisters | | | -0.237*** | 4.58 |
| Joint *F*-test for birth-cohort dummy variables, *df* = (10, 2,590) | 81.97*** | | 81.94*** | |
| *R*-squared | 0.452 | | 0.453 | |
| Number of families | 2,591 | | 2,591 | |
| Number of observations | 10,654 | | 10,654 | |

Note: Coefficients are OLS estimates, and *t* values refer to the null hypothesis of the true coefficient being zero, with robust standard errors. Model B pools the model by gender. Model B′ separates the model by gender.

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

we reran the regressions and present the results in Table 2.[8] In this table, Model B shows that both brothers and sisters have detrimental effects on the respondents' educational attainment, and the magnitudes of these two coefficients are similar in size. The results of Model B′ resemble those of Model A′ (see Table 1), with siblings of both genders showing negative effects on females and no effects on males. Since the other findings are similar to those in Table 1, we do not repeat the interpretation here.

We further divided the siblings into two groups—those spaced closely and those spaced apart—and present the results in Table 3. Model C of Table 3 shows that siblings (brothers or sisters) who are spaced apart have negative effects on education, yet the effects of siblings who are spaced closely are not significant. Again, this surprising finding directly contradicts the conventional resource theory formulated by Powell and Steelman (1990, 1993). Model C′ of Table 3 shows more interesting patterns: While sib-

**Table 3. Estimated Effects of Sibship Size, by Gender and Density, on Educational Attainment**

| | Model C | | Model C′ | |
|---|---|---|---|---|
| Explanatory Variables | Coefficient | *t* value | Coefficient | *t* value |
| Constant | 7.477*** | 15.69 | 7.805*** | 16.14 |
| Male | 1.055*** | 15.81 | 0.413** | 2.09 |
| Father's Schooling | 0.284*** | 18.34 | 0.284*** | 18.33 |
| Mother's Schooling | 0.196*** | 11.66 | 0.198*** | 11.77 |
| Mother Ever Worked | -0.358*** | 3.27 | -0.347*** | 3.16 |
| Father's Ethnicity | | | | |
| Fukkien | 2.235*** | 6.60 | 2.269*** | 6.71 |
| Hakka | 2.661*** | 7.40 | 2.683*** | 7.47 |
| Mainlander | 3.051*** | 8.38 | 3.072*** | 8.46 |
| Brothers Spaced Closely | -0.028 | 0.49 | | |
| Male X Brothers Spaced Closely | | | -0.060 | 0.78 |
| Female X Brothers Spaced Closely | | | -0.022 | 0.31 |
| Brothers Spaced Apart | -0.103* | 1.94 | | |
| Male X Brothers Spaced Apart | | | 0.036 | 0.52 |
| Female X Brothers Spaced Apart | | | -0.250*** | 3.94 |
| Sisters Spaced Closely | -0.025 | 0.49 | | |
| Male X Sisters Spaced Closely | | | 0.034 | 0.53 |
| Female X Sisters Spaced Closely | | | -0.078 | 1.15 |
| Sisters Spaced Apart | -0.129*** | 2.79 | | |
| Male X Sisters Spaced Apart | | | 0.035 | 0.64 |
| Female X Sisters Spaced Apart | | | -0.309*** | 4.81 |
| Joint *F*-test for birth cohort dummy variables, *df* = (10, 2,590) | 78.08*** | | 77.00*** | |
| *R*-squared | 0.452 | | 0.455 | |
| Number of families | 2,591 | | 2,591 | |
| Number of observations | 10,654 | | 10,654 | |



Note: Coefficients are OLS estimates, and t values refer to the null hypothesis of the true coefficient being zero, with robust standard errors. Model C pools the model by gender. Model C′ separates the model by gender.

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

lings (brothers or sisters) who are spaced apart are detrimental to females, they have no influence on males.

Finally, to examine whether younger or older spaced-apart siblings are detrimental to the respondents' educational attainment, we further divided sibship size by seniority for the analyses reported in Table 4. The results of Model D are straightforward: Only younger siblings who are spaced apart show negative effects. From Model D′, we further confirm that only females are influenced by siblings who are spaced apart, such effects being more pronounced for females with younger siblings who are spaced apart than for those with older siblings who are spaced apart. The finding that the number of older siblings who are spaced apart has a weak negative effect on females' educational attainment seems to be puzzling. One possible interpretation is that a younger sister may not gain from the resources that the older siblings bring to the family or that families of such sibling configurations somehow have poor economic resources. As long as a younger sister has to compete with her siblings for the family resources, siblings who are spaced apart, either younger or older, are associated with a lower level of educational attainment.

We now present evidence that directly bears on the conjecture that an elder sister may start working earlier under the presence of a much younger brother. For this analysis, we used the responses to a question on the PSFD questionnaire pertaining to the year when the respondent started a formal job, defined as a full-time paid job that lasted more than one month. We used age at first job as the dependent variable and estimated regression models with similar specifications to those in Table 4. The results, presented in Table 5, indicate that the number of younger brothers who are spaced apart has a significantly negative effect on the age of first job for females. The point estimate reveals that an elder sister would start working 0.4 year earlier for each additional younger brother. There is no other sibling effect on age of first job. Although preliminary, this finding is consistent with what we hypothesized.

The main findings of Tables 1–4 are summarized in the first two columns of Table 6. From these two columns, we may conclude that sibship size does not matter for males, while the educational attainment of females is affected by the composition of sibling structure. Siblings who are spaced apart, regardless of their gender or seniority, have negative effects on the educational attainment of females. To explore whether the coefficients of individual sibship-size variables are equivalent between males and females, we conducted a *t*-test, the results of which are presented in the third column of Table 6. An *F*-test was also performed to examine the overall difference between the genders, with the results listed in the final column of Table 6. The *F*-test statistics show that the differences in sibship effects between the genders are significant in all cases (Models A′, B′, C′, and D′).

To examine whether sibship density matters, given the same gender and seniority, we performed *t*-tests and *F*-tests and display the results in Table 7. The first two columns of Table 7 show that sibship density has asymmetric effects on males and females. Even though sibship density does not make any difference for males, it matters for females. Siblings who are spaced apart, especially younger siblings, are more detrimental to the educational opportunities of females than are their male counterparts. These results are consistent with our prior conjecture that females may sacrifice their own educational opportunities and act as resource providers for their spaced-apart siblings.

In summary, our study explored the effects of sibship on education in the Taiwanese context by refining sibship configuration and, in doing so, questioned the conventional wisdom based on American and Western European experiences. The key hypothesis is a modified resource-dilution model with the preference for sons, according to the Chinese family tradition, where family resources are composed of both parental earnings and sibling remittances. The son-preference culture suggests the likelihood of sacrificing the educational opportunity of older girls, who enter the labor market earlier and contribute to the family income pool. This is more likely to happen when the girl in question has more

**Table 4. Estimated Effects of Sibship Size, by Gender, Seniority, and Spacing, on Educational Attainment**

| | Model D | | Model D′ | |
|---|---|---|---|---|
| Explanatory Variables | Coefficient | *t* value | Coefficient | *t* value |
| Constant | 7.369*** | 15.39 | 7.673*** | 16.02 |
| Male | 1.043*** | 15.62 | 0.423** | 2.14 |
| Father's Schooling | 0.285*** | 18.40 | 0.285*** | 18.36 |
| Mother's Schooling | 0.198*** | 11.80 | 0.200*** | 11.85 |
| Mother Ever Worked | -0.352*** | 3.20 | -0.340*** | 3.10 |
| Father's Ethnicity | | | | |
| Fukkien | 2.229*** | 6.55 | 2.273*** | 6.70 |
| Hakka | 2.651*** | 7.34 | 2.683*** | 7.45 |
| Mainlander | 3.045*** | 8.33 | 3.077*** | 8.45 |
| Elder Brothers Spaced Closely | -0.066 | 1.04 | | |
| Male X Elder Brothers Spaced Closely | | | -0.117 | 1.38 |
| Female X Elder Brothers Spaced Closely | | | -0.031 | 0.36 |
| Elder Brothers Spaced Apart | -0.088 | 1.46 | | |
| Male X Elder Brothers Spaced Apart | | | -0.025 | 0.34 |
| Female X Elder Brothers Spaced Apart | | | -0.161** | 2.05 |
| Younger Brothers Spaced Closely | 0.004 | 0.07 | | |
| Male X Younger Brothers Spaced Closely | | | -0.015 | 0.17 |
| Female X Younger Brothers Spaced Closely | | | -0.024 | 0.29 |
| Younger Brothers Spaced Apart | -0.136** | 1.99 | | |
| Male X Younger Brothers Spaced Apart | | | 0.080 | 0.93 |
| Female X Younger Brothers Spaced Apart | | | -0.327*** | 3.86 |
| Elder Sisters Spaced Closely | -0.018 | 0.31 | | |
| Male X Elder Sisters Spaced Closely | | | -0.005 | 0.07 |
| Female X Elder Sisters Spaced Closely | | | -0.025 | 0.33 |
| Elder Sisters Spaced Apart | -0.053 | 1.03 | | |
| Male X Elder Sisters Spaced Apart | | | 0.027 | 0.44 |
| Female X Elder Sisters Spaced Apart | | | -0.150** | 2.15 |
| Younger Sisters Spaced Closely | -0.025 | 0.40 | | |
| Male X Younger Sisters Spaced Closely | | | 0.064 | 0.73 |
| Female X Younger Sisters Spaced Closely | | | -0.112 | 1.48 |
| Younger Sisters Spaced Apart | -0.242*** | 3.86 | | |
| Male X Younger Sisters Spaced Apart | | | 0.046 | 0.58 |
| Female X Younger Sisters Spaced Apart | | | -0.491*** | 6.28 |
| Joint *F*- test for birth-cohort dummy variables, *df* = (10, 2,590) | 51.56*** | | 52.24*** | |
| *R*-squared | 0.453 | | 0.457 | |
| Number of families | 2,591 | | 2,591 | |
| Number of observations | 10,654 | | 10,654 | |



Note: Coefficients are OLS estimates, and t values refer to the null hypothesis of the true coefficient being zero, with robust standard errors. Model D pools the model by gender. Model D′ separates the model by gender.

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

**Table 5. Estimated Effects of Sibship Size, by Gender, Seniority, and Spacing, on Age at First Job**

| | Model D | | Model D′ | |
|---|---|---|---|---|
| Explanatory Variables | Coefficient | *t* value | Coefficient | *t* value |
| Constant | 16.233*** | 18.02 | 16.202*** | 17.52 |
| Male | 1.125*** | 5.72 | 1.240*** | 2.61 |
| Father's Schooling | 0.155*** | 4.96 | 0.155*** | 4.96 |
| Mother's Schooling | 0.179*** | 5.17 | 0.182*** | 5.24 |
| Father's Ethnicity | | | | |
| Fukkien | 1.532* | 1.90 | 1.488* | 1.85 |
| Hakka | 1.096 | 1.29 | 1.093 | 1.29 |
| Mainlander | 2.223*** | 2.60 | 2.183** | 2.55 |
| Elder Brothers Spaced Closely | -0.022 | 0.12 | | |
| Male X Elder Brothers Spaced Closely | | | -0.061 | 0.24 |
| Female X Elder Brothers Spaced Closely | | | -0.003 | 0.01 |
| Elder Brothers Spaced Apart | -0.134 | 0.85 | | |
| Male X Elder Brothers Spaced Apart | | | -0.330 | 1.57 |
| Female X Elder Brothers Spaced Apart | | | 0.108 | 0.46 |
| Younger Brothers Spaced Closely | -0.086 | 0.50 | | |
| Male X Younger Brothers Spaced Closely | | | -0.131 | 0.53 |
| Female X Younger Brothers Spaced Closely | | | -0.033 | 0.14 |
| Younger Brothers Spaced Apart | -0.255 | 1.62 | | |
| Male X Younger Brothers Spaced Apart | | | -0.097 | 0.45 |
| Female X Younger Brothers Spaced Apart | | | -0.409* | 1.85 |
| Elder Sisters Spaced Closely | 0.116 | 0.69 | | |
| Male X Elder Sisters Spaced Closely | | | 0.084 | 0.37 |
| Female X Elder Sisters Spaced Closely | | | 0.153 | 0.62 |
| Elder Sisters Spaced Apart | -0.014 | 0.10 | | |
| Male X Elder Sisters Spaced Apart | | | 0.165 | 0.92 |
| Female X Elder Sisters Spaced Apart | | | -0.242 | 1.22 |
| Younger Sisters Spaced Closely | 0.007 | 0.04 | | |
| Male X Younger Sisters Spaced Closely | | | 0.075 | 0.31 |
| Female X Younger Sisters Spaced Closely | | | -0.043 | 0.19 |
| Younger Sisters Spaced Apart | 0.011 | 0.07 | | |
| Male X Younger Sisters Spaced Apart | | | -0.315 | 1.37 |
| Female X Younger Sisters Spaced Apart | | | 0.275 | 1.32 |
| Joint *F*-test for birth-cohort dummy variables | 2.40** *df* = (7, 2,445) | | 2.49** *df* = (7, 2,437) | |
| *R*-squared | 0.085 | | 0.088 | |
| Number of observations | 2,467 | | 2,467 | |

Note: The sample is confined to the respondents, since information on the time of first job is available only for the respondents. Coefficients are OLS estimates, and t values refer to the null hypothesis of the true coefficient being zero. Model D pools the model by gender. Model D′ separates the model by gender.

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.



younger siblings who are spaced apart, who increase the burden on the family budget. Thus, the younger siblings indeed dilute parental resources, whereas the older sisters expand such resources by stopping schooling and devoting themselves to the job market. This is a complicated scenario and can be identified only when the sibling structure is refined according to the sex-seniority-space dimensions.

**Table 6. Summary Results for Estimated Coefficients**

| Model and Variables | Coefficients: Male | Coefficients: Female | *t* Statistic for Difference Between Genders | *F* Statistic for Overall Difference Between Genders |
|---|---|---|---|---|
| Model A′ | | | | |
| Sibship size | 0.032 | -0.217*** | 4.99*** | |
| Model B′ | | | | |
| Brothers | 0.007 | -0.182*** | 2.76*** | 13.24*** |
| Sisters | 0.051 | -0.237*** | 4.81*** | *df* = (2, 2,590) |
| Model C′ | | | | |
| Brothers spaced closely | -0.060 | -0.022 | 0.39 | |
| Brothers spaced apart | 0.036 | -0.250*** | 3.54*** | 10.99*** |
| Sisters spaced closely | 0.034 | -0.078 | 1.33 | *df* = (4, 2,590) |
| Sisters spaced apart | 0.035 | -0.309*** | 4.65*** | |
| Model D′ (Table 4-1) | | | | |
| Elder brothers spaced closely | -0.117 | -0.031 | 0.75 | |
| Elder brothers spaced apart | -0.025 | -0.161** | 1.45 | |
| Younger brothers spaced closely | -0.015 | -0.024 | 0.10 | |
| Younger brothers spaced apart | 0.080 | -0.327*** | 3.93*** | 8.80*** |
| Elder sisters spaced closely | -0.005 | -0.025 | 0.20 | *df* = (8, 2,590) |
| Elder sisters spaced apart | 0.027 | -0.150** | 2.20** | |
| Younger sisters spaced closely | 0.064 | -0.112 | 1.66* | |
| Younger sisters spaced apart | 0.046 | -0.491*** | 5.65*** | |



***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

**Table 7. Tests for the Equivalence of Coefficients of Sibship Size**

| Model/Tests | Male: *t* Statistic for Individual Test | Male: *F* Statistic for Joint Test | Female: *t* Statistic for Individual Test | Female: *F* Statistic for Joint Test |
|---|---|---|---|---|
| Model B′ | | | | |
| Brothers = Sisters | 0.51 | | 0.72 | |
| Model C′ | | | | |
| Brothers spaced closely | 1.22 | | | |
| = Brothers spaced apart | | 0.61 | 3.30*** | 8.63*** |
| Sisters spaced closely | 0.00 | *df*= (2, 2,590) | 2.92*** | *df*= (2, 2,590) |
| = Sisters spaced apart | | | | |
| Model D′ | | | | |
| Elder brothers spaced closely | 0.90 | | 1.40 | |
| = Elder brothers spaced apart | | | | |
| Younger brothers spaced closely | 0.73 | 0.34 | 2.97*** | 5.39*** |
| = Younger brothers spaced apart | | *df*= (4, 2,590) | | *df*= (4, 2,590) |
| Elder sisters spaced closely | 0.15 | | 1.38 | |
| = Elder sisters spaced apart | | | | |
| Younger sisters spaced closely | 0.03 | | 3.80*** | |
| = Younger sisters spaced apart | | | | |

***, **, and * denote significance at the .01, .05, and .10 levels, respectively.

## DISCUSSION AND CONCLUSION

In this article, we proposed an extension of the resource-dilution hypothesis for the Taiwanese context: If resources from all family members are pooled together, families may sacrifice the educational opportunities of older (female) siblings and transfer their resources to improve the educational outcomes of younger, especially male, siblings. With analyses of data from the PSFD, we found empirical evidence in support of this explanation. In particular, we found that the negative effects of sibship size are the strongest for girls who have younger brothers and sisters who are *spaced apart*. We interpret this unusual high-order interaction involving sibship size, gender, density, and seniority in the context of Taiwan's patriarchal culture, in which families often favor boys over girls.

While our work was motivated by Greenhalgh's (1985) insight that Taiwanese parents mobilize resources from older daughters to benefit younger sons, the full story seems more complicated. Despite the son-preference culture, there was virtually no sex-selective abortion, since the requisite technology was not available in Taiwan during the period under study. There is, however, some evidence of sex preference in fertility behavior. In our data, the correlation coefficient between the proportion of daughters in the family and sibship size is positive (0.1802, significant at less than .01), indicating that parents continued their fertility so as to have a son if they were not satisfied with the number of sons.

The sex of each child was a random event. In families in which sons were born ahead of daughters, parents did not have easy mechanisms with which to sacrifice the education of later-born daughters for the benefit of sons. Only when daughters were born first and much younger siblings were on the horizon did parents discontinue the education of their older daughters and transfer their resources to benefit the family, in general, and possibly their much younger children, in particular. It is interesting that older sisters' education is sacrificed to benefit both younger brothers and younger sisters. While there is gender asymmetry in terms of which older siblings were sacrificed, there is no gender asymmetry in terms of which young siblings benefited from the intrafamily transfer. In light of these findings, Parish and Willis's (1993) interpretation is appealing: Parents may extract resources from their older daughters because they lack economic resources owing to the lack of a credit market. Once they have resources (say, from older daughters), they no longer discriminate against younger daughters. This interpretation suggests that parents' differential treatment of sons and daughters is an extreme measure under severe resource constraints. Once parents have adequate resources, their treatment of daughters is not too different from their treatment of sons.

## NOTES

1. The monopoly of teacher training was finally abolished in 1997, and the uniform professor licensure system was decentralized in 1991, but these recent changes could not have affected the previous decisions of the respondents.



2. For instance, in 2000, 125,498 students registered for the JEE of colleges. The overall entrance rate from high school to college was 59.98 percent. The most preferred college overall was National Taiwan University, which allowed only 3,244 students to enter. Students whose scores were lower than the rank criterion of the various departments at National Taiwan University had to choose other universities. In the same year, 22,115 students participated in the JEE from junior high to high school in the Taipei area; corresponding figures in other areas are omitted.

3. Since mandatory military service is obligatory for males for at least two years, we choose age 25 as the cutoff point for a completed education.

4. The measure for sibling density is not the same as that adopted by Powell and Steelman (1990, 1993). Powell and Steelman defined closely spaced siblings as those whose age difference was within two or three years. We also tried measures similar to Powell and Steelman's and found similar results.

5. Since the estimator of the standard errors is robust to the deviation from the stan-

dard assumption of the i.i.d. (independent and identically distributed) sample, the Huber-White adjusted estimator of variance is also known as the robust estimator of variance. Further information about this correction procedure can be found in Huber (1967) and White (1980).

6. Since the estimates of the birth-cohort dummy variables in the other regression models are similar to those presented in Table 1, they are not listed in the other tables for brevity of presentation. Detailed results are available from us on request.

7. Because of our concern that mother's work status may be contaminated by measurement error, we also experimented with specifications that removed the variable from the models. However, the main results remained unchanged. The results from alternative specifications are available from us on request.

8. The models in Tables 2, 3, and 4 are also estimated by OLS with Huber-White adjustment (as in Table 1). The birth-cohort dummy variables are also controlled in these models.

## APPENDIX

**Table A1. Average Year of Schooling, by Sibling Size**

| | All | Male | Female |
|---|---|---|---|
| Sibship Size | | | |
| 0 | 9.012 | 10.408 | 7.793 |
| 1 | 11.460 | 12.163 | 10.403 |
| 2 | 12.270 | 12.405 | 12.076 |
| 3 | 11.849 | 12.019 | 11.664 |
| 4 | 10.645 | 11.160 | 10.205 |
| 5+ | 9.186 | 9.886 | 8.593 |
| Number of Brothers | | | |
| 0 | 10.992 | 11.991 | 9.631 |
| 1 | 11.455 | 11.847 | 11.035 |
| 2 | 10.529 | 10.889 | 10.214 |
| 3 | 9.632 | 10.386 | 8.951 |
| 4 | 9.234 | 9.952 | 8.542 |
| 5+ | 9.317 | 9.542 | 9.019 |
| Number of Sisters | | | |
| 0 | 11.341 | 11.573 | 11.093 |
| 1 | 11.116 | 11.619 | 10.523 |
| 2 | 10.512 | 11.046 | 10.009 |
| 3 | 10.104 | 10.802 | 9.452 |
| 4 | 9.888 | 10.524 | 9.396 |
| 5+ | 10.000 | 11.039 | 9.108 |

**Table A2. Summary of Means and Standard Deviations**

| Variables and Observations | All (10,654) | Male (5,317) | Female (5,337) |
|---|---|---|---|
| Child's schooling | 10.640 | 11.200 | 10.083 |
| | (4.189) | (3.899) | (4.389) |
| Father's schooling | 5.849 | 5.849 | 5.849 |
| | (4.323) | (4.350) | (4.296) |
| Mother's schooling | 3.597 | 3.585 | 3.609 |
| | (3.822) | (3.835) | (3.809) |
| Mother ever worked | 0.263 | 0.271 | 0.256 |
| | (0.440) | (0.444) | (0.436) |
| Father Fukkien | 0.779 | 0.777 | 0.780 |
| | (0.415) | (0.415) | (0.414) |
| Father Hakka | 0.116 | 0.115 | 0.117 |
| | (0.320) | (0.319) | (0.322) |
| Father Mainlander | 0.089 | 0.095 | 0.083 |
| | (0.285) | (0.293) | (0.276) |
| Sibship size | 3.676 | 3.558 | 3.793 |
| | (1.331) | (1.353) | (1.299) |
| Brothers | 1.776 | 1.724 | 1.827 |
| | (1.102) | (1.127) | (1.074) |
| Sisters | 1.900 | 1.833 | 1.966 |
| | (1.256) | (1.239) | (1.269) |
| Brothers spaced closely (age difference 4) | 0.913 | 0.900 | 0.926 |
| | (0.817) | (0.813) | (0.822) |
| Brothers spaced apart (age difference > 4) | 0.863 | 0.825 | 0.902 |
| | (0.916) | (0.915) | (0.916) |
| Sisters spaced closely | 0.970 | 0.929 | 1.011 |
| | (0.889) | (0.857) | (0.920) |
| Sisters spaced apart | 0.930 | 0.904 | 0.955 |
| | (0.996) | (1.007) | (0.985) |
| Elder brothers spaced closely | 0.437 | 0.450 | 0.424 |
| | (0.603) | (0.607) | (0.599) |
| Elder brothers spaced apart | 0.401 | 0.412 | 0.390 |
| | (0.731) | (0.746) | (0.715) |
| Younger brothers spaced closely | 0.476 | 0.450 | 0.502 |
| | (0.620) | (0.607) | (0.631) |
| Younger brothers spaced apart | 0.462 | 0.412 | 0.511 |
| | (0.753) | (0.727) | (0.774) |
| Elder sisters spaced closely | 0.505 | 0.504 | 0.506 |
| | (0.655) | (0.652) | (0.657) |
| Elder sisters spaced apart | 0.495 | 0.512 | 0.477 |
| | (0.841) | (0.870) | (0.812) |
| Younger sisters spaced closely | 0.466 | 0.425 | 0.506 |
| | (0.634) | (0.607) | (0.657) |
| Younger sisters spaced apart | 0.435 | 0.392 | 0.478 |
| | (0.774) | (0.743) | (0.801) |

**Table A3. Mean Education, by Number of Closely Spaced Siblings and Total Number of Siblings: Total Sample**

| Total Number of Siblings | Number of Closely Spaced Siblings (age difference ≤4) 0 | 1 | 2 | 3 | 4 | 5+ | Total | Number of Sample |
|---|---|---|---|---|---|---|---|---|
| Junior High School Graduation | | | | | | | | |
| 0 | 0.540 | — | — | — | — | — | 0.540 | 163 |
| 1 | 0.696 | 0.801 | — | — | — | — | 0.774 | 398 |
| 2 | 0.765 | 0.852 | 0.919 | — | — | — | 0.886 | 1,725 |
| 3 | 0.719 | 0.833 | 0.900 | 0.930 | — | — | 0.879 | 2,228 |
| 4 | 0.774 | 0.700 | 0.770 | 0.809 | 0.832 | — | 0.766 | 2,196 |
| 5+ | 0.554 | 0.558 | 0.579 | 0.641 | 0.628 | 0.833 | 0.597 | 3,884 |
| Total | 0.661 | 0.726 | 0.769 | 0.765 | 0.686 | 0.833 | 0.745 | |
| Number of sample | 818 | 2,846 | 4,362 | 2,074 | 506 | 48 | | 10,654 |
| Senior High School Graduation | | | | | | | | |
| 0 | 0.387 | — | — | — | — | — | 0.387 | 163 |
| 1 | 0.569 | 0.699 | — | — | — | — | 0.666 | 398 |
| 2 | 0.597 | 0.708 | 0.795 | — | — | — | 0.752 | 1,725 |
| 3 | 0.556 | 0.624 | 0.733 | 0.822 | — | — | 0.717 | 2,228 |
| 4 | 0.626 | 0.509 | 0.563 | 0.645 | 0.685 | — | 0.580 | 2,196 |
| 5+ | 0.422 | 0.376 | 0.415 | 0.470 | 0.466 | 0.521 | 0.426 | 3,884 |
| Total | 0.512 | 0.553 | 0.605 | 0.614 | 0.528 | 0.521 | 0.582 | |
| Number of sample | 818 | 2,846 | 4,362 | 2,074 | 506 | 48 | | 10,654 |
| College Graduation | | | | | | | | |
| 0 | 0.104 | — | — | — | — | — | 0.104 | 163 |
| 1 | 0.137 | 0.250 | — | — | — | — | 0.221 | 398 |
| 2 | 0.176 | 0.245 | 0.247 | — | — | — | 0.241 | 1,725 |
| 3 | 0.150 | 0.153 | 0.204 | 0.228 | — | — | 0.194 | 2,228 |
| 4 | 0.104 | 0.108 | 0.134 | 0.168 | 0.203 | — | 0.138 | 2,196 |
| 5+ | 0.072 | 0.073 | 0.078 | 0.096 | 0.088 | 0.021 | 0.081 | 3,884 |
| Total | 0.121 | 0.149 | 0.157 | 0.151 | 0.121 | 0.021 | 0.149 | |
| Number of sample | 818 | 2,846 | 4,362 | 2,074 | 506 | 48 | | 10,654 |
| Years of Schooling | | | | | | | | |
| 0 | 9.012 | — | — | — | — | — | 9.012 | 163 |
| 1 | 10.500 | 11.791 | — | — | — | — | 11.460 | 398 |
| 2 | 11.000 | 11.950 | 12.596 | — | — | — | 12.270 | 1,725 |
| 3 | 10.268 | 11.172 | 12.031 | 12.619 | — | — | 11.849 | 2,228 |
| 4 | 10.643 | 9.970 | 10.558 | 11.206 | 11.741 | — | 10.645 | 2,196 |
| 5+ | 8.699 | 8.707 | 9.060 | 9.685 | 9.595 | 10.083 | 9.186 | 3,884 |
| Total | 9.888 | 10.427 | 10.854 | 10.898 | 10.202 | 10.083 | 10.640 | |
| Number of sample | 818 | 2,846 | 4,362 | 2,074 | 506 | 48 | | 10,654 |

**Table A4. Mean Education, by Number of Closely Spaced Siblings and Total Number of Siblings: Male Sample**

| Total Number of Siblings | Number of Closely Spaced Siblings (age difference ≤4) 0 | 1 | 2 | 3 | 4 | 5+ | Total | Number of Sample |
|---|---|---|---|---|---|---|---|---|
| Junior High School Graduation | | | | | | | | |
| 0 | 0.697 | — | — | — | — | — | 0.697 | 76 |
| 1 | 0.788 | 0.866 | — | — | — | — | 0.849 | 239 |
| 2 | 0.866 | 0.858 | 0.931 | — | — | — | 0.903 | 1,018 |
| 3 | 0.779 | 0.882 | 0.918 | 0.932 | — | — | 0.903 | 1,194 |
| 4 | 0.915 | 0.755 | 0.807 | 0.855 | 0.902 | — | 0.815 | 1,011 |
| 5+ | 0.729 | 0.659 | 0.651 | 0.691 | 0.669 | 0.926 | 0.672 | 1,779 |
| Total | 0.788 | 0.792 | 0.818 | 0.806 | 0.734 | 0.926 | 0.803 | |
| Number of sample | 416 | 1,531 | 2,191 | 934 | 218 | 27 | | 5,317 |
| Senior High School Graduation | | | | | | | | |
| 0 | 0.474 | — | — | — | — | — | 0.474 | 76 |
| 1 | 0.635 | 0.743 | — | — | — | — | 0.720 | 239 |
| 2 | 0.612 | 0.695 | 0.791 | — | — | — | 0.748 | 1,018 |
| 3 | 0.636 | 0.619 | 0.731 | 0.797 | — | — | 0.711 | 1,194 |
| 4 | 0.729 | 0.560 | 0.575 | 0.682 | 0.754 | — | 0.614 | 1,011 |
| 5+ | 0.541 | 0.420 | 0.465 | 0.519 | 0.503 | 0.593 | 0.476 | 1,779 |
| Total | 0.596 | 0.587 | 0.637 | 0.646 | 0.573 | 0.593 | 0.618 | |
| Number of sample | 416 | 1,531 | 2,191 | 934 | 218 | 27 | | 5,317 |
| College Graduation | | | | | | | | |
| 0 | 0.171 | — | — | — | — | — | 0.171 | 76 |
| 1 | 0.135 | 0.283 | — | — | — | — | 0.251 | 239 |
| 2 | 0.224 | 0.251 | 0.266 | — | — | — | 0.258 | 1,018 |
| 3 | 0.143 | 0.170 | 0.229 | 0.213 | — | — | 0.204 | 1,194 |
| 4 | 0.085 | 0.161 | 0.143 | 0.195 | 0.262 | — | 0.163 | 1,011 |
| 5+ | 0.118 | 0.073 | 0.098 | 0.100 | 0.115 | 0.037 | 0.094 | 1,779 |
| Total | 0.147 | 0.174 | 0.183 | 0.158 | 0.156 | 0.037 | 0.172 | |
| Number of sample | 416 | 1,531 | 2,191 | 934 | 218 | 27 | | 5,317 |
| Years of Schooling | | | | | | | | |
| 0 | 10.408 | — | — | — | — | — | 10.408 | 76 |
| 1 | 11.077 | 12.465 | — | — | — | — | 12.163 | 239 |
| 2 | 11.567 | 11.965 | 12.739 | — | — | — | 12.405 | 1,018 |
| 3 | 10.922 | 11.505 | 12.245 | 12.486 | — | — | 12.019 | 1,194 |
| 4 | 11.678 | 10.722 | 10.912 | 11.655 | 12.459 | — | 11.160 | 1,011 |
| 5+ | 10.353 | 9.532 | 9.754 | 10.244 | 10.013 | 10.889 | 9.886 | 1,779 |
| Total | 10.942 | 11.056 | 11.366 | 11.287 | 10.697 | 10.889 | 11.200 | |
| Number of sample | 416 | 1,531 | 2,191 | 934 | 218 | 27 | | 5,317 |

**Table A5. Mean Education, by Number of Closely Spaced Siblings and Total Number of Siblings: Female Sample**

| Total Number of Siblings | Number of Closely Spaced Siblings (age difference ≤4) 0 | 1 | 2 | 3 | 4 | 5+ | Total | Number of Sample |
|---|---|---|---|---|---|---|---|---|
| Junior High School Graduation | | | | | | | | |
| 0 | 0.402 | — | — | — | — | — | 0.402 | 87 |
| 1 | 0.600 | 0.688 | — | — | — | — | 0.660 | 59 |
| 2 | 0.635 | 0.845 | 0.902 | — | — | — | 0.863 | 707 |
| 3 | 0.658 | 0.768 | 0.882 | 0.927 | — | — | 0.853 | 1,094 |
| 4 | 0.625 | 0.649 | 0.738 | 0.777 | 0.780 | — | 0.724 | 1,185 |
| 5+ | 0.370 | 0.462 | 0.520 | 0.602 | 0.597 | 0.714 | 0.533 | 2,105 |
| Total | 0.530 | 0.649 | 0.719 | 0.732 | 0.649 | 0.714 | 0.686 | |
| Number of sample | 402 | 1,315 | 2,171 | 1,140 | 288 | 21 | | 5,337 |
| Senior High School Graduation | | | | | | | | |
| 0 | 0.310 | — | — | — | — | — | 0.310 | 87 |
| 1 | 0.500 | 0.624 | — | — | — | — | 0.585 | 59 |
| 2 | 0.577 | 0.727 | 0.801 | — | — | — | 0.760 | 707 |
| 3 | 0.474 | 0.630 | 0.736 | 0.847 | — | — | 0.723 | 1,094 |
| 4 | 0.518 | 0.460 | 0.552 | 0.619 | 0.634 | — | 0.551 | 1,185 |
| 5+ | 0.296 | 0.334 | 0.373 | 0.433 | 0.437 | 0.429 | 0.384 | 2,105 |
| Total | 0.425 | 0.513 | 0.573 | 0.588 | 0.493 | 0.429 | 0.545 | |
| Number of sample | 402 | 1,315 | 2,171 | 1,140 | 288 | 21 | | 5,337 |
| College Graduation | | | | | | | | |
| 0 | 0.046 | — | — | — | — | — | 0.046 | 87 |
| 1 | 0.140 | 0.193 | — | — | — | — | 0.176 | 59 |
| 2 | 0.115 | 0.235 | 0.218 | — | — | — | 0.216 | 707 |
| 3 | 0.158 | 0.130 | 0.179 | 0.244 | — | — | 0.184 | 1,094 |
| 4 | 0.125 | 0.058 | 0.126 | 0.148 | 0.159 | — | 0.117 | 1,185 |
| 5+ | 0.025 | 0.072 | 0.062 | 0.092 | 0.068 | 0.000 | 0.070 | 2,105 |
| Total | 0.095 | 0.119 | 0.131 | 0.146 | 0.094 | 0.000 | 0.126 | |
| Number of sample | 402 | 1,315 | 2,171 | 1,140 | 288 | 21 | | 5,337 |
| Years of Schooling | | | | | | | | |
| 0 | 7.793 | — | — | — | — | — | 7.793 | 87 |
| 1 | 9.900 | 10.633 | — | — | — | — | 10.403 | 59 |
| 2 | 10.269 | 11.929 | 12.386 | — | — | — | 12.076 | 707 |
| 3 | 9.605 | 10.736 | 11.810 | 12.756 | — | — | 11.664 | 1,094 |
| 4 | 9.554 | 9.265 | 10.242 | 10.887 | 11.207 | — | 10.205 | 1,185 |
| 5+ | 6.963 | 7.923 | 8.486 | 9.254 | 9.277 | 9.048 | 8.593 | 2,105 |
| Total | 8.796 | 9.696 | 10.339 | 10.580 | 9.826 | 9.048 | 10.083 | |
| Number of sample | 402 | 1,315 | 2,171 | 1,140 | 288 | 21 | | 5,337 |

## REFERENCES

Behrman, Jere R., John F. Hoddinott, John A. Maluccio, Erica Soler-Hampejsek, Emily L. Behrman, Reynaldo Martolrell, Manuel Ramirez-Zea, and Aryeh D. Stein. 2005. "What Determines Adult Cognitive Skills? Impacts of Pre-School, School-Years and Post-School Experiences in Guatemala." Unpublished manuscript. Available online at http://www.cgdev.org/doc/event%20docs/Behrman.cogskills.pdf

Blake, Judith. 1981. "Family Size and the Quality of Children. *Demography* 18:421–42.

——. 1989. *Family Size and Achievement.* Berkeley: University of California Press.

Blau, Peter M., and Otis Dudley Duncan. 1967. *The American Occupational Structure*. New York: John Wiley & Sons.

Downey, Douglas B. 1995. "When Bigger Is Not Better: Family Size, Parental Resources, and Children's Educational Performance." *American Sociological Review* 60:746–61.

Downey, Douglas B., Brian Powell, Lala Carr Steelman, and Shana Pribesh. 1999. "Much Ado about Siblings: Change Models, Sibship Size, and Intellectual Development: Comment on Guo and VanWey." *American Sociological Review* 64:193–98.

Ernst, Cecile, and Jules Angst. 1983. *Birth Order: Its Influence on Personality*. New York: Springer-Verlag.

Greene, William. 2003. *Econometric Analysis* (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Greenhalgh, Susan. 1985. "Sexual Stratification: The Other Side of 'Growth with Equity' in East Asia." *Population and Development Review* 11:265–314.

Griliches, Zvi. 1979. "Sibling Models and Data in Economics: Beginnings of a Survey." *Journal of Political Economy* 87: S37–S64.

Guo, Guang, and Leah K. VanWey. 1999. "Sibship Size and Intellectual Development: Is the Relationship Causal?" *American Sociological Review* 64:169–87.

Hauser, Robert M., and Hsiang-Hui Daphne Kuo. 1998. "Does the Gender Composition of Sibships Affect Women's Educational Attainment?" *Journal of Human Resources* 33: 644–57.

Hauser, Robert M., and William H. Sewell. 1985. "Birth Order and Educational Attainment in Full Sibships." *American Educational Research Journal* 22:1–23.

Huber, Peter J. 1967. "The Behavior of Maximum Likelihood Estimates under Nonstandard Conditions." *Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability* 1: 221-233.

Kuo, Hsiang-Hui Daphne, and Robert M. Hauser, 1997. "How Does Size of Sibship Matter? Family Configuration and Family Effects on Educational Attainment." *Social Science Research* 26:69–94.

Mincer, Jacob. 1974. *Schooling, Experience, and Earnings*. New York: National Bureau of Economic Research.

Parish, William L., and Robert J. Willis. 1993. "Daughters, Education, and Family Budgets Taiwan Experiences." *Journal of Human Resources* 28:863–98.

Powell, Brian, and Lala Carr Steelman. 1989. "The Liability of Having Brothers: Paying for College and the Sex Composition of the Family." *Sociology of Education* 62:134–47.

——. 1990. "Beyond Sibship Size: Sibling Density, Sex Composition, and Educational Outcomes." *Social Forces* 69:181–206.

——. 1993. "The Educational Benefits of Being Spaced Out: Sibship Density and Educational Progress." *American Sociological Review* 58:367–81.

Retherford, Robert D., and William H. Sewell. 1991. "Birth Order and Intelligence: Further Tests of the Confluence Model." *American Sociological Review* 56:141–58.

Sanbonmatsu, Lisa, Jeffrey R. Kling, Greg J. Duncan, and Jeanne Brooks-Gunn. 2004. "Neighborhoods and Academic Achievement: Results from the Moving to Opportunity Experiment." Working Paper 7, Education Research Section, Princeton University.

Shavit, Yossi, and Hans-Peter Blossfeld. 1993. *Persistent Inequality: Changing Educational Attainment in Thirteen Countries*. Boulder, CO: Westview Press.

Steelman, Lala Carr, Brian Powell, Regina Werum, and Scott Carter. 2002. "Reconsidering the Effects of Sibling Configuration: Recent Advances and Challenges." *Annual Review of Sociology* 28:243–69.

Thornton, Arland, & Hui-Sheng Lin. (1994). *Social Change and the Family in Taiwan*. Chicago: University of Chicago Press.

White, Halbert. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48:827–38.

Zajonc, Robert B., and Gregory B. Markus. 1975. "Birth Order and Intellectual Development." *Psychological Review* 82:74–88.

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