中央研究院經濟所學術研討論文
IEAS Working Paper

A New Model for Family Resource Allocation Among Siblings: Competition, Forbearance, and Support

C. Y. Cyrus Chu, R. R. Yu and Ruey S. Tsay

IEAS Working Paper No. 04-A014

May, 2004

Institute of Economics
Academia Sinica
Taipei 115, TAIWAN
http://www.sinica.edu.tw/econon/

中央研究院　經濟研究所

INSTITUTE OF ECONOMICS, ACADEMIA SINICA

TAIWAN

A New Model for Family Resource Allocation Among Siblings: Competition, Forbearance, and Support[1]

C. Y. Cyrus Chu, Institute of Economics, Academia Sinica, Taiwan

R. R. Yu, Center for Survey Research, Academia Sinica, Taiwan

Ruey S. Tsay, Graduate School of Business, University of Chicago.[2]

May 27, 2004

[1]We are indebted to D. Lam, A. Thornton, Yu Xie, Ronald Lee, and seminar participants at ISA RC28 conference (Neuchatel), Academia Sinica, University of Michigan, and University of California, Berkeley for their comments and suggestions on an earlier draft.

[2]Correspondence author. Email: rst@gsbrst.uchicago.edu.

Abstract

Previous research analyzing within-family education resource allocation usually employs the sibship and birth order of a child as explanatory variables. We argue in this paper that to correctly characterize the resource competition and support scenario within a family, one should identify the Sex, Seniority, and most importantly Age Difference of a child's sibling structure, and hence we call our analysis a SSAD model of family resource allocation. We show that siblings with different combinations of SSAD may play distinct roles in family resource allocation. Ignoring such facts may distort the significance and/or direction of the prediction. We support our analysis with empirical evidence using data from Taiwan.

1 Introduction

There were many studies in the past to analyze the effect of sibship or birth order on children's education achievement, measured by their performance scores or years of schooling. The general conclusion is that a child's education achievement is negatively affected by his or her sibship, but the effect of birth order is ambiguous.[3]

Leaving aside the case of primogeniture primarily in some ancient periods, unequal parental treatment to children of specific birth order does not seem to have any strong theoretical support.[4] Since we do not have any established theory in psychology to support parents' *subjective* unequal altruism toward children of various birth orders, if a child of a particular birth order does turn out to perform better, then the revealed connection between child performance and birth order must involve some *objective* factors in the environment that are associated with birth order. The purpose of this paper is to disentangle, both conceptually and empirically, the complicated objective factors for which birth order might be used as a proxy, and to clarify the competing and supporting relationship among siblings for education resources.

The rest of this paper is organized as follows. In the next section we clarify some conceptual ideas associated with the previous discussion of birth order

[3]Related literature abounds. For earlier discussions in psychology and sociology, see Altus (1966), Adams (1972), Schooler (1972), Zajonc (1976), and Davis (1977). Recent research using more refined data or analysis can be found in Behrman and Taubman (1986), Birdsall (1991), Kessler (1991), Parish and Willis (1993), Butcher and Case (1994), and Kuo and Hauser (1997).

[4]Galton (1874) believed that the custom of primogeniture is the reason why the first-born has a better achievement in the sample he observed. Chu (1991) provided some theoretical arguments behind primogeniture in ancient periods. Focusing on the child mortality of India, Das Gupta (1987) argued that the sex discrimination against girls may particularly be on the ones with higher birth orders. More details will be given later.

in the literature. We then present the proposed analysis and derive some testable implications in section 3. We argue that to correctly characterize the resource competition and support scenario within a family, one must consider the Sex, Seniority, and most important Age Difference of a child's sibling structure, and hence we call the proposed analysis a SSAD model of family resource allocation. Section 4 introduces the econometric model used in the paper whereas section 5 provides a description of the data and the relevant education system in Taiwan. The empirical result is presented in section 6, which shows that siblings with different combinations of SSAD may play distinct roles in family resource allocation. Ignoring such facts may distort the significance and/or direction of the empirical prediction. The final section concludes.

2 Clarifying Some Conceptual Issues

Let us first summarize the arguments that have been proposed in the literature to support the possible correlation between a child's birth order and his or her education achievement. We then examine the complex proxy roles behind the birth-order variable. The arguments include:

1. Children with higher birth orders tend to be born by older mothers, and hence they are more likely to have weaker natural endowments, dizygotic multiple births, or even birth defects; Behrman and Taubman (1986).

2. Children with higher birth orders tend to receive better care from their parents, who are more experienced in child caring; Kessler (1991).

3. Children with higher birth orders often face a later and usually better environment in a growing economy, either in the macro environment

they face in general, or in their families in particular, and hence they tend to receive a better education; Davis (1977).

4. Children with lower birth orders have less competitors in family resources, and thereby are at an advantage in family education support; Kessler (1991).

5. Children with higher birth orders often obtain help or care, sometimes even financial support, from elder siblings, and therefore can receive a better education; Davis (1977).

6. Children of lower birth orders (especially females) are likely to receive less education, because their parents tend to let them go into the job market early in order to help their younger siblings' education; Parish and Willis (1993).[5]

The above-mentioned, to some extent mutually conflicting, "explanations" for the effect of birth order actually are not characterizations of the impact of birth order *per se*. They often refer to other socioeconomic variables, of which birth order is just a related proxy. Let us examine their meanings in detail below.

Social Background and Family Characteristics: Evidently, the risk of birth defection specified in item 1 is better captured by the birth age of the mother, rather than by the birth order of the child. Parents' ability in taking care of their children listed in item 2 is dependent not only on the number of senior siblings of the child, but also (if not more) on parents' age, social

[5]Das Gupta (1987) showed that female children of higher birth orders are likely to receive less food and nutrition, because parents may have a preference for "removing unwanted daughters as early as possible" (p.93). The decision of nutrition resource allocation she discussed affects the *survival* probability of children, whereas our focus is on the achievement of the *survived* children.

experience, human capital, and many other factors. As such, birth order is actually a proxy of other variables. Concerning item 3 above, the capacity of supporting a child's education should depend on the economic status of the parent and the society; again the birth-order variable is used to carry other family background information.

The Importance of Sibling Age Difference: The reasons characterized in items 4 to 6 are related to the sibling structure faced by the child in question, and deserve a further investigation. As we shall explain below, whether a child of a particular birth order can receive more resources critically hinges upon the age difference between the child and his or her neighboring siblings. For instance, consider two children, ordered respectively first and second in a family. Suppose the age difference between the two siblings is 10. We can then think of the following two impacts: i) At the time when the parent is considering whether to let the *first* child go to college, if the family budget is tight and if parents foresee that they are more capable of supporting the second child's college expenses after 10 years of savings, then they may decide to let their first child enter the labor market. ii) At the time when parents are considering whether to let the *second* child go to college, the first child may have been in the labor market for a while, and is more likely to play a supporting role to the second child. Thus, for families with a tight budget larger age difference between two siblings is likely to be detrimental to the senior and helpful to the junior in college education.

Now we consider the second possibility that these two siblings are a pair of twins or have a 1-year age difference. In this case, sacrificing the elder child does not create as much financial advantage to the parents as in the case of a 10-year age difference.[6] If the parents can only afford one child's education expenses, then the child chosen by the parents is less likely to be related to his or her birth order. The third possibility is that the age

[6]The resource competition between two siblings will be discussed in more detail later.

difference is somewhere in between, say 5 years. The first child to some limited extent can then relieve the parents' financial burden. On the other hand, the two children with a 5-year age difference may also compete for education resources from their parents at the same time. As such, the third scenario seems to be between the 10-year age difference case and the twin case.

In summary, we see that birth order alone is not necessarily related to the resource concerns within the family; what is crucial is the *age difference* between the child in question and his or her siblings.[7]

The Confusing Sibship Effect: As the concern of age difference is brought up, we also realize that the *sibship* variable may also carry misleading information. For example, consider again two extreme cases of three siblings. The first case is a 1-year interval between every two consecutive births, and the second case is a 7-year interval between two consecutive births. Evidently, the former case is more likely to cause resource *competition* between the three children, and the latter case is likely to generate strong support for the youngest child. Thus, without taking into account the *age difference* factor, the *sibship* variable simply carries too much (possibly conflicting) information to be instructive. As a result, the corresponding empirical analysis may generate an estimate either insignificant or diluted in size.

Seniority Asymmetry: Another related point from the above discussion is the senior-junior *asymmetry* between siblings. Typically, it seems intuitive that a younger child is less likely to *support* his or her elder siblings

[7]Notice that our argument is consistent with, but different from, the *confluence* theory of psychologists. The confluence theory proposed by Zajonc (1976) hypothesizes that the development of a child's intelligence depends on that of all other family members, who interact with the child in question. Zajonc pointed out that one way of characterizing the intellectual environment of a family is its age configuration. In our model, the supporting role of an elder sibling can arise not because of his or her possibly more mature intelligence, but because of the interplay of resource constraints.

within a reasonable range of age differences, whereas an elder child may either compete with or support for his or her younger siblings. This kind of *seniority asymmetry*, to our knowledge, has never been taken into account in the previous literature.

Gender Difference: The final complexity is the interaction between birth order and child sex characterized in item 6 above, and also briefly mentioned in Schooler (1972) and Butcher and Case (1994). Given the same sibship and birth order, in many societies a female child is more likely to play a supporting rather than a competing role (Greenhalgh 1985). We should note that in societies with potential gender-specific differential treatment, the interplay of such age differences with child gender may also show a sophisticated pattern.

3 Sibling Age Differences and Family Resource Allocation

Consider the simplest situation where the parent of a household has two children. Each child faces two education choices: either to enter the job market after the mandatory education, say 12 years, or continue on to college education, say for another 4 years. Since our focus is on resource allocation, we normalize the time to be $t = 0$ when the first child finishes his or her mandatory education. The age difference between these two children is denoted ΔA.

3.1 Constrained Utility Maximization

Let the family consumption at time t be denoted by c_t. For simplicity, we assume that the discount rate is zero. The family head wishes to maximize the following lifetime utility:

$$\int_0^T u(c_t)dt + V(E_1, E_2), \tag{1}$$

where u is the usual increasing concave function, T is the time bound of the parent's planning horizon, $E_1, E_2 \in \{0, 1\}$ with $E_i = 1(0),\ i = 1, 2$ indicating that child i gets (does not get) a college degree, and V characterizes the parent's utility from their children's education achievement. If parents are assumed to favor a child of a particular birth order, then essentially any unequal education resource allocation is possible. Hence, we rule out this *ad hoc* assumption and concentrate on the possible impact created by the budget constraint of the family. We therefore assume $V(0, 1) = V(1, 0)$ for the time being, meaning that the parent does not have a priori reasons to favor one of the two children, and we shall relax this assumption later.

We propose the following assumptions and derive their implications.

Assumptions: (A1) *there is no capital market for student loans;* (A2) *educated children do not make contribution to the parents' budget.*

Of course, the above assumptions are not entirely consistent with the reality in many societies. For instance, in all economies there are alsways some formal or informal capital markets for all kinds of needs; but as long as these markets are imperfect, parental supports are important and our analysis goes through. Other variations of these assumptions will also be discussed later in the paper.

Let I_t be the parent's exogenous income at t, a_t be the parent's assets, $\dot{a}_t$ be the instantaneous change of a_t, and r be the interest rate. To maximize the utility function in expression (**??**), the parent faces the following budget constraint:

$$c_t + n_t p \leq I_t + r a_t - \dot{a}_t, \quad a_0 \text{ given}, \tag{2}$$

where p is the instantaneous expenses of going to college, and $n_t \in \{0, 1, 2\}$ is the number of children going to college at t. In our later analysis, we shall assume that inflationary factors have been controlled so that r in the above expression is the real interest rate and p is a constant. Note that if college education takes 4 years, then the expenditure flow p has to last 4 years for each child to change his or her E from 0 to 1.[8]

3.2 Implications

What we shall emphasize in this paper is the *postponement* effect caused by sibling age differences in family resource allocation. We will have this effect mainly because of Assumptions (A1) and (A2). Because there is no market for student loans, children's education will rely on savings by their parents. Thus, a longer period of savings will entail a more likely education support. Below we shall present our points one by one.[9]

Age Difference between Siblings: If parents are constrained in their budget so that they can allow only one child to go to college, then sacrificing the first child's education has the advantage of *postponing* the related expenditure, which can be saved and can help expand the budget set for the life cycle planning. As long as parents are indifferent between the two children ($V(1,0) = V(0,1)$), they should be willing to do this. The implication of this result is the disadvantageous situation faced by the elder child, especially when a parent's financial situation is sufficient to support only one child's college expenses. We shall call this the *forced forbearance effect* of the elder child. In addition, the disadvantage of the elder child increases when the age difference between siblings increases. Furthermore, whatever education the parents choose for their first child, the education opportunity for the second child improves as the age difference between the two children

[8]For simplicity, we assume away the complexity that a child may drop out of college, or may stop a while after high school graduation before going to college. Taking into account these complexities only makes the analysis tedious and does not change the insight.

[9]Technical details are available from the authors on request.

increases.

Sex-specific Differential Treatment: So far we have assumed that $V(0,1) = V(1,0)$ to support our argument. Many researchers have pointed out, however, that there has been differential treatment against girls in many East Asia countries.[10] Suppose there is a strong preference against girls. On the one hand, if the first child is a boy and the second is a girl, then it can be easily shown that our previous prediction can be overturned: parents with strong enough gender preferences [$V(1,0) - V(0,1)$ large] may still let their elder boy undergo more education and suppress the opportunity of the younger girl. On the other hand, if the first child is a girl and the second a boy, then the forbearance effect of the first child would be even stronger. The above discussion suggests that, other than differentiating siblings according to their age differences, male and female siblings should be treated differently in the empirical analysis.

The Financial Support Effect: If a parent decides to let the elder child have $E_1 = 0$ and go to work after high school, then at least for some time this elder child may contribute some of his or her earnings and increase the household income. This will also help relax the household budget constraint and is called the *financial support effect*. The period of this financial remittance is unknown, because it usually stops or shrinks significantly after the working child gets married and begins his or her own household.

The Ambiguous Competition Effect: Now consider a child C. If C has a sibling B who has a small age difference with C, then their parents may send either B or C to college, because the financial advantage of postponing the senior child (favoring the junior child) would be small. Thus, as far as the education opportunity of B and C is concerned, there are two conflicting effects involved. 1) Other things being equal, a child's probability of going to college is reduced nearly by 1/2, because of the existence of a competing

[10] See e.g., Greenhalgh (1985) and Parish and Willis (1993).

sibling.[11] 2) If parents let one child, say B, go to the labor market, then his or her remittance can create a financial support effect for the family, as argued above. It is possible that the parents originally cannot afford C's college expenses without B's remittance, but with such a remittance from B, C's opportunity of going to college increases. These two conflicting effects combined make us unable to predict the impact of adding a similar-age sibling on a child's education opportunity. In short, the impact on Child C's education opportunity from adding a senior or junior sibling who has a small age difference with C is ambiguous.

So far our discussion has been restricted to the scenario with two children. When there are more than 2 children in a family, the analysis is essentially the same as before. Parents will have to exhaust all pairwise comparisons to decide the education resource allocation. The competition, forbearance, or supporting effects evidently remain. A corresponding analysis is similar and is therefore skipped.

In summary, the above discussion tells us that we should go beyond the conventional argument that a child's education is affected by his or her birth order and sibship. Below we shall investigate the competing and supporting roles of siblings, taking into account all elements mentioned in the above discussion. In particular, after controlling the socioeconomic background of the economy and the family, we shall study the impact of siblings of different SSAD groups on a particular child's education achievement.

[11] Take the extreme case of a twin as an example: if the parents can afford only one child's college expenses, then they may let either one go to college, depending on their preferences and the children's relative performance.

4 Empirical Setting

Let S_{ik} be the education achievement of child k in family i. We suppose that S_{ik} is influenced by three major factors. First, the Societal Economic Status (denoted SES_{ik} for child k in family i) reveals the general economic condition of the society faced by the family head in question. Factor SES plays a role, because education takes resources, and only sufficiently rich economies (which do not need children to help sustain the family's basic consumption) can support children to receive a higher education. In general, this economic background can be captured by the father's birth year or birth cohort.

The second factor is the Family Economic Status the child faces (denoted FES_{ik}). If the father is the key income earner, then this variable should be characterized by the father's life-cycle income. Because most data sets do not have such detailed records of life-cycle parental incomes, we adopt the usual approach and treat the father's education as a proxy of his lifetime wealth. Other transitory fluctuations are assumed to be absorbed by the error term. The same argument appplies to mothers and we also include mother's education in our analysis.

The above-mentioned two groups of factors (SES and FES) control the objective environment a child faces in our empirical analysis. The third category of variables, the competing or supporting factors among siblings, is the focus of our investigation, and they are to be introduced below. Unlike the confluence theory of Zajonc's (1976), where the author used the average age of family members to capture the intelligence maturity faced by a child, our scenario of competition and supporting is more refined. As we argued in sections 2 and 3, a child's siblings should be separated into several SSAD groups in order to capture the true interactions within a family. We hope that this refinement can help clarify the ambiguous effects of sibship and birth order raised in the previous literature.

For child k in family i, let the competing/supporting influence from junior female siblings be denoted IJF_{ik}. Similarly, IJM_{ik}, ISF_{ik}, and ISM_{ik} denote respectively the influence from junior male, senior female, and senior male siblings. Taking into account these impacts, S_{ik} can be written as

$$S_{ik} = f(SES_{ik}, FES_{ik}, IJF_{ik}, IJM_{ik}, ISF_{ik}, ISM_{ik}). \tag{3}$$

In equation (**??**), the first two elements control the environment of the society and the household, and the remaining four capture the between-sibling resource interactions.

Let JF represent the set of a child's junior female siblings, and let JM, SF and SM be similarly defined. To capture the importance of sibling age differences, we further separate the siblings in JF, JM, SF, and SM categories into three age groups, and let $N3^-$, $N47$, and $N8^+$ denote the number of siblings whose age difference with the child in question is less than or equal to 3, between 4 and 7, and larger than or equal to 8, respectively. Leaving aside the within-group constant term, which is to be absorbed into the regression constant, we can characterize the impact from siblings in group $g \in G \equiv \{JF, JM, SF, SM\}$ as

$$Ig = a_g(N3^-)_g + b_g(N47)_g + c_g(N8^+)_g,$$

where a_g, b_g, and c_g are three coefficients for group g.

Suppose the above-mentioned factors each play the role of an additive or multiplicative adjustment factor in influencing child k's schooling.[12] Equation (**??**) can then be written as[13]

$$S_{ik} = SES_{ik} + FES_{ik} + \sum_{g \in G} [a_g(N3^-)_g + b_g(N47)_g + c_g(N8^+)_g] + \epsilon_{ik}, \tag{4}$$

[12]If the effect is multiplicative, then taking a logorithm will transform it into an additive form.

[13]In terms of the psychology literature, IJF, IJM, ISF, and ISM respectively characterize the *confluence* effect from siblings of different groups. The distinction here is that

where G consists of sibling categories. Let the variables that influence SES and FES be jointly characterized by a vector X_{ik}, and let the total influence be $X_{ik}\beta$. Substituting this specification into Eq. (**??**), we now have the following expression:

$$S_{ik} = X_{ik}\beta + \sum_{g \in G} [a_g(N3^-)_g + b_g(N47)_g + c_g(N8^+)_g] + \epsilon_{ik}. \quad (5)$$

In equation (**??**), because of the existence of a common family effect for all siblings in family i, the errors ϵ_{ik} are not independently distributed. Any least squares estimation failing to take into account this dependence will result in an inefficient estimation. Furthermore, as pointed out by Griliches (1979), applying the fixed effect model to the family context may exacerbate other econometric problems such as measurement errors and variable endogeneity and may interfere with the estimation of common-to-all-sibling variables. Care must be exercised. To overcome these potential problems in the estimation, we compute the covariance matrix of the estimates using the consistent method for serial correlation and conditional heteroskedasticity; see Newey and West (1987), White (1980), and Huber (1967).

5 Data Description and Social Background

5.1 Data and Variable Definitions

The data set we use is from the first wave of PSFD (Panel Study of Family Dynamics) survey conducted in Taiwan.[14] Since Taiwan is a well-known area

we explicitly assume seniority asymmetry and gender differences. Moreover, equation (4) has a theoretical foundation described in section 2, and it has controlled the interactions of social and family economic environments. These modifications allow sophisticated interactions among distinct sibling groups, which would not appear in a confluence model.

[14]The purpose of this survey is to construct a unique panel in a Chinese society. The project, entitled PSFD, was conducted with the support of the Chiang Ching-Kuo (CCK)

undergoing rapid economic and demographic transitions,[15] parents' attitude toward their children's education is expected to change significantly from the past. Against this changing background, one is more likely to observe co-existing samples with contrasting socioeconomic characteristics, which are particularly appropriate for the empirical study of family behavior.

The first wave of PSFD survey conducted during 1999 – 2003 includes roughly 4,000 respondents from cohorts born between 1934 and 1974 (inclusive). The questionaire covers detailed socio-economic information about family members of the interviewed individual as well as their relations with each other. In particular, for each randomly-sampled respondent, information concerning the education background of almost all of his or her siblings was also collected. ¿From the information of the respondent and his (her) siblings, we construct family-siblings data set in order to estimate the differential education achievement among siblings. After deleting observations with missing variables, the final sample size is 10,764 children from 2,626 families.

The definition, sample mean, and standard deviation of the variables used in our empirical analysis are listed in Table 1. As one can see from the Table, the average year of schooling for males is longer than that of females, revealing a possible pattern of sex-specific differential treatment. The same phenomenon is also reflected in the difference of years of schooling between the father and mother of a respondent.

Insert Table 1 about here.

foundation, the National Science Council, and Academia Sinica of Taiwan, under the guidance of Gary Becker, Angus Deaton, Robert Hauser, James Heckman, Cheng Hsiao, Ronald Lee, William Parish, George Tiao, Jim Vaupel, Arthur Wolf, Cyrus Chu, and other local collaborators. For details, see http://psfd.sinica.edu.tw.

[15] See Chu and Lee (2000) for more details.

5.2 The Education System in Taiwan

Since our purpose is to analyze the causes of differential education achievement among siblings, we feel obliged to introduce the education system in Taiwan. There are five main tiers of regular schools in Taiwan, namely elementary (6 years), junior high (3 years), high school (3 years), college (4 years) and graduate schools, together with some supplementary vocational schools. Although various schools used to screen their own students, starting from 1950 most schools in Taiwan have participated in the *joint entrance examinations* (JEE) to exercise student screening. As one can see, nearly all our sampled respondents are subject to the JEE system. Before 1968, for the entrance from elementary to junior high, 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 join the competition. After 1968, the mandatory education extended from six to nine years, and hence the JEE from elementary to junior high was abolished.

In Taiwan, because i) the training of teachers of all school tiers was monopolized by national normal colleges, ii) the salary scales of teachers and professors are seniority-based, and iii) the university professor licensure was uniformly regulated by the Ministry of Education in most relevant periods of our study,[16] there is not much *a priori* reasons to expect quality differences among school teachers. Moreover, the tuition upper bound of private schools regulated by the government also renders constraints to their quality improvement. Thus, most parents and students in Taiwan prefer to go to the less-expensive public schools and universities rather than the private

[16]The monopoly of training teachers 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. For a related discussion of controlling school quality, see Behrman and Birdsall (1983).

ones. The JEE ranks all lower-tier graduates according to their JEE scores, and higher-score students are allowed to choose schools (or departments) to enter before lower-score students do. In the end, there are always some disappointed students who do not have any desirable match.[17]

The JEE in Taiwan is basically a written exam and therefore the criterion of admission is very uniform. Given the above-mentioned 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 devoted by his or her parents (e.g., for after-school tutoring). The resource devotion from parents to children of course depends on the parents' education background, ethnicity, and in particular their sex preferences and budget constraint. For instance, if the parents have financial constraints and are only able to afford one child to go to college, then child gender or birth order may play an important role. In summary, the uniform JEE system in Taiwan makes all students' upward-moving ladders relatively standard, and hence it is appropriate for our econometric analysis.

5.3 Variable Choices

In our empirical analysis (**??**), most of the explanatory variables, such as parents' education, mother's working status, and father's birth cohort, father's ethnic background, are the same as those in the literature introduced in sections 1 and 2. We also include the born-after-1956 dummy to capture

[17]For instance, in the year 2000, 125,498 students registered for the JEE of colleges. The overall entrance rate from high school to college was 59.98%. The most-preferred college in general was the 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 to study. In the same year, there were 22,115 students participating the JEE from junior high to high school in the Taipei area; corresponding figures in other areas are omitted.

the effect of the extension of mandatory education in 1968, which applies to cohorts born since 1956. To capture the risk of birth defect from older mothers (Item 1 listed in section 2), we include a dummy variable, which equals 1 if the child in question was born when the mother was over 40 years old and 0 otherwise.

Our strategy is to control the macroeconomic as well as family backgrounds of a child and to investigate the effect of sibship of various SSAD groups on the child's education S_{ik}. These variables, according to our theoretical conjecture in section 2, are expected to have different effects on S_{ik}.

6 Estimation Results

We first run a benchmark model in Table 2, which is the case similar to the traditional analysis. The significant coefficients associated with the father's birth cohort dummies indicate that younger parents who face a better economic environment are more capable of supporting their children's education. The significant estimates of the father's ethnicity dummies reveal that Taiwan's aborigines are relatively disadvantageous in education opportunity. Both these findings are consistent with our general perception. Other explanatory variables such as parents' education, mother's working status, child's gender, and child birth dummy all have significant coefficients with expected signs. The dummy of mother's age (at the birth of the child), however, is not significant.

Insert Table 2 about here.

Other than the above-mentioned background variables, we find that the sibship is significantly negative at the 1% level and that [birth-order]^2 is significantly positive at the 5% level. These results tend to support the general finding concerning the effects of sibship and birth order. However, as we argued in the previous discussion, such interpretations may be misleading.

For instance, it may be the case that a 1-year older senior sibling does not have any significant impact on a child, while another 6-year older senior sibling has a significantly positive impact. As we mingle together these two siblings into a *sibship* variable, we either find the coefficient insignificant, or it remains significant, but the effect of the 6-year senior sibling is diluted. For another instance, a boy with a high birth order may receive more education not because of his birth order per se, but because his older female siblings remit some income to support the parents. Thus, without differentiating siblings with different seniority-sex-age backgrounds, the superficial effect of birth order may capture other factors and is difficult to interpret.

6.1 Refined Sibling Effect

In Table 3 we present the results with SSAD-specific sibships as explanatory variables. The theoretical predictions presented in section 3 show that, in a family under a financial constraint, the senior child may have to give up his or her chance of education in order to support the younger ones, especially when the younger ones' age difference with the child in question is sufficiently large. These predictions are typically verified by the results of Table 3. As one can see from the [All] column, which is based on the whole sample, the marginal effect of younger siblings with large age differences (≥ 8) on the child's education is negative, with a magnitude of roughly 0.46 years per younger brother and 0.55 years per younger sister. These negative coefficients represent the forbearance effects imposed on the senior child in question, as predicted in section 3. It is noted that the corresponding coefficient (-.46 or -.55) is larger in absolute value than that of the overall sibship effect -0.225 in Table 2. This reveals the dilution caused by mingling siblings who are supposed to play different roles. On the other hand, siblings with a small age difference ($[0, 3]$), either junior or senior, do not have a significant impact on the child's education, which is consistent with our implications derived.

Insert Table 3 about here.

The [All] column of Table 3 also shows that the effects of female senior siblings with an age difference of 4-7 and 8^+ years are positive with asymptotic t-value of 2.60 and 1.63, respectively, indicating that they can help the younger siblings' education. While these effects are significant at the 1% and 11% level, they are consistent with the results of Greenhalgh (1985) and Parish and Willis (1993). Elder sisters with a large age difference $[\geq 8]$ do not help as much as the ones with $[4, 7]$ age difference; this may be due to the termination of remittance of the former group after they form their own households. As to the effect of male senior siblings with an age difference of 8^+, a significantly positive coefficient (5%) leads to the conclusion that elder brothers with a large age difference $[\geq 8]$ are also helpful for the younger siblings' education.

6.2 Sex Differences

It is believed that for children of different sexes, the pressure and support they have from siblings are different. In a family with typical differential treatment against girls, a parent is more likely to ask a senior female child to forgo education than to ask a senior male. We therefore separate our respondents into males and females and run the regression separately. The results are presented in the [Female] and [Male] columns of Table 3.

¿From Table 3 we first note that female respondents seem to be more sensitive to the number of junior siblings, as revealed by the absolute values of significant coefficients. For a male respondent, increasing one junior male and female sibling with an age difference larger than 8 will reduce his own year of education by 0.312 and 0.417 years respectively. However, if the respondent is a female, then the same effect increases to 0.578 and 0.671

years, sizeably larger (in absolute value) than that of the male counterparts.

The [Female] and [Male] columns also reveal another interesting fact. ¿From the (significant) coefficients associated with elder brothers and sisters, we find that elder brothers and sisters are both helpful to the schooling of female respondents, yet the results for the male sample show a different pattern. For the schooling of males, we find that elder sisters (with age difference of 4-7) are beneficial while elder brothers (with age difference [≤ 3]) are detrimental. We also find that *older sisters are more helpful* to young siblings than older brothers. This seems to reveal that elder sisters are more likely to be secondary income earners to a family.

A related phenomenon we find is the following: We can separate the environmental pressures a child faces (in terms of education opportunity) into three categories: the father's birth cohort characterizes the *macro* factor from the economic environment, the schooling of parents captures the *micro* economic pressure within family, and the 1956 dummy is a change in the *institutional* pressure by increasing mandatory education from 6 to 9 years. For these above-mentioned variables, we find that the coefficients associated with the female sample are always larger than those of males, it suggests that when the pressure increases, it is the female who is sacrificed; and when the pressure reduces, it is also the female who benefits more. This means that girls are indeed the vulnerable group; they are the ones who absorb all kinds of outside sensitivities.

To examine whether the SSAD-specific sibships behave differently for male and female respondents, we rerun the regression with the whole sample by adding the interaction terms of female dummy and SSAD-specific variables. The results are not listed in Table 3; but it does turn out that younger siblings are more detrimental to the females than to the males. In addition, younger siblings with large age difference are more detrimental to the females than the ones with small age difference. A simple F test is performed to examine whether the interaction terms are jointly zero. The corresponding F statistic ($F = 6.40$ with degrees of freedom $= 12, 2625$) indeed rejects the hypothesis that the male and female groups have the same sets of coefficients associated with SSAD-specific sibships.

6.3 Differences Due to Fathers' Cohorts

It is believed that parents are intrinsically altruistic toward all children, so that their possible discrimination against girls (in terms of education resource allocation) would be necessary only if the economic environment cannot allow them to support all their children's education. To investigate the impact of a changing economic environment, we separate our samples into two groups, roughly of equal sizes, one with fathers born before 1930 and the other born after 1930. Since the former group of parents is expected to face more stringent economic conditions than the latter group, we suspect that the regression results may be different between the two groups.

Table 4 presents the results for the two groups. Comparing the two columns of the table, we make the following observations. First, the support effect of senior siblings as shown by marginally significant *positive* estimates in the column of Old Cohort have changed to competing effect shown by the significant *negative* estimates in Young Cohort column. Presumably the improved economic environment implied that parents no longer needed the financial support from their older children. In fact, parents were more willing to send their children into college, resulting in resource competition among children regardless of their birth order. Second, the number of elder sisters has no siginicant impact on a child's education in the Young Cohort. This indicates that the improvements in economic condition and parents' education have had a positive impact concerning discrimination against girls in Taiwan. Third, for the young cohort group, the competing effect of younger siblings (both brothers and sisters) have spreaded to all age difference categories. However, the magnitues of the estimates are proportional to age differences. Therefore, young siblings with larger age differences continue to be detrimental to the education of older children. For instance, consider the case of young brothers in the Young Cohort column. The estimated impact of a younger brother with age difference 8^+ years is more than four times of that of one with age difference less than 3 years. The same is true for the younger sisters. These observations show that the importance of SSAD in studying education resource allocation within a family continues to hold regardless of the status of economic environment.

Insert Table 4 about here.

Another important implication of the results of Table 4 is related to the "practice of family planning." One might argue that family education resouce allocation could be influenced by family planning and fertility. We examine the history of family planning on Taiwan. The island-wide family planning program on Taiwan began in 1964; see Chow (1974). And the acceptance rates of contraceptive methods offered by the program have increased steadily since then. By the end of 1973, birth control became commonpractice and nearly 50% of married couples adopted certain kinds of contraceptive devices.

Since we don't have data available concerning family planning of the sampled families, it seems reasonable to assume that families with fathers born after 1930 (i.e. fathers in the Young cohort) were subject to the practice of family planning and had some control over fertility, whereas birth control is presumably looser for families with fathers born before 1930 (i.e. fathers in the Old cohort). The results of Table 4, therefore, also provide information concerning the effects of family planning on our study. The fact that both columns of Table 4 support the SSAD sibship effects on family education resource allocation suggests that changes in the "practice of birth control" cannot explain away our findings on the importance of SSAD.

6.4 Cohort Effects

A main finding discussed earlier is that the sibship effects are much stronger when siblings are more than 8 years apart. Children with much-older siblings benefit the most, while those with much-younger siblings are at a disadvantage. A possible explanation for the findings is due to birth cohorts. That is, respondents with much-younger siblings were born early and had fewer years of schoolings, whereas respondents with much-older siblings were born late and had more years of schooling.

To examine this possibility, we add in the birth cohort dummies and rerun the regressions. The results given in Table 5 show that all the cohort dummies are highly significant. And in comparison with the results in the All column of Table 3, some significant sibship variables in Table 3 turn out to be insignificant in Table 5. However, younger siblings with age difference more than 8 years are still significant. The column [All-(2)] of Table 5 gives the results when the cohort's average years of schooling is used as an additional explanaroty variable. Again, this addition does not alter the results of our analysis. These results show that our findings concerning SSAD are quite robust under different settings.

Insert Table 5 about here.

7 Conclusions

In this paper we propose a Sex, Seniority, and Age Difference (SSAD) model for studying family education resource allocation. We argue that because siblings of different sex-seniority-age difference combinations may have distinct implications in family resource allocations, it is inappropriate to mingle these variables into a sibship or birth-order variable in empirical analysis. Our theoretical investigation shows that a crucial variable that differentiates the various impacts is the age difference between two siblings. When the economic environment the parents face is at the margin, they tend to sacrifice their elder female child's education opportunity, especially when the younger sibling is a boy with a larger age difference.

Based on our theoretical framework, we set up an empirical framework accordingly. Statistical tests generally cannot reject our hypotheses. Comparing our results with that available in the literature, we show that siblings with distinct characteristics have positive or negative effects on a child's education opportunity. Without differentiating the seniority-sex-age distinctions, the estimates associated with a mingled variable "sibship" may be seriously diluted, or even become insignificant. We believe that our refined framework and empirical analysis can help clarify the problem of family resource allocation and explain the differences in previous research.

References

1. Adams, Bert N. (1972) "Birth Order: A Critical Review," *Sociometry* 3: 411 – 439.

2. Altus, William D. (1966) "Birth Order and Its Sequelae," *Science* 151: 44 – 49.

3. Behrman, Jere and Birdsall, Nancy (1983) "The Quality of Schooling: Quantity Alone is Misleading," *American Economic Review* 73: 928 – 946.

4. Behrman, Jere and Taubman, Paul (1986) "Birth Order, Schooling, and Earnings," *Journal of Labor Economics* 4: S121 – S145.

5. Birdsall, Nancy (1991) "Birth Order Effects and Time Allocation," *Research in Population Economics* 7: 191 – 213.

6. Butcher, Kristin F. and Anne Case (1994) "The Effect of Sibling Sex Composition on Women's Education and Earnings," *Quarterly Journal of Economics* 109: 531 – 563.

7. Chow, L. P. (1974) "The Island-wide Family Planning Program in Taiwan: Analysis of Accomplishments of the Past Eight Years," *Population Studies* 28: 107 – 126.

8. Chu, C. Y. Cyrus (1991) "Primogeniture," *Journal of Political Economy* 99: 78 – 99.

9. —— and Ronald D. Lee (2000) *Population and Economic Change in East Asia*, a supplement to *Population and Development Review* vol. 26.

10. Das Gupta, Monica (1987) "Selective Discrimination Against Female Children in Rural Punjab, India," *Population and Development Review* 13: 77-100.

11. Davis, Daniel J. (1977) "Birth Order and Intellectual Development: The Confluence Model in the Light of Cross-cultural Evidence," *Science* 196: 1470 – 1472.

12. Galton, Francis (1874) *English Men of Science: Their Nature and Nurture*. London: MacMillan

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

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

15. Huber, P. 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.

16. Kessler, Daniel (1991) "Birth Order, Family Size, and Achievement: Family Structure and Wage Determination," *Journal of Labor Economics* 9: 413 – 426.

17. Kuo, Hsiang-Hui D. and Hauser, Robert M. (1997) "How Does Size of Sibship Matter? Family Configuration and Family Effect on Education Attainment," *Social Science Research* 26: 69 – 94.

18. Newey, Whitney and West, Kenneth (1987) "A Simple Positive Semi-Definite, Heteroskedastic and Autocorrelation Consistent Covariance Matrix," *Econometrica* 55: 703 – 708.

19. Parish, William L. and Willis, Robert (1993) "Daughters, Education, and Family Budgets," *Journal of Human Resources* 28: 863 – 898.

20. Schooler, Carmi (1972) "Birth Order Effects: Not Here, Not Now," *Psychological Bulletin* 78: 161 – 175.

21. White, Halbert (1980) "A Heteroskedasticity-Consistent Covariance Matrix Estimators and a Direct Test for Heteroskedasticty," *Econometrica* 48: 827 – 838.

22. Zajonc, R. B. (1976) "Family Configuration and Intelligence," *Science* 192: 227 – 235.

Appendix: Formal Propositions

Note: This Appendix is not part of this paper, and will be provided on a website available for interested readers in the future.

Given a pair of (E_1, E_2) and subject to the constraint in (2), let the maximum utility derived from (1) be $W(E_1, E_2)$.

Proposition 1 (*Disadvantage* of the *elder* child): Suppose assumptions (A1) and (A2) hold. *If* $V(1,0) = V(0,1)$, *then* $W(0,1) - W(1,0) > 0$. *Furthermore,* $W(0,1) - W(1,0)$ *increases in* ΔA.

Proof of Propositions 1: Consider the scenario with $E_1 = 1$ and $E_2 = 0$, and suppose the optimal consumption path derived is c_t^* and the corresponding saving path is s_t^*. Since $E_1 = 1$ by assumption, the parent must spend p during the period between $t = 0$ and $t = 4$. Now consider the alternative with $E_1 = 0$ so that p is saved for $t \in [0, 4]$. Suppose the parent consumes $c_t' \equiv c_t^* + \epsilon$ and saves $s_t' \equiv s_t^* + (p - \epsilon)$ for $t \in [0, 4]$, where ϵ is a small positive amount.[18] The present value of this extra savings flow is $\int_0^4 (p - \epsilon) e^{-rt} dt$, which at the time when the second child is going to college (which is time ΔA in out notation), has the value

$$\psi_1 \equiv e^{\Delta A r} \int_0^4 (p - \epsilon) e^{-rt} dt. \qquad (X1)$$

At time ΔA, the discounted value needed for the second child's college expenses is

$$\psi_2 \equiv \int_{\Delta A}^{\Delta A + 4} p e^{-r(t - \Delta A)} dt = \int_0^4 p e^{-rt} dt. \qquad (X2)$$

Comparing $(X1)$ and $(X2)$, we see that as long as ϵ is small enough, $\psi_1 > \psi_2$ must hold. Thus, as far as the family budget is concerned, sending the second

[18] It may be the case that college expenses rise with time, so that p is an increasing function of time. It can be easily shown that as long as the appreciation rate of p is less than or equal to the interest rate r, then our analysis remains valid.

instead of the first child to college can enlarge the household's feasible set (the postponement effect). Furthermore, the parent can actually do even better, because the consumption plan $c_t^* + \epsilon$ is not yet the optimal plan. Since the parent is indifferent between the two children, the first part of proposition 1 is proved.

¿From $(X1)$ and $(X2)$, it is easy to see that $\psi_1 - \psi_2$ is increasing in ΔA. This implies that the financial advantage of sacrificing the first child enlarges as ΔA increases. Because $W(1,0)$ is independent of ΔA and $W(0,1)$ increases in ΔA, $W(0,1) - W(1,0)$ also increases in ΔA.

Proposition 2: *Suppose assumptions (A1) and (A2) hold. For any given* $E_1(= 0 \textit{ or } 1)$, $W(0,1) - W(1,0)$ *increases in* ΔA.

Proof of Proposition 2: For any given $E_1 = 0$ *or* 1, if the parent considers a change from $E_2 = 0$ to $E_2 = 1$, then the extra budget deficit for the parent (at time 0) is

$$D \equiv e^{-r\Delta A} \int_{\Delta A}^{\Delta A+4} pe^{-r(t-\Delta A)} dt = e^{-r\Delta A} \int_0^4 pe^{-rt} dt.$$

Evidently, when ΔA increases, the budget deficit decreases. On the one hand, the envelope theorem tells us that the drop in $\int_0^T u(c_t)e^{-rt}dt$ due to this extra budget deficit decreases as D declines. On the other hand, the change in E_2 generates a utility increment of size $V(E_1, 1) - V(E_1, 0)$, which is a constant. As such, we know that when ΔA increases, it is more likely that $V(E_1, 1) - V(E_1, 0)$ will outweigh the utility drop in $\int_0^T u(c_t)e^{-rt}dt$.

Proposition 3: *The impact on a child C's education opportunity from adding a senior or junior sibling who has a small age difference with C is ambiguous.*

Proof of Proposition 3: The case is not interesting if the parents are so rich that both B and C can go to college, or so poor that neither B nor

C goes to college. Thus, our discussion will focus on the intermediate case where parents may afford one of the two children to go to college. To simplify the presentation, sex preferences on the parents' side are ignored.

Propositions 1 and 2 tell us that there exists a critical b such that if the age difference between B and C is $\Delta A < b$, then the probability a particular child is sent to college is roughly 1/2. If child C goes to the labor market and remits an amount R_t to his or her parents, the family budget constraint becomes

$$c_t + n_t p \leq M_t = I_t + R_t + r a_t - \dot{a}_t, \quad a_0 \text{ given.}$$

Now consider child B. If he does not have a sibling C, then his parents' initial a_0 would be higher, because the resource competition between B and C disappears. This would increase the probability of supporting B to attend college. On the other hand, without C the flow of remittance R_t would also disappear, which reduces B's possibility of going to college. The net impact certainly depends on the relative size of these two effects.

Table 1. Summary of Statistics

Variables	All	Female	Male	Old Cohort Father's Birthyear <1930	Young Cohort Father's Birthyear >=1930
Child's schooling	10.659	10.115	11.206	9.364	12.268
	(4.185)	(4.387)	(3.897)	(4.486)	(3.099)
Father's birth cohort					
before 1915 (ref)	0.080	0.080	0.081	0.145	0.000
	(0.272)	(0.271)	(0.273)	(0.352)	(0.000)
1915-1924	0.307	0.308	0.306	0.554	0.000
	(0.461)	(0.462)	(0.461)	(0.497)	(0.000)
1925-1934	0.316	0.310	0.322	0.301	0.334
	(0.465)	(0.463)	(0.467)	(0.459)	(0.472)
After 1935	0.297	0.302	0.292	0.000	0.666
	(0.457)	(0.459)	(0.455)	(0.000)	(0.472)
Born after1956	0.609	0.607	0.612	0.337	0.948
	(0.488)	(0.489)	(0.487)	(0.473)	(0.222)
Gender (Male=1)	0.499	—	—	0.500	0.498
	(0.500)			(0.500)	(0.500)
Number of children	4.677	4.796	4.558	5.048	4.216
	(1.330)	(1.296)	(1.352)	(1.317)	(1.193)
Birth order	2.832	2.793	2.870	3.022	2.595
	(1.524)	(1.500)	(1.547)	(1.617)	(1.363)
Number of elder brothers with					
Age difference [0,3]	0.330	0.315	0.345	0.321	0.341
	(0.512)	(0.504)	(0.519)	(0.508)	(0.516)
Age difference [4,7]	0.308	0.305	0.310	0.347	0.258
	(0.550)	(0.548)	(0.552)	(0.577)	(0.511)
Age difference >=8	0.198	0.191	0.206	0.284	0.093
	(0.522)	(0.505)	(0.537)	(0.611)	(0.355)
Number of elder sisters with					
Age difference [0,3]	0.378	0.381	0.376	0.349	0.416
	(0.543)	(0.543)	(0.542)	(0.516)	(0.572)
Age difference [4,7]	0.374	0.370	0.378	0.390	0.353
	(0.615)	(0.612)	(0.619)	(0.615)	(0.615)
Age difference >=8	0.244	0.230	0.257	0.331	0.135
	(0.604)	(0.576)	(0.630)	(0.690)	(0.453)

Table 1. Summary of Statistics (continued)

Variables	All	Female	Male	Old Cohort Father's Birthyear <1930	Young Cohort Father's Birthyear >=1930
Number of younger brothers with					
Age difference [0,3]	0.360	0.375	0.345	0.341	0.383
	(0.527)	(0.533)	(0.520)	(0.518)	(0.536)
Age difference [4,7]	0.345	0.379	0.311	0.373	0.309
	(0.566)	(0.588)	(0.541)	(0.584)	(0.540)
Age difference >=8	0.237	0.263	0.211	0.321	0.132
	(0.548)	(0.575)	(0.518)	(0.626)	(0.407)
Number of younger sisters with					
Age difference [0,3]	0.349	0.382	0.317	0.329	0.375
	(0.524)	(0.543)	(0.502)	(0.504)	(0.547)
Age difference [4,7]	0.339	0.371	0.308	0.365	0.308
	(0.580)	(0.605)	(0.552)	(0.589)	(0.567)
Age difference >=8	0.215	0.234	0.196	0.296	0.114
	(0.541)	(0.560)	(0.521)	(0.626)	(0.388)
Father's schooling	5.872	5.875	5.869	5.044	6.901
	(4.32)	(4.293)	(4.346)	(4.455)	(3.909)
Mother's schooling	3.623	3.635	3.612	2.712	4.755
	(3.828)	(3.808)	(3.849)	(3.664)	(3.725)
Mother older than 40	0.024	0.022	0.026	0.038	0.006
	(0.152)	(0.146)	(0.159)	(0.192)	(0.075)
Working mother	0.265	0.257	0.273	0.223	0.317
	(0.441)	(0.437)	(0.446)	(0.416)	(0.465)
Father's ethnicity					
Aborigines	0.013	0.015	0.010	0.012	0.013
	(0.111)	(0.122)	(0.100)	(0.111)	(0.112)
Fukkien	0.778	0.779	0.777	0.743	0.821
	(0.416)	(0.415)	(0.417)	(0.437)	(0.384)
Hakka	0.117	0.118	0.116	0.115	0.118
	(0.321)	(0.322)	(0.320)	(0.319)	(0.323)
Mainlander	0.089	0.084	0.095	0.126	0.044
	(0.285)	(0.277)	(0.293)	(0.331)	(0.205)
Number of observations	10,764	5,393	5,371	5,964	4,800

Note: Standard deviations are in the parentheses.

Table 2. The Effects of Sibship and Birth Order on Schooling

Explanatory Variables	Entire Sample
Constant	3.713***
	(7.99)
Father's birth cohort	
before 1915（ref）	—
1915-1924	0.900***
	(3.82)
1925-1934	1.715***
	(7.14)
After 1935	2.638***
	(10.41)
Born after1956	1.066***
	(8.60)
Gender (Male=1)	0.996***
	(14.80)
Number of children	-0.225***
	(5.83)
Birth order	0.137*
	(1.95)
Birth order squared	0.027**
	(2.46)
Father's schooling	0.285***
	(17.99)
Mother's schooling	0.206***
	(12.15)
Mother's age >=40	0.289
	(1.19)
Working mother	-0.330***
	(3.01)
Father's ethnicity	
Aborigines（ref）	—
Fukkien	2.114***
	(5.99)
Hakka	2.498***
	(6.71)
Mainlander	3.509***
	(9.25)
R^2	0.4387
Number of families	2,626
Number of observations	10,764

Note: ***, **, * denote significance at 1%, 5%, 10% levels respectively.
Absolute *t* values are in the parentheses.

Table 3. The Effects of Age-sex-specific Siblings on Years of Schooling

Explanatory Variables	All	Female	Male
Constant	3.603*** (8.06)	2.995*** (5.65)	5.369*** (9.86)
Father's birth cohort			
1915-1924	0.858*** (3.62)	1.114*** (4.03)	0.623** (2.28)
1925-1934	1.660*** (6.85)	1.975*** (6.89)	1.368*** (4.80)
After 1935	2.559*** (9.95)	3.319*** (10.76)	1.805*** (5.88)
Born after1956	0.979*** (7.74)	1.231*** (7.27)	0.702*** (4.51)
Gender (Male=1)	1.015*** (15.05)	—	—
Number of elder brothers with			
Age difference [0,3]	-0.026 (0.37)	0.092 (0.97)	-0.178* (1.83)
Age difference [4,7]	0.019 (0.27)	0.071 (0.75)	-0.044 (0.50)
Age difference >=8	0.174** (2.23)	0.253** (2.47)	0.060 (0.60)
Number of elder sisters with			
Age difference [0,3]	-0.001 (0.01)	0.015 (0.17)	-0.026 (0.30)
Age difference [4,7]	0.150*** (2.60)	0.122 (1.48)	0.150* (1.98)
Age difference >=8	0.114 (1.63)	0.173* (1.79)	0.056 (0.66)
Number of younger brothers with			
Age difference [0,3]	0.028 (0.39)	0.016 (0.18)	-0.063 (0.63)
Age difference [4,7]	-0.041 (0.59)	0.070 (0.75)	-0.229** (2.44)
Age difference >=8	-0.461*** (5.28)	-0.578*** (5.12)	-0.312*** (2.67)
Number of younger sisters with			
Age difference [0,3]	-0.062 (0.90)	-0.190** (2.16)	0.022 (0.23)
Age difference [4,7]	-0.075 (1.09)	-0.115 (1.26)	-0.087 (0.89)
Age difference >=8	-0.554*** (6.92)	-0.671*** (6.43)	-0.417*** (4.06)

Table 3. The Effects of Age-sex-specific Siblings on Years of schooling (continued)

Explanatory Variables	All	Female	Male
Father’s schooling	0.285***	0.292***	0.276***
	(18.05)	(14.74)	(15.20)
Mother’s schooling	0.203***	0.224***	0.183***
	(12.10)	(10.51)	(9.35)
Mother’s age >= 40	0.302	-0.069	0.582**
	(1.25)	(0.18)	(1.96)
Working mother	-0.321***	-0.167	-0.447***
	(2.94)	(1.25)	(3.45)
Father’s ethnicity			
Fukkien	2.105***	2.004***	2.198***
	(5.93)	(4.57)	(5.12)
Hakka	2.490***	2.369***	2.603***
	(6.66)	(5.13)	(5.75)
Mainlander	3.493***	3.512***	3.466***
	(9.18)	(7.47)	(7.61)
R^2	0.4434	0.5016	0.3753
Number of families	2,626	2,318	2,423
Number of observations	10,764	5,393	5,371

Note: ***, **, * denote significance at 1%, 5%, 10% levels respectively.
Absolute *t* values are in the parentheses.

Table 4. The Effects of Age-sex-specific Siblings on Years of Schooling, by Father's Birth Cohort

Explanatory Variables	Old Cohort Father's Birthyear <1930	Young Cohort Father's Birthyear >=1930
Constant	2.903***	8.185***
	(5.59)	(14.60)
Born after1956	1.270***	1.046***
	(8.80)	(3.74)
Gender (Male=1)	1.532***	0.298***
	(15.81)	(3.53)
Number of elder brothers with		
Age difference [0,3]	-0.091	-0.138
	(0.96)	(1.45)
Age difference [4,7]	0.077	-0.283***
	(0.80)	(3.02)
Age difference >=8	0.161*	-0.216*
	(1.76)	(1.74)
Number of elder sisters with		
Age difference [0,3]	0.000	-0.115
	(0.01)	(1.41)
Age difference [4,7]	0.143*	-0.015
	(1.67)	(0.20)
Age difference >=8	0.092	-0.007
	(1.03)	(0.07)
Number of younger brothers with		
Age difference [0,3]	0.063	-0.189**
	(0.61)	(2.06)
Age difference [4,7]	0.075	-0.387***
	(0.77)	(4.20)
Age difference >=8	-0.403***	-0.828***
	(3.92)	(5.33)
Number of younger sisters with		
Age difference [0,3]	-0.063	-0.146*
	(0.62)	(1.65)
Age difference [4,7]	0.020	-0.315***
	(0.21)	(3.37)
Age difference >=8	-0.571***	-0.655***
	(5.94)	(4.77)
Father's schooling	0.331***	0.220***
	(14.51)	(10.89)
Mother's schooling	0.271***	0.158***
	(10.59)	(8.03)
Mother's age >= 40	0.209	-0.027
	(0.78)	(0.06)
Working mother	-0.168	-0.400***
	(0.93)	(3.27)

Table 4. The Effects of Age-sex-specific Siblings on Years of Schooling, by Father's Birth Cohort (continued)

Explanatory Variables	Old Cohort Father's Birthyear <1930	Young Cohort Father's Birthyear >=1930
Father's ethnicity		
Fukkien	2.82***	1.532***
	(6.20)	(3.52)
Hakka	3.401***	1.687***
	(6.96)	(3.71)
Mainlander	4.275***	1.458***
	(8.96)	(2.98)
R^2	0.4212	0.2721
Number of families	1,358	1,268
Number of observations	5,964	4,800

Note: ***, **, * denote significance at 1%, 5%, 10% levels respectively.
Absolute *t* values are in the parentheses.

Table 5. The Effects of Age-sex-specific Siblings on Years of Schooling: Birth Cohort Dummies Included

Explanatory Variables	All-(1)	All-(2)
Constant	3.609***	-0.766
	(8.84)	(1.58)
Cohort's average years of schooling	—	0.636***
		(21.88)
Birth cohort		
Before 1950 (ref)	—	—
1950-1959	1.765***	—
	(12.34)	
1960-1969	3.000***	—
	(18.20)	
After 1970	3.501***	—
	(19.95)	
Gender (Male=1)	1.010***	1.025***
	(15.20)	(15.48)
Number of elder brothers with		
Age difference [0,3]	-0.099	-0.067
	(1.43)	(0.98)
Age difference [4,7]	-0.030	-0.039
	(0.44)	(0.57)
Age difference >=8	-0.026	-0.001
	(0.35)	(0.02)
Number of elder sisters with		
Age difference [0,3]	-0.047	-0.056
	(0.74)	(0.87)
Age difference [4,7]	0.091	0.064
	(1.60)	(1.14)
Age difference >=8	-0.083	-0.071
	(1.22)	(1.05)
Number of younger brothers with		
Age difference [0,3]	0.038	0.073
	(0.53)	(1.04)
Age difference [4,7]	0.011	0.038
	(0.16)	(0.55)
Age difference >=8	-0.363***	-0.273***
	(4.13)	(3.08)
Number of younger sisters with		
Age difference [0,3]	-0.048	-0.021
	(0.70)	(0.31)
Age difference [4,7]	-0.017	0.012
	(0.25)	(0.18)
Age difference >=8	-0.443***	-0.349***
	(5.50)	(4.31)

Table 5. The Effects of Age-sex-specific Siblings on Years of Schooling: Birth Cohort Dummies Included (continued)

Explanatory Variables	All-(1)	All-(2)
Father's schooling	0.291***	0.285***
	(18.85)	(18.44)
Mother's schooling	0.202***	0.193***
	(12.23)	(11.71)
Mother's age >=40	-0.136	-0.193
	(0.55)	(0.78)
Working mother	-0.346***	-0.385***
	(3.18)	(3.53)
Father's ethnicity		
Aborigines（ref）	—	—
Fukkien	2.240***	2.256***
	(6.41)	(6.47)
Hakka	2.622***	2.665***
	(7.11)	(7.24)
Mainlander	3.088***	3.158***
	(8.29)	(8.49)
R^2	0.4449	0.4536
Number of families	2,626	2,626
Number of observations	10,764	10,764

Note: ***, **, * denote significance at 1%, 5%, 10% levels respectively.
Absolute *t* values are in the parentheses.

Number	Author(s)	Title	Date
04-A014	C. Y. Cyrus Chu R. R. Yu Ruey S. Tsay	A New Model for Family Resource Allocation Among Siblings: Competition, Forbearance, and Support	05/04
04-A013	C. Y. Cyrus Chu Ruey S. Tsay Huoying Wu	Transmission of Sex Preferences Across Generations: The Allocation of Educational Resources Among Siblings	05/04
04-A012	C. Y. Cyrus Chu	Children as Refrigerators: When Would Backward Altruism Appear?	05/04
04-A011	Marcus Berliant Shin-Kun Peng Ping Wang	Welfare Analysis of Number and Locations of Local Public Facilities	05/04
04-A010	Daigee Shaw Yue-Mi Tsai	Assessing Alternative Policies for Reducing Household Waste in Taiwan	03/04
04-A009	Daigee Shaw Chin-Hsiung Loh Chin-Hsun Yeh Wen-Yu Jean Yen-lien Kuo	A Probabilistic Risk Analysis for Taipei Seismic Hazards: An Application of HAZ-Taiwan with its Pre-processor and Post-processor	03/04
04-A008	Yu-Lan Chien Cliff J. Huang Daigee Shaw	A General Model of Starting Point Bias in Double-Bounded Dichotomous Contingent Valuation Surveys	03/04
04-A007	鍾經樊 詹維玲 張光亮	財富在不同時期對台灣消費行為的影響：多變量馬可夫結構轉換模型的應用	02/04
04-A006	Chun-chieh Huang Ching-Chong Lai Juin-Jen Chang	Working Hours Reduction and Endogenous Growth	02/04

04-A005	Juin-Jen Chang Ching-Chong Lai Ping Wang	On the Public Economics of Casino Gambling	02/04
04-A004	Ming-Fu Shaw Shu-Hua Chen Ching-Chong Lai Juin-Jen Chang	Interest Rate Rules, Target Policies, and Endogenous Economic Growth in an Open Economy	02/04
04-A003	Po-Hsuan Hsu Chung-Ming Kuan	Re-Examining the Profitability of Technical Analysis with White's Reality Check	02/04
04-A002	Kamhon Kan Wei-Der Tsai	Obesity and Risk Knowledge	01/04
04-A001	Chi-Chung Chen Ching-Cheng Chang	Climate Change and Crop Yield Distribution: Some New Evidence from Panel Data Models	01/04
03-A009	Joseph Greenberg Sudheer Gupta Xiao Luo	Towering over Babel: Worlds Apart but Acting Together	12/03
03-A008	Shin-Kun Peng Ping Wang	Sorting by Foot: Consumable Travel – for Local Public Good and Equilibrium Stratification	12/03
03-A007	Been-Lon Chen	Economic Growth With Optimal Public Spending Compositional	12/03
03-A006	Been-Lon Chen	Factor Taxation and Labor Supply In A Dynamic One-Sector Growth Model	12/03
03-A005	Kamhon Kan Wei-Der Tsai	Parenting Practices and Children's Education Outcome	11/03