The Influence of Sibling Structure on Middle School Students' Cognitive Ability and Its Mechanism: An Empirical Analysis Based on the Data of China Education Follow-Up Survey

Xiaoming Yan*

Department of International Education, Canvard College, Beijing Technology and Business University, No.1 Songzhuang South Road, Tongzhou, Beijing, China

*Corresponding Author.

Keywords: Sibling structure; Cognitive ability; Economic input; Non-economic input

Abstract: In this paper, the influence of sibling structure on middle school students' cognitive ability and its internal influence mechanism are comprehensively discussed based on the data of China education follow-up study. The results show that: (1) The number of siblings, birth order and gender composition all have significant effects on the cognitive ability of middle school students; (2) The sibling structure affects the cognitive ability of middle school students by affecting the family economic input and non-economic input. Moreover, the effectiveness of non-economic input in explaining the cognitive ability of middle school students is significantly higher than that of economic input. Educational expectation is particularly crucial to the improvement of cognitive ability of middle school students.

1. Introduction

Under the background of low birth rate and the adjustment to pronatalist policy, the sibling structure and the allocation of educational resources for children have attracted more and more attention. [1] Moreover, with the implementation of the "three children" policy, the sibling structure of our population will continue to change in the future. Family, as an important place to influence individual growth, plays an important role in the study of social stratification, in which the composition of brothers and sisters has an important influence on educational attainment. When the family budget is constrained, parents will invest more economic resources in children with higher returns. Boys usually have higher returns, so girls with brothers will get less economic input. [2-3] In the past literature, the relationship between the number of siblings, gender structure and educational opportunities was analyzed, and the research results generally support the hypothesis that "resource dilution theory" does exist within the family, and the number of siblings has a inhibitory effect on the achievement of education[4-10]. However, previous studies have paid little attention to such factors as birth order and gender composition in the sibling structure, thus making it impossible to compare the important roles of the sibling structure. At the same time, there are few studies on how the sibling structure affects cognitive ability, and there is still a lack of research on the process of individuals obtaining educational resources from their families. In this paper, the relationship between sibling structure and middle school students' cognitive ability is comprehensively investigated by using the data of China Education Follow-up Study from 2013 to 2014, and the internal mechanism of sibling structure affecting middle school students' cognitive ability is discussed.

2. Data and methodology

2.1. Data sources

The data in this paper were from the China Education Follow-up Study from 2013 to 2014. In this survey, the multi-stage probability and scale proportional sampling method was used. Starting from the two corresponding groups of Grade 1 and Grade 3 in middle school, the survey aims to

reveal the impacts of family, school, community and macro-social structure on individual education. A total of 112 schools, 438 classes and 19,487 students were selected and interviewed in the survey.

2.2. Measurement

In this paper, children's cognitive ability test scores were used to represent children's cognitive ability, divided into three dimensions, including language, graphics, calculation and logic, to measure middle school students' logical thinking and problem-solving ability, and the three-parameter model was used to standardize children's test scores. The core explanatory variable is the sibling structure of the interviewee, mainly including the number of siblings, birth order, whether there are brothers or not, and the proportion of girls.

In this paper, there are two kinds of intermediary variables: economic input and non-economic input, each of which contains more detailed variables. Specifically, the economic input includes four sub-variables, that is, whether the child participates in extracurricular remedial classes or interest classes, whether there is an independent desk at home, whether there is a computer at home and the total educational input of the child in the semester; and non-economic input also includes four sub-variables, that is, whether parents often check their children's homework, whether parents often discuss school matters with their children, whether parents know friends who often play with their children and whether parents expect their children to go to college.

Table 1 shows the cognitive abilities of children grouped according to the size and gender structure of their siblings. The results show that children's cognitive ability is declining with the increase of sibling size. Children's cognitive ability is related to their siblings' gender structure and birth order while keeping their siblings' size unchanged. Specifically, the cognitive abilities of individuals with sisters are higher than those without sisters, and those with brothers are lower than those without brothers. At the same time, the higher the birth order, the higher the children's cognitive ability.

Table 1 Sibling structure and cognitive ability

Number of siblings	General	Brothers		Sisters		Birth order	
		With brothers	Without brothers	With sisters	Without sisters	First	Not first
0	0.22 （0.86）		0.22 （0.86）		0.22 （0.86）	0.22 （0.86）	
1	-0.10 （0.83）	-0.13 （0.82）	-0.07 （0.83）	-0.07 （0.83）	-0.13 （0.82）	-0.09 （0.82）	-0.10 （0.82）
2	-0.32 （0.81）	-0.34 （0.82）	-0.28 （0.80）	-0.30 （0.80）	-0.42 （0.85）	-0.26 （0.81）	-0.35 （0.81）
3	-0.42 （0.80）	-0.42 （0.82）	-0.40 （0.75）	-0.41 （0.80）	-0.47 （0.80）	-0.33 （0.77）	-0.44 （0.80）
4	-0.49 （0.86）	-0.45 （0.85）	-0.98 （0.90）	-0.42 （0.85）	-0.50 （0.10）	-0.45 （0.75）	-0.49 （0.87）
5	-0.47 （0.86）	-0.47 （0.86）	-0.57 （1.40）	-0.46 （0.86）	-0.70 （0.49）	-0.46 （0.76）	-0.47 （0.86）

Note: Standard deviation in brackets.

2.3. Methodology

In this paper, the basic equation of the influence of sibling structure on children's cognitive ability in previous studies [11] was used for reference:

$$S_i = \alpha_0 + \alpha_i Sib_i + X_i'\gamma + \mu_i \tag{1}$$

Where,

S_i = children's cognitive ability;

Sib_i = children's sibling structure, including the number of siblings, birth order, whether there are brothers or not, and the proportion of girls;

X_i = a series of control variables;

μ_i = the random disturbance items.

Mediating variables in this paper refer to variables that are influenced by sibling structure and then affect children's cognitive ability. When exploring the influence channels of sibling structure on children's cognitive ability, the mediating variable C_i was gradually added to the basic equation:

$$S_i = \beta_0 + \beta_i Sib_i + X_i'\gamma + C_i\eta + \mu_i \tag{2}$$

In this paper, focus is put on the influence of two kinds of variables on children's cognitive ability, including family economic input and non-economic input. After the coefficients α and β of sibling structure was estimated by equation (1) and equation (2) respectively, $1 - \beta/\alpha$ is the proportion of the mediating variable in explaining the role of sibling structure in children's cognitive ability.

3. Results

3.1. The influence of sibling structure on children's cognitive ability

Table 2 shows the simple effect of sibling structure on children's cognitive ability. The results show that children's cognitive ability has a strong sibling effect after controlling factors such as individual characteristics, family characteristics and school characteristics. Specifically, with the increase in the number of siblings, children's academic performance has decreased; the first place in birth order is beneficial to the acquisition of children's cognitive ability; the cognitive ability of children with brothers is decreased by 4% compared with those without brothers ($p < 0.05$); and the high proportion of girls in siblings has brought significant positive effects on children's cognitive ability.

The regression results in Table 2 also show that parents' educational level and economic status also have a significant positive impact on children's cognitive ability. Relatively speaking, the higher parents' educational level, the better family's economic status, and the higher their children's cognitive ability, which also indirectly reflects that the constraints of family educational resources and family values may be the important influencing factors of children's low educational level. Compared with non-public schools, students in public schools have relatively higher scores. Generally, the larger the proportion of teachers above junior college, the smaller the ratio of students to teachers, which is more conducive to children's access to educational resources, thus better improving children's cognitive ability.

Table 2 The influence of sibling structure on children's cognitive ability

Variables	The explained variable: children's cognitive ability		
	（1）	（2）	（3）
Number of siblings	-0.147***	-0.097***	-0.097***
	(-12.24)	(-7.74)	(-7.76)
Order of birth (Not the first to be born=0	0.071***	0.030*	0.029*
	(4.19)	(1.70)	(1.67)
With brothers (without brothers=0	-0.110***	-0.046**	-0.044**
	(-4.22)	(-2.70)	(-2.64)
Proportion of girls	0.035**	0.032**	0.031**
	(2.29)	(1.98)	(1.99)
Gender (girl=0)	-0.031	-0.003	-0.001
	(-0.97)	(-0.09)	(-0.02)
Age	-0.124***	-0.088***	-0.085***
	(-17.34)	(-11.88)	(-11.39)
Registered permanent residence (non-local=0)	-0.033**	-0.031*	-0.032*

		(-2.06)	(-1.85)	(-1.95)
Grade (Grade 7=0)	0.235***	0.185***	0.179***
	(12.43)	(9.53)	(9.16)
Educational level of mother		0.073***	0.071***
		(7.89)	(7.65)
Educational level of father		0.085***	0.084***
		(9.23)	(9.05)
Occupational status of mother		0.044***	0.046***
		(3.92)	(4.07)
Occupational status of father		0.033***	0.032***
		(3.08)	(3.01)
Economic condition of the family		0.109***	0.109***
		(9.08)	(9.07)
Nature of school (non-public school =0)			0.058**
			(2.35)
Teacher-student ratio			-0.046***
			(-3.39)
Proportion of teachers above junior college level			0.078**
			(2.35)
Constant term	1.760***	0.508***	0.456***
	(17.14)	(4.38)	(3.74)
Observed value	18226	16638	15813
Adj R-squared	0.13	0.17	0.18

Note: *, * *, * * * represent significance at the levels of 10%, 5% and 1%, respectively, with t values in brackets.

3.2. The influence mechanism of sibling structure on children's cognitive ability

The sibling structure does affect children's cognitive ability, but how does it affect it? Economic input behavior is mainly reflected in the budget constraint in educational resources, while non-economic input is mainly reflected in the role of family concept in educational resources. In this paper, the influence channels of economic input and non-economic input on the structure of siblings will be further analyzed.

3.2.1. Sibling structure and access to educational resources

Because the differences in cognitive abilities of individuals with different sibling structures are largely caused by different educational resources input, it is necessary to understand the differences in educational resources input of families in order to deeply understand the differences in cognitive abilities brought about by sibling structures. Table 3 shows the regression results of various educational resources obtained by children, including economic and non-economic inputs, on the structure of children's siblings after controlling the children's individual characteristics, family characteristics and school characteristics.

The economic input in educational resources will be significantly affected by the structure of sibling. On the whole, children's economic input decreases with the increase of the number of siblings that the higher the birth order is, the larger the economic input is; having siblings is not conducive to children's economic resources; and the larger the proportion of girls, the more economic input children receive. Table 3 also gives the estimated results of the influence of the sibling structure on non-economic inputs that the fewer the number of siblings, the higher the birth order, the larger the proportion of girls, and children without siblings, the more they have significant advantages in the acquisition of non-economic input. The model shows that sibling structure does affect children's access to educational resources.

Table 3 Sibling structure and access to educational resources

	Economic input					Non-economic input		
	Instruction after class	Independent desk	Educational input	Computer purchase	Homework checking	Talking About school life	Familiarity with children's friends	Educational expectation
Number of siblings	-0.276 ***	-0.286 ***	-0.134 ***	-0.24 4***	-0.138 ***	-0.196 ***	-0.144 ***	-0.141* **
	(-6.06)	(-7.19)	(-3.48)	(-6.33)	(-4.73)	(-5.63)	(-3.74)	(-3.93)
Birth order	0.104 *	0.118 **	0.003	0.236 ***	-0.012	0.034	0.156 ***	0.090 *
	(1.83)	(2.20)	(0.06)	(4.64)	(-0.32)	(0.73)	(2.84)	(1.76)
With brothers	-0.283 ***	-0.441 ***	-0.318 ***	-0.523 ***	-0.255 ***	-0.025	-0.193 **	0.008
	(-3.18)	(-4.96)	(-4.00)	(-6.31)	(-4.18)	(-0.34)	(-2.30)	(0.10)
Proportion of girls	0.096	0.299 **	0.170	0.520 ***	0.255 ***	0.285 **	0.027	0.234 *
Constant term	(0.72)	(1.98)	(1.39)	(3.80)	(2.66)	(2.53)	(0.20)	(1.85)
N				15813				

Note: Except for the children's educational input in the semester, the rest are classified variables; *, * * and * * * represent the significance at 10%, 5% and 1% levels, respectively, with t values in brackets.

3.2.2. Path analysis and effect decomposition of sibling structure's influence on children's cognitive ability

The sibling structure has a significant impact on children's cognitive ability, and is closely related to the economic input and non-economic input in educational resources. Are these two mediating variables different in explaining the influence of the sibling structure on children's cognitive ability, and what is their relative importance?

Table 4 shows the mediating role of educational resources. Equation (1) is the regression result without controlling any mediating variables. Equations (2)-(4) are the variable groups which are respectively included in economic input, non-economic input and economic input and non-economic input on the basis of (1). The regression results show that the increase of economic input and non-economic input plays an important role in explaining the effect of the sibling structure on children's cognitive ability. The two types of resources together explain 26.8% of the effect of the number of siblings on cognitive ability, 20.6% of the effect of the birth order on cognitive ability, and more than 45% of the effect on whether there is a brother or not and the proportion of girls. Among them, the explanation of economic input to the structure of siblings is 15.4%, 10.3%, 47.7%, 9.6%, that of non-economic input is 21.6%, 24.1%, 86.3%, 58.1%, respectively. Thus, non-economic input is an important channel for sibling structure to affect children's cognitive ability, indicating that although sibling structure will affect children's cognitive ability by influencing family's economic input, it will improve children's cognitive level by influencing family's non-economic input combination more importantly.

Table 4 Path analysis of the influence of sibling structure on children's cognitive ability

Variables	The explained variable: children's cognitive ability			
	（1）	（2）	（3）	（4）

Number of siblings	-0.097***	-0.082***	-0.076***	-0.071***
	(-7.76)	(-6.35)	(-6.55)	(-5.36)
Birth order	0.029*	0.026*	0.022	0.023
	(1.67)	(1.66)	(1.40)	(1.44)
With brothers	-0.044**	-0.023**	-0.006	-0.024
	(-2.64)	(-2.17)	(-0.20)	(-0.83)
Proportion of girls	0.031**	0.058	0.013	0.016
	(1.99)	(1.35)	(0.30)	(0.35)
Economic input				
Instruction after class		0.086***		0.047***
		(5.69)		(3.02)
Independent desk		0.169***		0.153***
		(9.40)		(8.06)
Educational input		0.189***		0.180***
		(12.79)		(12.12)
Computer purchase		0.136***		0.135***
		(8.24)		(7.91)
Non-economic input				
Checking homework			0.025***	0.02***
			(4.38)	(4.21)
Talking about school life			0.131***	0.123***
			(9.54)	(8.89)
Familiarity with children's friends			0.029**	0.023
			(1.96)	(1.53)
Educational expectation			0.375***	0.358***
			(22.59)	(21.20)
Individual characteristics	Controlled	Controlled	Controlled	Controlled
Family characteristics	Controlled	Controlled	Controlled	Controlled
School characteristics	Controlled	Controlled	Controlled	Controlled
Adj R-squared	0.18	0.19	0.19	0.20

Note: *, * *, * * * represent significance at the levels of 10%, 5% and 1%, respectively, with t values in brackets; It should be pointed out that the proportion of the effect of sibling structure on cognitive ability explained by simultaneously controlling these two kinds of variables is not a simple sum of the respective explanation proportions of these two kinds of factors, because these two kinds of factors are not completely opposite, and there is certain influence between them. However, the test shows that non-economic input is not greatly influenced by economic input.

4. Conclusion and policy implications

4.1. Conclusion

In this paper, the influence of sibling structure on middle school students' cognitive ability and its internal mechanism are comprehensively discussed by using the data of China Education Follow-up Study. Research findings are as follows:

(1) Sibling structure has a significant impact on middle school students' cognitive ability. First of all, the increase in the number of siblings reduces the cognitive ability of middle school students. Secondly, as Chinese families tend to favor individuals with the highest birth order when investing in education, the higher the birth order, the greater the input in education and the higher the cognitive ability of middle school students. Finally, having brothers is not conducive to obtaining

individual education, while the higher the proportion of girls among siblings, the better the improvement of individual cognitive ability.

(2) Sibling structure affects middle school students' cognitive ability by influencing family economic input and non-economic input. The comparison of the two types of intermediary variables reveals that the effectiveness of non-economic input in explaining middle school students' cognitive ability is significantly higher than that of economic input, especially the educational expectation has a key influence on the improvement of middle school students' cognitive ability.

4.2. Policy implications

The policy implications of this paper are:

(1) Because the improvement of non-economic input can promote the improvement of middle school students' cognitive ability more than economic input, in the long run, it is necessary to continuously improve family environment resources, strengthen parents' participation and other non-economic input factors in order to improve middle school students' cognitive ability.

(2) With the introduction of the three-child policy, the sibling competition effect will also receive attention again. The discussion on sibling structure, access to educational resources and children's cognitive ability in this paper will help to understand the differences between the only child and all the others more comprehensively.

References

[1] Wang Jiwen. (2018)A Study on China's Fertility Desire and Influencing Factors under the Background of Very Low Birth Rate--An Analysis Based on the Repeated Survey Data of CGSS (2010-2015). Northwest Population Journal, 39(04): 73-80+88.

[2] Judith Blake. (1981)Family Size and the Quality of Children. Demography, 18(4), 3-6.

[3] Li Hongbin and Zhang Junsen. (2008)Human Capital Input and Return in China, Beijing: Peking University Press, 11-15.

[4] Zheng Lei. (2013) Sibling Gender Structure, Resource Allocation and Education within Families. Sociological Study, 28 (05): 76-103+243-244.

[5] Yuan Lulu, Luo Chuliang (2021). Spillover Effect of Brothers and Sisters on Higher Education Attainment of Siblings. Financial Research, 47(05): 79-93.

[6] Zhang Kezhong, Tao Dongjie, Jiang Qiuchuan. (2013) Sibling Competitive Effect of Education for Rural Children in China. Education and Economy, 6: 44-53.

[7] Xu Yan. Social Capital and Children's Well-being --- A Theoretical Review Based on Sociological Perspective. (2015) Journal of Sun Yat-sen University (Social Science Edition), 55 (05): 159-171.

[8] Zhang Yueyun, Xie Yu. (2015) Number of Brothers and Sisters, Access to Educational Resources and Academic Achievements of Children under the Background of Low Birth Rate[J]. Population Research, 39 (04): 19-34.

[9] M Grossman，R Kaestner.(1997)Effects of education on health. The social benefits of education. Ann Arbor University of Michigan, 19-33.

[10] Hu Yongmei, Yang Suhong.(2010) The Relationship between Student Academic Achievement and Educational Expectations - Empirical Analysis Based on Rural Primary Schools in Five Provinces in West China. Journal of Tianzhong, 25 (06): 125-129.

[11] Ye Hua, Wu Xiaogang. (2011) Fertility Decline and Equalization Trend of Education between Men and Women in China. Sociological Research, 26 (05): 153-177+245.