



## Birth order effects and parenting behaviors

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### ABSTRACT

While it is well known that there are systematic birth order effects on life cycle outcomes, there is less consensus about underlying channels and mechanisms of birth order effects. We find negative birth order effects among Chinese adolescents, favoring earlier-born children within household in academic achievement, cognitive skill measures, and in parenting behaviors including harsh parenting and parental investment. We highlight harsh parenting as a novel channel of birth order effects, in which earlier-born children are less likely to be physically punished by their parents. Heterogeneity analysis results are consistent with parents reinforcing academic advantage of better-performing earlier-born children, but do not support resource dilution, son preference, or reputation concerns as primary mechanisms underlying birth order effects. Our findings are in contrast to positive birth order effects found among earlier generations of Chinese siblings reported in the literature.

Understanding birth order effects, where children systematically out-perform or under-perform their siblings within a household by their birth order, may advance our understanding of the nature of quantity-quality trade-off at home (Becker, 1960), and can facilitate more targeted development of policies that affect families. A large body of evidence shows negative birth order effects (better outcomes for earlier-born children) in developed countries (Behrman & Taubman, 1986; Black, Devereux, & Salvanes, 2005), whereas the evidence is mixed for developing countries (positive birth order effects in Ejrnæs & Pörtner (2004), Khanam & Rahman (2007), Patrinos & Psacharopoulos (1997); negative birth order effects in Behrman (1988), Horton (1988), Jayachandran & Pande (2017)). There is even less understanding of the channels and mechanisms that generate birth order effects. Studies point to the allocation of household resources and parenting behavior as likely channels of birth order effects (Behrman & Taubman, 1986; Price, 2008). But these studies do not always explain underlying mechanisms, i.e. why parents would choose to differentiate resource allocation or parenting behavior by the birth order of their children. Some of the explanations proposed to explain birth order effects include resource dilution (Lafortune & Lee, 2014), parent learning (Cho, 2019), reputation concern (Hao, Hotz, & Jin, 2008; Hotz & Pantano, 2015), response to unwanted fertility (Lin, Pantano, & Sun, 2020), and son preference (Jayachandran & Pande, 2017).

In this study, we investigate birth order effects among adolescents in contemporary China and investigate potential mechanisms that underlie birth order effects. We focus on academic achievement and cognitive skill measures as outcomes. We also study whether birth order effects are observed on parenting behaviors. Parenting behaviors are relatively unexplored in the literature even as they may be potential channels generating birth order effects. Further, we investigate potential mechanisms generating birth order effects including resource dilution, parenting reinforcing behaviors, son preference, and reputation concern.

We find evidence of negative birth order effects favoring earlier-born children in Chinese households on academic achievement and

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cognitive skills. We also find negative birth order effects on the parents' use of parenting behaviors such as the use of corporal punishment in response to child's misbehavior and checking the child's homework. The effects were stronger for firstborn sons and for those in low-income households, although the effects on supervising homework was stronger for firstborn daughters. Evidence of birth order effects on parent's use of harsh parenting such as corporal punishment is new in economics literature. Literature shows that harsh parenting has negative effects on child outcomes (Fiorini & Keane, 2014; Kim, Schulz, Zimmermann, & Hahlweg, 2018), suggesting that harsh parenting could be one of the channels generating birth order effects within a household.

We explore potential mechanisms underlying birth order effects. Although they do not exclude particular mechanisms, they provide suggestive evidence that may guide further research. First, we examine birth order effects by the number of children in the household. Although the birth order effects on academic achievement outcomes are greater in magnitude among three-child families, they are nevertheless observed among two-child families. Also, birth order effects on parenting behaviors do not systematically vary by family size, casting doubt on resource dilution as the primary mechanism. Second, we examine son preference by decomposing the birth order effect estimates by subgroups consisting of different sibling-gender compositions. We interpret negative birth order effects in families with earlier-born daughters and later-born sons as evidence of weak role of son preference in generating birth order effects. Our results show that son preference plays at best a limited role in explaining birth order effects on child development in contemporary China. Third, we find that negative birth order effects on academic achievement and parental investment (checking homework) are concentrated in households in which the firstborn children perform better than their peers from the parents' perspective. This result is consistent with parents' tendency to reinforce initial academic advantage among siblings (Dizon-Ross, 2019; Yi, Heckman, Zhang, & Conti, 2015). Finally, we examine whether the model of parental reputation concern could have generated negative birth order effects. Our tests of model implications do not support parental reputation concern model in our sample.

Our results stand in contrast to previous studies which found positive birth order effects in China (Weng, Gao, He, & Li, 2019) and that son preference was an important feature in explaining the variation in outcomes among siblings (Chen, 2020; Ebenstein, 2010; Lei, Shen, Smith, & Zhou, 2017; Weng et al., 2019; Zhang, 2019). These studies used older generations of Chinese, while our sample consists of children in late childhood and adolescence in contemporary China, likely reflecting the reduced importance of son preference among Chinese families today. These results imply that compared to previous generations, the Chinese home environment may be closer to those found in other, mostly developed countries also showing negative birth order effects.

## 1. Background

Studies based on data from mostly developed countries show that earlier-born children outperform their younger siblings in academic achievement (Behrman & Taubman, 1986; Black et al., 2005; Booth & Kee, 2009; Hotz & Pantano, 2015; Kantarevic & Mechoulan, 2006; Kim, 2020), cognitive skill (Black, Devereux, & Salvanes, 2011; Rohrer, Egloff, & Schmukle, 2015), risky behavior (Averett, Argys, & Rees, 2011; Breining, Doyle, Figlio, Karbownik, & Roth, 2020) earnings (Behrman & Taubman, 1986), and even intergenerational outcomes (Havari & Savegnago, 2020). Interestingly, studies based on developing countries tend to find later-born children outperforming earlier-born children (De Haan, Plug, & Rosero, 2014; Ejrnæs & Pörtner, 2004; Khanam & Rahman, 2007; Lafortune & Lee, 2014; Tenikue & Verheyden, 2010; Weng et al., 2019), although exceptions exist (Behrman, 1988; Horton, 1988; Jayachandran & Pande, 2017). In China, Weng et al. (2019) found positive birth order effects on academic performance, consistent with the evidence from developing countries. In contrast, negative birth order effects are shown in Shi (2020) and Xiong, Zang, Zhou, and Liu (2020) on outcomes including subjective well-being and years of schooling, respectively, although these two studies did not account for household-level unobservables.

Proposed channels of birth order effects include household resource allocation (Behrman & Taubman, 1986; De Haan, 2010; Mechoulan & Wolff, 2015; Monfardini & See, 2016), parental investment (Breining et al., 2020; Black, Grönqvist, & Öckert, 2018; De Haan et al., 2014; Kim, 2020; Lehmann, Nuevo-Chiquero, & Vidal-Fernandez, 2018; Price, 2008), and parental monitoring (Averett et al., 2011; Hao et al., 2008; Hotz & Pantano, 2015). These studies highlight the role of parents in generating birth order effects among siblings. Parental discipline, which recently emerged as another important dimension of parenting behavior that has long-run impact on child outcomes (Fiorini & Keane, 2014; Kim et al., 2018), remains relatively unexplored in the literature.

What can be underlying mechanisms that motivate the parents to differentiate resource allocation and parenting behavior among siblings? One explanation is resource dilution, implying negative birth order effects. Firstborn child monopolizes parental attention and household resources during early childhood until siblings are born, while later-born children do not enjoy such focused attention during early childhood, a critical period for human development (Heckman & Mosso, 2014).

Studies on India found that son preference can generate negative birth order effects. For example, Jayachandran and Pande (2017) showed that negative birth order effects in height among Indian children were primarily driven by households with characteristics predicting strong son preference based on Hindu culture and religion, and by households with earlier-born sons and later-born daughters. Similarly, Jayachandran and Kuziemko (2011) found that earlier-born daughters tend to receive less breastfeeding than sons or later-born daughters because parents in need of a son would soon get pregnant again, which hastens weaning of ongoing breastfeeding. These findings were replicated in Egypt and Pakistan (Chakravarty, 2015; Hafeez & Quintana-Domeque, 2018), also known for strong son preference. Son preference is a prominent feature of Chinese society, driven by patrilineal family system that emphasizes the role of the eldest son to carry on the family name and support the parents in old age (Murphy, Tao, & Lu, 2011). This led to serious gender imbalance in favor of more men, aided by fertility restriction policies such as One Child Policy (OCP) and the widespread availability of ultrasound technology that allows *in utero* sex determination (Chen, Li, & Meng, 2013; Ebenstein, 2010; Zhang, 2017). It is therefore possible that son preference and gender imbalance together generate birth order effects in Chinese population. The extent to which son preference explains birth order effects in China has not been examined in the literature.

Hao et al. (2008) proposed a game-theoretic model of reputation building by the parents, implying negative birth order effects. As more children are born, parents wishing to promote good behavior have an incentive to build a reputation to younger children as a “strict” type rather than a “lenient” type parents. This is achieved by setting stricter discipline to earlier-born children, improving their outcomes. Hao et al. (2008) and Hotz and Pantano (2015) present empirical evidence consistent with the implications of this model.

Other explanations suggest that parents may gain parenting experience over time, implying positive birth order effects. Evidence of this mechanism is rarely found. An exception is Cho (2019), showing that Korean parents are more likely to optimize birth month beneficial for school schedule for later births. Lin et al. (2020) proposed that later births are more likely to be unplanned, “accidental” births compared to earlier births. Surprised with unplanned fertility, the parents are forced to improvise, providing less than optimal care to later-born children. Changes in unwanted fertility seem to be important determinants of fertility trends and child outcomes among low-SES mothers in the US (Buckles, Guldi, & Schmidt, 2019).

A common explanation for positive birth order effects in developing countries is that parents having first children may be severely credit-constrained (Lafortune & Lee, 2014). As credit constraint eases over time, the parents may invest more on later-born children. Initial credit constraint can be so severe that earlier-born children may be asked to forego schooling and generate income for the household instead (Edmonds, 2006; Emerson & Souza, 2008; Patrinos & Psacharopoulos, 1997; Tenikue & Verheyden, 2010). Similarly, Coffey and Spears (2021) found that mother’s improving health over time could generate positive birth order effects in India.

## 2. Empirical strategy

### 2.1. Data

We use data from China Family Panel Studies (CFPS), which is a comprehensive survey across China, covering a variety of economic and non-economic issues. The CFPS 2010 baseline survey, 2012, 2014, 2016 and 2018 waves all include respondents’ cognitive test scores, which is crucial for our analysis. However, we do not use the 2012 wave because the cognitive tests in the 2012 wave were taken voluntarily, leading to many missing values. We restrict the sample to children aged 10–15 because academic achievement and parenting measures are available only for children in those ages. Siblings outside this age range are nevertheless accounted for in calculating family size and the number of younger siblings. We also exclude families with twins because the parent–child dynamic and sibling dynamic in twin-households are likely to be significantly different from those in other types of households.

The CFPS child questionnaire provides information on birth year, which enables us to define birth order. We construct the birth order indicators in two different ways. First, we create several dummy variables that equal 1 when the child is the 1st (First Child), 2nd (Second Child) and 3rd (Third Child) born child. Second, we use the number of younger siblings (NYS) the child has as a proxy of birth order.

The data allows us to create child outcome variables related to school performance, cognitive skill and parenting behaviors. School performance is measured by parents’ perception of their children’s Chinese and Math grades. Parents were asked: “How is the child’s Chinese (Math) grade? Is it top, above the median, in the median or below the median in the class?” We construct dummy variables for Chinese and Math, coded as 1 if the parent believes the child is above class median in the respective subjects.

We use two tests from each wave of CFPS to construct our cognitive skill measure. The 2010, 2014 and 2018 waves of CFPS employ a word test and a math test to measure respondents’ cognitive skill. In the word test, respondents were shown 34 Chinese characters, ordered from easy to difficult. The test would terminate if they read three words incorrectly in a row. The score was equal to the sequence of the most difficult character that a respondent read correctly. In the math test, respondents answered 24 math questions, ordered from easy to difficult. Like the word test, the math test also ended when a respondent answered three questions incorrectly in a row. The score was determined by the sequence of the most difficult questions the respondent answered correctly. We use the sum scores of the two tests, normalized to be mean 0 and standard deviation 1 within children’s age and survey year.

Unlike the other three waves, the 2016 wave include a memory test and a sequence test. In the memory test, the interviewer read 10 common words (mountain, rice, river, etc.) to the respondent, and the respondent was asked immediately to recall the words after the interviewer finished reading. The total number of words answered correctly was the memory test score. The sequence test was conducted in two stages. In the first stage, a respondent answers three series of questions, thus obtaining the number of correct answers (0 to 3). In the second stage, the interviewer chose one of the four prepared sets of questions to test the respondent based on his/her score of in the first stage. The four sets of questions were of varying difficulty, and respondents who scored higher in the first stage would take the most difficult questions. Given the systematic differences in the difficulty of the tests for different groups of people, we cannot score respondents on the number of correct answers. Therefore, we use the scores calculated by the CFPS official based on Rasch model. Similar to cognitive skill measures in other waves, we construct sum scores as a sum of scores from the memory and the sequence test, which are normalized to be mean 0 and standard deviation 1 within children’s age and survey year.

We also create two variables for parenting behaviors: checking homework and corporal punishment use. For checking homework, the parent was asked: “How often do you check the child’s homework?” The responses include: 6–7 times per week; 2–3 times per week; once per week; once per month; or never. The variable equals 1 if the parent checked the child’s homework once a week or more. For corporal punishment, the parent was asked: “What would you do if the child fails to perform as expected at school?” The responses include: contacting the child’s teacher; scolding the child; punishing the child physically; telling the child to work harder; limiting the child’s activities; helping the child more; and doing nothing. Parents could choose one or more of these options. The variable is coded as 1 if the parent chose “punishing the child physically” and 0 otherwise.

We consider three categories of baseline control variables. On the children’s level, we control for child age and gender. On the parents’ level, we control for both father and mother’s years of schooling. On the family level, we control for the number of children,

**Table 1**  
Descriptive statistics by birth order.

Variable	First Child		Second Child		Third Child	
	Mean	SD	Mean	SD	Mean	SD
<i>School Performance</i>						
Chinese	0.50	0.50	0.52	0.50	0.39	0.49
Math	0.45	0.50	0.51	0.50	0.49	0.50
Cognitive Skill	0.03	0.98	0.00	1.00	-0.27	1.05
<i>Parenting Behavior</i>						
Checking Homework	0.51	0.50	0.62	0.49	0.48	0.50
Corporal Punishment	0.02	0.13	0.04	0.19	0.10	0.30
<i>Family Controls</i>						
Rural Hukou	0.92	0.27	0.92	0.27	0.95	0.23
Number of Children	2.35	0.68	2.35	0.67	3.37	0.77
Family Income (10,000 RMB)	30.25	34.35	30.19	34.33	26.26	30.74
<i>Child Controls</i>						
Male	0.38	0.49	0.60	0.49	0.59	0.49
Age	13.83	1.16	11.33	1.22	10.69	0.82
<i>Parent Controls</i>						
Father's Education	6.20	4.06	6.190	4.060	6.28	4.08
Mother's Education	4.48	4.21	4.570	4.220	3.71	4.24
Sample Size	1130		1132		112	

Notes: Sample is drawn from 2010, 2014, 2016, and 2018 waves of CFPS. Income is deflated to 2010 values in units of 10,000 RMB. Math and Chinese variables equal 1 if the parent believes the child is above class median in the respective subjects. Parents' education variables are coded as 0 = illiterate, 6 = primary school, 9 = middle school, 12 = high school, 14 = junior college and 16 = bachelor. Checking Homework variable equals 1 if the parent checks the child's homework once a week or more. Corporal Punishment variable equals 1 if the parent shows intention to use corporal punishment if the child performs poorly at school.

**Table 2**  
Effects of birth order on academic achievement and parenting style.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	-0.061 (0.054)	0.001 (0.057)	-0.227** (0.110)	0.041** (0.020)	-0.047 (0.046)
BirthOrder3	-0.234** (0.110)	-0.015 (0.110)	-0.529*** (0.199)	0.122** (0.050)	-0.212** (0.084)
$H_0: BO2 = BO3$	0.035	0.839	0.033	0.044	0.005
N	2028	2028	1936	2042	2029
adj. R <sup>2</sup>	0.274	0.206	0.399	0.122	0.409
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
NYS	0.093* (0.051)	0.002 (0.051)	0.250*** (0.096)	-0.053** (0.021)	0.085** (0.040)
N	2028	2028	1936	2042	2029
adj. R <sup>2</sup>	0.272	0.206	0.399	0.120	0.408

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.  $H_0: BO2 = BO3$  row presents  $p$ -values from testing the equality of coefficients for BirthOrder2 and BirthOrder3 variables. Standard errors clustered at family level are in parentheses.

rural hukou status, and family income. Family income is adjusted for inflation with 2010 as the base.

Table 1 presents the descriptive statistics based on the analysis sample. The average outcomes are lower for the third children than for the first and the second children, but the difference between the first and the second children are not pronounced. Similarly, the average values of household income and mother's education level are lower for the third children than for the first and the second children, while the latter two have similar average values. About 60% of the second and the third children are male while only 38% of the first children are male, suggesting that sex selection is more likely to occur at later births than earlier births. This pattern is consistent with the evidence in the literature showing stronger evidence of sex selection at higher birth parities (Chen et al., 2013; Egan et al., 2011).

**Table 3**  
Birth order effects by the number of families.

<i>Two-child Families</i>		(1)	(2)	(3)	(4)	(5)
<i>All Hukou</i>		Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2		-0.050 (0.060)	-0.003 (0.063)	-0.187 (0.124)	0.034 (0.023)	-0.068 (0.051)
adj. R <sup>2</sup>		0.303	0.217	0.392	0.179	0.414
NYS		0.050 (0.060)	0.003 (0.063)	0.187 (0.124)	-0.034 (0.023)	0.068 (0.051)
adj. R <sup>2</sup>		0.303	0.217	0.392	0.179	0.414
N		1752	1752	1671	1760	1750
<i>Rural Hukou</i>						
BirthOrder2		-0.037 (0.061)	0.020 (0.067)	-0.203 (0.136)	0.042* (0.024)	-0.080 (0.054)
adj. R <sup>2</sup>		0.320	0.226	0.379	0.167	0.438
NYS		0.037 (0.061)	-0.020 (0.067)	0.203 (0.136)	-0.042* (0.024)	0.080 (0.054)
adj. R <sup>2</sup>		0.320	0.226	0.379	0.167	0.438
N		1616	1616	1539	1622	1614
<i>Three-child Families</i>						
<i>All Hukou</i>		Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2		-0.101 (0.154)	0.005 (0.160)	-0.352 (0.286)	0.090 (0.065)	0.059 (0.115)
BirthOrder3		-0.380 (0.271)	0.005 (0.285)	-0.764 (0.490)	0.187 (0.117)	-0.047 (0.211)
adj. R <sup>2</sup>		0.304	0.248	0.535	0.323	0.479
NYS		0.192 (0.135)	-0.002 (0.142)	0.383 (0.244)	-0.094 (0.058)	0.027 (0.107)
adj. R <sup>2</sup>		0.297	0.252	0.537	0.327	0.473
N		276	276	265	282	279
<i>Rural Hukou</i>						
BirthOrder2		0.012 (0.152)	0.058 (0.166)	-0.278 (0.308)	0.095 (0.070)	0.044 (0.122)
BirthOrder3		-0.240 (0.272)	0.072 (0.292)	-0.674 (0.524)	0.195 (0.125)	-0.039 (0.222)
adj. R <sup>2</sup>		0.343	0.256	0.540	0.325	0.475
NYS		0.131 (0.137)	-0.034 (0.146)	0.342 (0.260)	-0.097 (0.062)	0.025 (0.112)
adj. R <sup>2</sup>		0.323	0.260	0.542	0.329	0.472
N		259	259	248	265	262

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent’s self-reported intention to use corporal punishment in response to children’s low grades at school. NYS: number of younger siblings. Control variables include father’s education level, mother’s education level, rural hukou status, number of siblings, household income, child’s age, gender, year fixed effects, and family fixed effects. Standard errors clustered at family level are in parentheses.

2.2. Empirical model

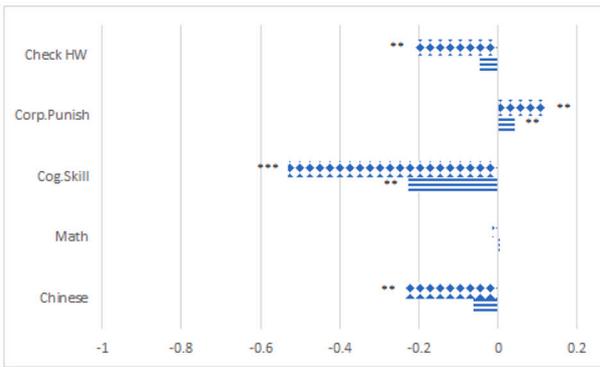
We estimate the following models using OLS:

$$Y_{iht} = \alpha + \sum_{k=2}^3 \beta_k BirthOrder_{kiht} + \gamma X_{iht} + \lambda_t + \lambda_h + \epsilon_{iht} \tag{1}$$

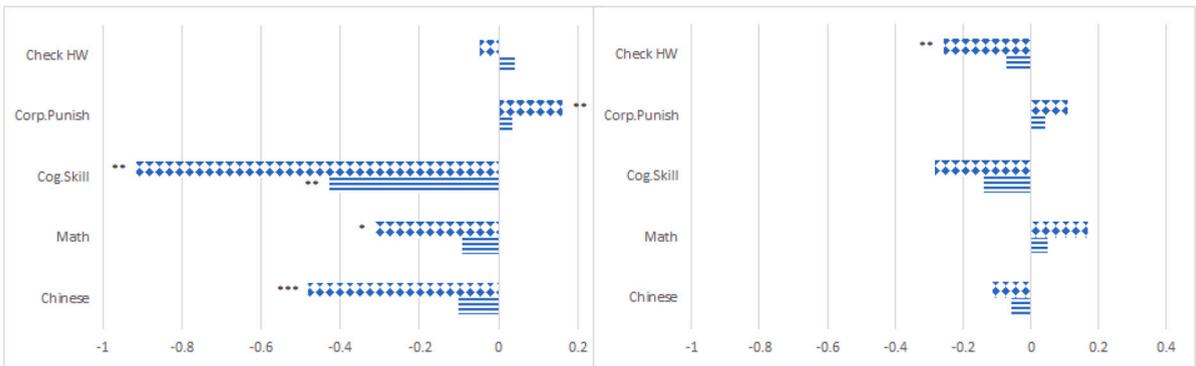
$$Y_{iht} = \alpha + \beta_{nys} NYS_{iht} + \gamma X_{iht} + \lambda_t + \lambda_h + \epsilon_{iht} \tag{2}$$

$Y_{iht}$  is the dependent variable, for child  $i$  in family  $h$  at time  $t$ ;  $BirthOrder_{kiht}$  is the indicator variable for the child of birth order  $k$ ;  $NYS_{iht}$  is the number of younger siblings;  $X_{iht}$  is a vector of family characteristics including child’s age, gender, mother’s education, father’s education, family size (number of children), hukou status of the survey respondent, and household income;  $\lambda_t$  and  $\lambda_h$  represent year and family fixed effects, respectively.  $\epsilon_{iht}$  is clustered at household level.

Outcome variables include indicators for whether the parent thinks the child’s performance in Chinese and math is above median in class; cognitive skill measures normalized to be mean 0 and standard deviation 1 within child’s age and survey year; indicator for whether the parent intends to use corporal punishment for poor academic performance; and indicator for whether the parent

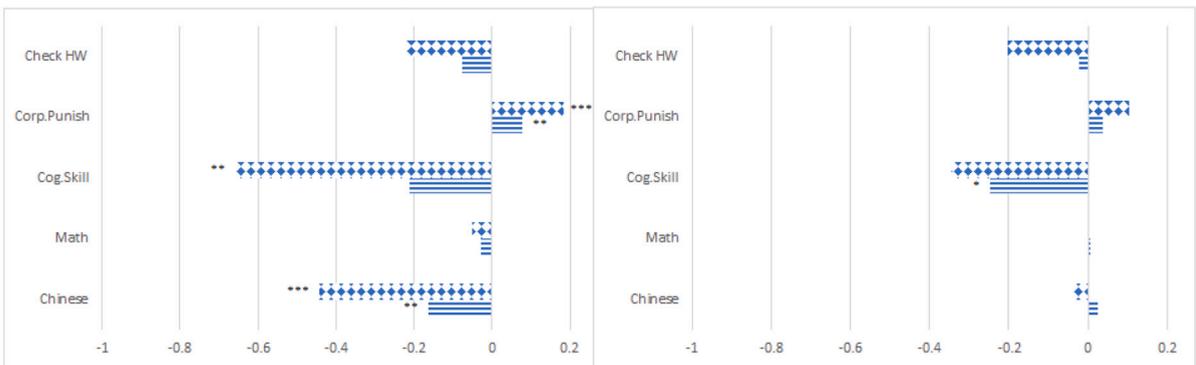


(a) Baseline



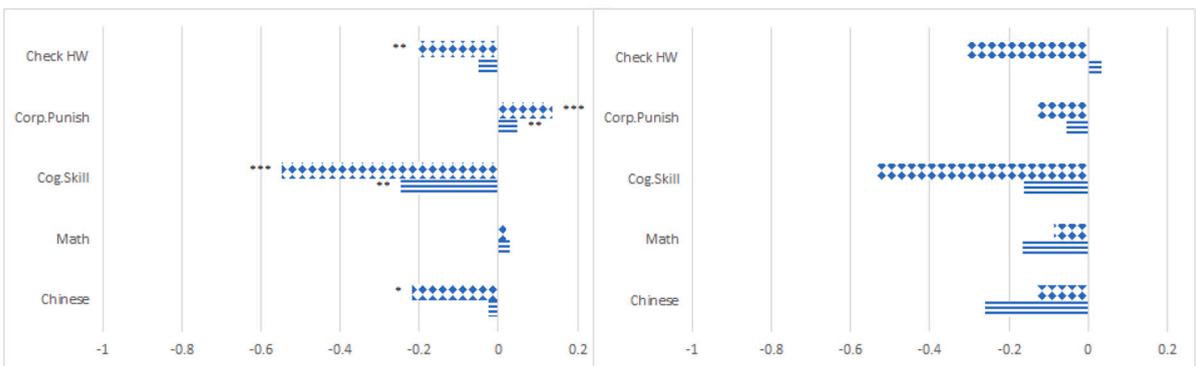
(b) First child boy

(c) First child girl



(d) Low income household

(e) High income household



(f) Rural household

(g) Urban household

(caption on next page)

**Fig. 1.** Birth order effects heterogeneity. *Notes:* \*\*\*/\*\*/\*: significant at the 1/5/10% level. Appendix Tables A1–A6 contain values used to generate the plot. Bar graph with horizontal stripe pattern: birth order 2 effect; bar graph with diamond pattern: birth order 3 effect.

supervises homework more than once a week.

### 3. Main results

Table 2 shows evidence of negative birth order effects on children’s Chinese grade and cognitive skill, but not on Math grade. While the effects on Chinese grade are greater for the third birth, the effects on cognitive skill, which are arguably more objectively measured, are observed for both the second birth and the third birth. These results are consistent with a large body of empirical evidence showing negative birth order effects in academic achievement in samples from developed countries (Black et al., 2005). It is however inconsistent with positive birth order effects reported by Weng et al. (2019) in a sample of older cohorts of Chinese.

We also find negative birth order effects in parenting behaviors that favor earlier-born children. Earlier born children are more likely to receive parental supervision in doing homework and are less likely to receive corporal punishment. While previous studies reported negative birth order effects in parental monitoring and supervision (Hotz & Pantano, 2015), the relationship between birth order and the parents’ use of harsh punishment remains unknown in the literature. Harsh parenting is commonly practiced around the world and leads to negative child outcomes (Fiorini & Keane, 2014; Kim et al., 2018), suggesting that differential use of harsh parenting by birth order may generate birth order effects on children’s academic achievement.

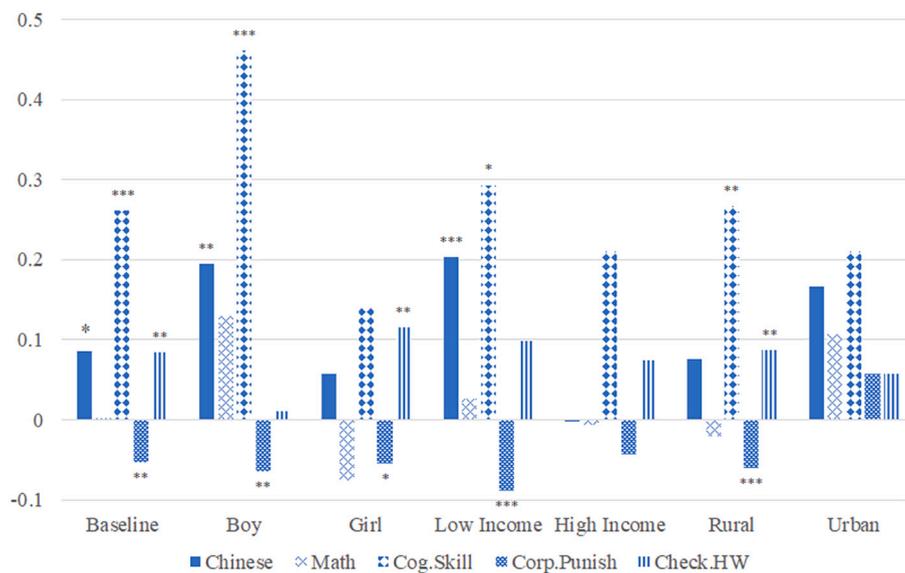
Table 1 showed that outcome differences were smaller between the firstborn and the second-born children. In Table 3, we examine birth order effects for the sample of two-child families, forcing the comparisons to be between the firstborn and the second-born. The results are consistent with those found in Table 2.

We then examine heterogeneity in birth order effects. We examine heterogeneity by the gender of the first child, since younger sibling’s gender may be endogenous to family size and confounds the estimate with gender composition effect (Weng et al., 2019). We also examine heterogeneity due to household income by dividing the sample at the sample median household income. Finally, we examine heterogeneity by whether the responding parent has rural or urban hukou, because rural and urban households are subject to different fertility restriction policies, potentially affecting family size and gender composition.

Figs. 1 and 2 show that the effects are concentrated on firstborn boys, although there is evidence of birth order effects among girls as well, especially on parenting behaviors. Birth order effects are stronger among low-income households. The effects are more significant and somewhat stronger among rural residents, although non-significance among urban residents may reflect smaller sample size (less than 10% of the sample have urban hukou).

### 4. Mechanisms

In this section, we explore some of the potential mechanisms underlying birth order effects in China, including resource dilution, son preference, reinforcing parenting, and reputation concerns. We do not seek to provide conclusive evidence on the presence or absence of specific underlying channels. Instead, we examine whether available evidence is consistent with the implications of each

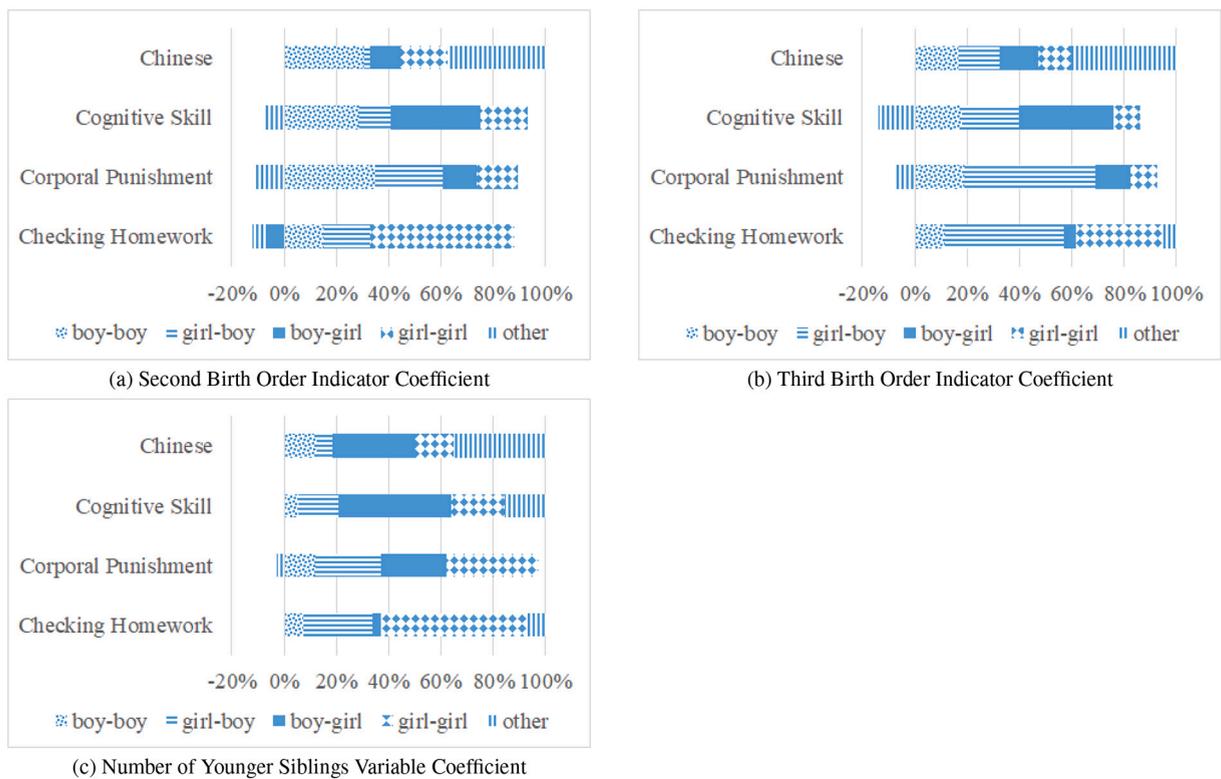


**Fig. 2.** Birth order effects heterogeneity (number of siblings).*Notes:* \*\*\*/\*\*/\*: significant at the 1/5/10% level. Appendix Tables A1–A6 contain values used to generate the plot.

**Table 4**  
Birth order effects with expanded sample.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	0.011 (0.020)	0.001 (0.021)	-0.117*** (0.042)	0.018** (0.007)	-0.022 (0.019)
BirthOrder3	-0.163*** (0.061)	-0.028 (0.063)	-0.327** (0.136)	0.083** (0.034)	-0.157*** (0.056)
adj. R <sup>2</sup>	0.049	0.028	0.109	0.008	0.063
NYS	0.015 (0.019)	0.003 (0.020)	0.130*** (0.040)	-0.025*** (0.008)	0.038** (0.018)
adj. R <sup>2</sup>	0.047	0.028	0.109	0.007	0.063
N	3833	3833	3620	3853	3836

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent’s self-reported intention to use corporal punishment in response to children’s low grades at school. NYS: number of younger siblings. Control variables include father’s education level, mother’s education level, rural hukou status, number of siblings, household income, child’s age, gender, and year fixed effects. Sample includes all households with at least one child in the 10–15 age range. Standard errors clustered at family level are in parentheses.



**Fig. 3.** Decomposition of birth order effects. Notes: Coefficient size scaled to be 1. See Tables A7–A9 in the Appendix for the values used to generate the figure. Decomposition for Math outcome is not shown in the figure for visibility but appears in the Appendix tables. Control variables include father’s education level, mother’s education level, rural hukou status, number of siblings, household income, child’s age, gender, year fixed effects, and family fixed effects.

mechanism. We find limited evidence in support of resource dilution, son preference, or reputation concerns, but find some evidence consistent with parents reinforcing investments on earlier born children who show academic advantages.

4.1. Resource dilution

We begin by examining the possibility that birth order effects were generated by resource dilution. As the number of children increases, the resources dedicated to each child decreases. Therefore, the firstborn child enjoys undiluted access to household resources during early childhood period before siblings are born. The main analysis includes both two- and three-child families,

**Table 5**  
Birth order effects by the first child's achievements.

	(1)	(2)	(3)	(4)	(5)
<i>High-Achieving First Child</i>	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	−0.238*** (0.073)	−0.233*** (0.085)	−0.450*** (0.155)	0.025 (0.030)	−0.134* (0.075)
BirthOrder3	−0.484*** (0.147)	−0.280* (0.169)	−0.705** (0.276)	0.151** (0.077)	−0.433*** (0.138)
adj. R <sup>2</sup>	0.262	0.087	0.398	0.139	0.369
NYS	0.241*** (0.068)	0.178** (0.078)	0.388*** (0.133)	−0.056* (0.031)	0.184*** (0.068)
adj. R <sup>2</sup>	0.263	0.082	0.397	0.127	0.365
N	976	976	902	978	971
<i>Low-Achieving First Child</i>	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	0.131* (0.071)	0.237*** (0.070)	−0.086 (0.160)	0.056** (0.027)	0.001 (0.054)
BirthOrder3	−0.037 (0.132)	0.271** (0.129)	−0.378 (0.292)	0.094 (0.064)	−0.030 (0.113)
adj. R <sup>2</sup>	0.238	0.230	0.357	0.183	0.521
NYS	−0.042 (0.066)	−0.176*** (0.062)	0.146 (0.140)	−0.050* (0.028)	0.009 (0.050)
adj. R <sup>2</sup>	0.219	0.222	0.356	0.184	0.521
N	1052	1052	1034	1064	1058

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects. Standard errors clustered at family level are in parentheses. Sample includes two- and three-child families.

potentially confounding both birth order effects and resource dilution. We are unable to examine the role of resource dilution directly without a credible source of exogenous variation in family size. Instead, we examine birth order effects by alternatively restricting the sample to two-child families and three-child families, and on rural-*hukou* families.

Table 3 shows that although negative birth order effects on academic achievements are greater in magnitude among the three-child families, as implied by resource dilution, we nevertheless observe birth order effects among two-child families. Further, we do not find that the birth order effects on parenting behavior as measured by "checking homework" are greater in magnitude among three-child families than among two-child families. This pattern holds when the sample is restricted to rural households, and when the sample restriction is relaxed to include households whose children are not in the 10–15 age range (in Table 4).<sup>1</sup> Although we cannot rule out resource dilution as the primary explanation, it does not seem to explain all birth order effects we observe, especially on parenting behaviors.

#### 4.2. Son preference

Low-income status and rural residence predict stronger son preference in China (Burgess & Zhuang, 2002; Lei & Pals, 2011). Together with stronger effects for firstborn boys, the results in the previous section do not rule out son preference as a possible mechanism. It is however difficult to determine if son preference played an important role in generating birth order effects from these results alone. Higher income may allow households to act on their son preference, by gaining access to sex-selective abortion or by allocating relatively more resources to sons rather than daughters (Almond, Li, & Zhang, 2019). Also, while son preference is generally associated with households in rural area, One-Child Policy was enforced more strictly in the urban area, increasing the incentive for urban families to act on their son preference (Ebenstein, 2010).

In this section, we implement a series of supplementary analyses to learn whether the negative birth order effects can be explained by son preference. We first decompose the baseline results in Table 2 by households with different gender compositions. In the appendix, we implement tests of son preference used in the literature to see whether the observed effects are consistent with the presence of son preference across siblings within each household.

First, we propose a mechanical decomposition of birth order effects by subgroups of households with different sibling gender composition.<sup>2</sup> Consider coefficient  $\beta$  in Eq. (2) which captures the effect of the number of younger siblings (*NYS*) on the child outcome.

<sup>1</sup> Main results are within-household comparisons based on households with children in ages 10–15 for whom outcome measures are available. By including households some of whose children fall outside this age range, the estimates become across-household comparisons.

<sup>2</sup> We do not implement the conventional subsample regression because the sample size for each subsample is too small to make any meaningful statistical inference using our models.

**Table 6**  
Birth order effects by the first child's achievements, by the number of children.

<i>Two-child Families</i>		(1)	(2)	(3)	(4)	(5)
<i>High-Achieving First Child</i>		Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2		-0.231*** (0.081)	-0.228** (0.093)	-0.410** (0.179)	0.023 (0.035)	-0.158* (0.081)
adj. R <sup>2</sup>		0.254	0.083	0.381	0.143	0.362
NYS		0.231*** (0.081)	0.228** (0.093)	0.410** (0.179)	-0.023 (0.035)	0.158* (0.081)
adj. R <sup>2</sup>		0.254	0.083	0.381	0.143	0.362
N		855	855	783	854	849
<i>Low-Achieving First Child</i>						
BirthOrder2		0.154* (0.079)	0.236*** (0.077)	-0.046 (0.179)	0.054* (0.029)	0.005 (0.062)
adj. R <sup>2</sup>		0.246	0.202	0.336	0.194	0.518
NYS		-0.154* (0.079)	-0.236*** (0.077)	0.046 (0.179)	-0.054* (0.029)	-0.005 (0.062)
adj. R <sup>2</sup>		0.246	0.202	0.336	0.194	0.518
N		897	897	888	906	901
<i>Three-child Families</i>						
<i>High-Achieving First Child</i>		Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2		-0.283 (0.210)	-0.281 (0.262)	-0.333 (0.452)	0.082 (0.104)	0.020 (0.209)
BirthOrder3		-0.595 (0.389)	-0.400 (0.453)	-0.600 (0.827)	0.254 (0.183)	-0.218 (0.374)
adj. R <sup>2</sup>		0.417	0.182	0.464	0.137	0.575
NYS		0.299 (0.195)	0.188 (0.222)	0.297 (0.410)	-0.131 (0.089)	0.121 (0.186)
adj. R <sup>2</sup>		0.425	0.184	0.471	0.136	0.557
N		121	121	119	124	122
<i>Low-Achieving First Child</i>						
BirthOrder2		0.043 (0.203)	0.211 (0.186)	-0.316 (0.395)	0.098 (0.090)	0.037 (0.131)
BirthOrder3		-0.226 (0.355)	0.206 (0.328)	-0.794 (0.644)	0.122 (0.160)	-0.038 (0.251)
adj. R <sup>2</sup>		0.273	0.370	0.533	0.457	0.514
NYS		0.097 (0.175)	-0.114 (0.164)	0.389 (0.321)	-0.064 (0.080)	0.016 (0.125)
adj. R <sup>2</sup>		0.242	0.357	0.537	0.455	0.514
N		155	155	146	158	157

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects. Standard errors clustered at family level are in parentheses.

We can write the decomposition as

$$\beta = \sum_{l=1}^L w_l \beta_l, \quad w_l \geq 0, \quad \sum_{l=1}^L w_l = 1$$

where each  $\beta_l$  represents the relationship between the dependent variable  $Y$  and the independent variable  $NYS$  within subgroup  $l$ .  $\beta$  is now expressed as a weighted sum of  $\beta_l$  from  $L$  subgroups in the sample.

This decomposition can be done as follows. For a subsample  $l$  of size  $n_l$  and individuals  $j_l$  in the subsample  $l$ , one can estimate a univariate regression of  $Y_{j_l} = \beta_l X_{j_l} + \epsilon_{j_l}$  (without a constant) and obtain an estimate of  $\hat{\beta}_l$  as

$$\hat{\beta}_l = \frac{\sum_{j_l} X_{j_l} Y_{j_l}}{\sum_{j_l} X_{j_l}^2} \tag{3}$$

From the entire sample, we have

**Table 7**  
Birth order effects and reputation concerns.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	-0.019 (0.041)	0.023 (0.045)	-0.073 (0.090)	0.030** (0.015)	-0.052 (0.041)
Age Gap	0.000 (0.000)	0.001** (0.000)	0.001** (0.001)	0.000 (0.000)	0.000 (0.000)
adj. R <sup>2</sup>	0.055	0.038	0.128	0.002	0.061
NYS	0.019 (0.041)	-0.023 (0.045)	0.073 (0.090)	-0.030** (0.015)	0.052 (0.041)
Age Gap	0.000 (0.000)	0.001** (0.000)	0.001** (0.001)	0.000 (0.000)	0.000 (0.000)
adj. R <sup>2</sup>	0.055	0.038	0.128	0.002	0.061
N	2427	2427	2276	2437	2435

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects. Standard errors clustered at family level are in parentheses. Sample includes two- and three-child families.

**Table A1**  
Birth order effects when the first child is a son.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	-0.108 (0.082)	-0.097 (0.098)	-0.444** (0.191)	0.037 (0.036)	0.041 (0.076)
BirthOrder3	-0.489*** (0.168)	-0.317* (0.169)	-0.938** (0.369)	0.162** (0.074)	-0.050 (0.139)
N	751	751	723	756	747
adj. R <sup>2</sup>	0.333	0.169	0.416	0.130	0.452
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	0.195** (0.080)	0.130 (0.082)	0.461*** (0.171)	-0.064** (0.032)	0.010 (0.066)
N	751	751	723	756	747
adj. R <sup>2</sup>	0.322	0.167	0.417	0.122	0.451

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

**Table A2**  
Birth order effects when the first child is a daughter.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	-0.059 (0.082)	0.050 (0.085)	-0.140 (0.151)	0.042 (0.030)	-0.071 (0.068)
BirthOrder3	-0.114 (0.140)	0.168 (0.149)	-0.282 (0.264)	0.109 (0.067)	-0.258** (0.112)
N	1277	1277	1213	1286	1282
adj. R <sup>2</sup>	0.263	0.239	0.390	0.161	0.417
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	0.058 (0.069)	-0.076 (0.074)	0.141 (0.130)	-0.054* (0.031)	0.115** (0.056)
N	1277	1277	1213	1286	1282
adj. R <sup>2</sup>	0.264	0.240	0.391	0.162	0.416

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

**Table A3**  
Birth order effects for low-income households.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	-0.163** (0.080)	-0.027 (0.086)	-0.211 (0.179)	0.078** (0.031)	-0.075 (0.073)
BirthOrder3	-0.442*** (0.147)	-0.052 (0.158)	-0.656** (0.328)	0.185*** (0.071)	-0.219 (0.138)
N	1000	1000	955	1007	998
adj. R <sup>2</sup>	0.315	0.222	0.470	0.164	0.412

	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	0.203*** (0.072)	0.026 (0.077)	0.293* (0.160)	-0.089*** (0.031)	0.099 (0.066)
N	1000	1000	955	1007	998
adj. R <sup>2</sup>	0.314	0.224	0.469	0.164	0.412

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Households with annual income below sample median are included. Cog.Skill: Cognitive skill. Corp. Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

**Table A4**  
Birth order effects for high-income households.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	0.023 (0.077)	0.005 (0.081)	-0.255* (0.152)	0.036 (0.025)	-0.027 (0.065)
BirthOrder3	-0.041 (0.160)	-0.002 (0.165)	-0.354 (0.272)	0.105 (0.065)	-0.207 (0.130)
N	1028	1028	981	1035	1031
adj. R <sup>2</sup>	0.300	0.185	0.375	0.284	0.482

	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	-0.001 (0.070)	-0.006 (0.072)	0.211 (0.133)	-0.043 (0.026)	0.074 (0.059)
N	1028	1028	981	1035	1031
adj. R <sup>2</sup>	0.300	0.187	0.376	0.283	0.480

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Households with annual income above sample median are included. Cog.Skill: Cognitive skill. Corp. Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

$$\hat{\beta} = \frac{\sum_i^n X_i Y_i}{\sum_i^n X_i^2} = \sum_{l=1}^L \hat{w}_l \hat{\beta}_l \tag{4}$$

where  $n = \sum_{l=1}^L n_l$ . Recognizing  $\sum_i^n X_i^2 = \sum_l^L \sum_{j_l}^{n_l} X_{j_l}^2$  and  $\sum_i^n X_i Y_i = \sum_l^L \sum_{j_l}^{n_l} X_{j_l} Y_{j_l}$ , it is straightforward to show that<sup>3</sup>

$$\hat{w}_l = \frac{\sum_{j_l}^{n_l} X_{j_l}^2}{\sum_l^L \sum_{j_l}^{n_l} X_{j_l}^2} \tag{5}$$

This decomposition places a greater weight in larger subsamples with more variation in  $X_j$ .

In practice, we use partitioned regression to transform Eq. (2) into a univariate regression without a constant term. This procedure

<sup>3</sup> We thank Xi Wang for advice on this decomposition.

**Table A5**  
Birth order effects for rural households.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	-0.027 (0.056)	0.030 (0.060)	-0.251** (0.120)	0.048** (0.021)	-0.054 (0.048)
BirthOrder3	-0.220* (0.115)	0.019 (0.116)	-0.553*** (0.213)	0.136*** (0.052)	-0.208** (0.088)
N	1875	1875	1787	1887	1876
adj. R <sup>2</sup>	0.289	0.213	0.387	0.112	0.431

	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	0.076 (0.053)	-0.020 (0.054)	0.267** (0.104)	-0.060*** (0.022)	0.087** (0.042)
N	1875	1875	1787	1887	1876
adj. R <sup>2</sup>	0.285	0.214	0.387	0.110	0.430

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Respondents hold rural hukou. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

**Table A6**  
Birth order effects for urban households.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
BirthOrder2	-0.261 (0.227)	-0.166 (0.186)	-0.162 (0.261)	-0.053 (0.098)	0.034 (0.210)
BirthOrder3	-0.130 (0.500)	-0.087 (0.473)	-0.531 (0.603)	-0.126 (0.150)	-0.303 (0.326)
N	153	153	149	155	153
adj. R <sup>2</sup>	0.126	0.114	0.426	0.128	0.287

	Chinese	Math	Cognitive Skill	Corp. Punish.	Check HW
NYS	0.167 (0.205)	0.107 (0.185)	0.211 (0.262)	0.058 (0.085)	0.057 (0.167)
N	153	153	149	155	153
adj. R <sup>2</sup>	0.114	0.118	0.432	0.141	0.274

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Respondents hold urban hukou. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

also ensures that exactly the same set of controls are included in each of the regressions, so that Eq. (4) mechanically holds. Specifically, we can write

$$Y_{iht} = \alpha + \beta_{nys}NYS_{iht} + \gamma X_{iht} + \lambda_t + \lambda_h + \epsilon_{iht} \tag{6}$$

$$\rightarrow \tilde{Y}_{iht} = \beta_{nys}\tilde{NYS}_{iht} + \tilde{\epsilon}_{iht} \tag{7}$$

where we partial out all the independent variables except for  $NYS_{iht}$ . By Frisch-Waugh-Lovell theorem, the values of estimated  $\beta_{nys}$  are the same in Eq. (7) as in Eq. (2). Weights for each subsample is constructed using  $\tilde{NYS}_{iht}$  and  $\hat{\beta}_l$  coefficients are based on Eq. (7) for each subsample. To implement this procedure for Eq. (1), we partial out all the independent variables and one of the birth order indicators to obtain partitioned variable for the other birth order indicator.

We decompose the sample into five subgroups (earlier born-later born): boy-boy ( $N = 307$ ), girl-boy ( $N = 776$ ), boy-girl ( $N = 419$ ), girl-girl ( $N = 392$ ), and other families ( $N = 134$ ). For example, girl-boy group includes two-child families with elder daughter and younger son, and three-child families with earlier-born daughters and later-born sons (girl-girl-boy, girl-boy-boy). "Other" group includes three-child families with alternating sex compositions (boy-girl-boy, girl-boy-girl). If boy-girl group dominates the decompositions, it would be difficult to reject son preference as an important explanation for the negative birth order effects. If other groups dominate the decompositions, it would be unlikely that son preference drives the observed birth order effects.

**Table A7**  
Decomposition for birth order 2 coefficient.

Chinese					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.153	0.384	0.206	0.195	0.061
sub-sample coefficient	-0.110	-0.009	-0.041	-0.065	-0.136
weight $\times$ coefficient	-0.017	-0.003	-0.008	-0.013	-0.008
Math					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.153	0.384	0.206	0.195	0.061
sub-sample coefficient	-0.150	0.031	0.012	0.029	0.073
weight $\times$ coefficient	-0.023	0.012	0.002	0.006	0.004
Cognitive Skill					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.159	0.379	0.204	0.195	0.063
sub-sample coefficient	-0.352	-0.145	-0.425	-0.220	0.084
weight $\times$ coefficient	-0.056	-0.055	-0.087	-0.043	0.005
Corporal Punishment					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.155	0.383	0.205	0.196	0.061
sub-sample coefficient	0.076	0.057	0.028	0.035	-0.023
weight $\times$ coefficient	0.012	0.022	0.006	0.007	-0.001
Check HW					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.154	0.383	0.203	0.199	0.061
sub-sample coefficient	-0.043	-0.050	0.019	-0.155	0.015
weight $\times$ coefficient	-0.007	-0.019	0.004	-0.031	0.001

**Table A8**  
Decomposition for birth order 3 coefficient.

Chinese					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.111	0.364	0.182	0.121	0.222
sub-sample coefficient	-0.136	-0.040	-0.074	-0.095	-0.166
weight $\times$ coefficient	-0.015	-0.015	-0.013	-0.012	-0.037
Math					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.111	0.364	0.182	0.121	0.222
sub-sample coefficient	-0.156	0.024	0.005	0.022	0.066
weight $\times$ coefficient	-0.017	0.009	0.001	0.003	0.015
Cognitive Skill					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.115	0.375	0.177	0.104	0.229
sub-sample coefficient	-0.309	-0.113	-0.399	-0.185	0.118
weight $\times$ coefficient	-0.035	-0.042	-0.071	-0.019	0.027
Corporal Punishment					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.110	0.370	0.180	0.120	0.220
sub-sample coefficient	0.077	0.060	0.033	0.038	-0.015
weight $\times$ coefficient	0.008	0.022	0.006	0.005	-0.003
Check HW					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.110	0.370	0.180	0.120	0.220
sub-sample coefficient	-0.070	-0.083	-0.017	-0.186	-0.017
weight $\times$ coefficient	-0.008	-0.031	-0.003	-0.022	-0.004

In particular, considering the steep cost of having additional child under OCP, parents with son preference would strongly favor later-born sons when they have earlier-born daughters. Negative birth order effects on girl-boy subsample would therefore be difficult to be reconciled with the presence of strong son preference.

The results of this decomposition is presented in Fig. 3. The effects are scaled to sum up to 1 for visibility. For Chinese and cognitive skill outcomes, boy-girl subsamples represent a nontrivial portion of the decompositions, but other subgroups represent a sizable portion of the decompositions as well. In particular, girl-boy subsample is represented in all decompositions, contrary to the implications of strong son-preference mechanism. As for the decomposition of birth order effects for parenting behaviors, boy-girl subgroup represents even smaller part of the decompositions, while girl-boy subgroup component is large. Negative birth order effects shown by

**Table A9**  
Decomposition for NYS coefficient.

Chinese					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.070	0.224	0.222	0.306	0.178
sub-sample coefficient	0.154	0.024	0.126	0.042	0.174
weight × coefficient	0.011	0.005	0.028	0.013	0.031
Math					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.070	0.224	0.222	0.306	0.178
sub-sample coefficient	0.179	−0.055	0.055	−0.048	−0.098
weight × coefficient	0.013	−0.012	0.012	−0.015	−0.017
Cognitive Skill					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.072	0.226	0.218	0.301	0.184
sub-sample coefficient	0.204	0.174	0.511	0.172	0.220
weight × coefficient	0.015	0.039	0.111	0.052	0.040
Corporal Punishment					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.070	0.225	0.220	0.309	0.176
sub-sample coefficient	−0.085	−0.054	−0.056	−0.055	0.008
weight × coefficient	−0.006	−0.012	−0.012	−0.017	0.001
Check HW					
sub-sample	boy-boy	girl-boy	boy-girl	girl-girl	other
weight	0.070	0.225	0.217	0.311	0.177
sub-sample coefficient	0.094	0.107	0.013	0.162	0.037
weight × coefficient	0.007	0.024	0.003	0.050	0.007

**Table A10**  
Outcome of the youngest son by the gender of the firstborn child.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
Firstborn is a son	0.130*	−0.050	0.062	0.013	−0.061
	(0.075)	(0.083)	(0.150)	(0.030)	(0.064)
N	1108	1108	1060	1115	1109
adj. R <sup>2</sup>	0.258	0.246	0.440	0.098	0.451

Notes: \*: significant at the 10% level. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, year fixed effects, and family fixed effects.

**Table A11**  
Outcome of the youngest son by the gender of the firstborn child.

<i>Restriction: Two-child families</i>					
	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
Firstborn is a son	0.165**	−0.039	0.049	0.004	−0.048
	(0.083)	(0.095)	(0.157)	(0.032)	(0.069)
N	1108	1108	1060	1115	1109
adj. R <sup>2</sup>	0.258	0.246	0.440	0.098	0.451

Notes: \*\*: significant at the 5% level. Cog.Skill: Cognitive skill. Corp.Punish: Parent's self-reported intention to use corporal punishment in response to children's low grades at school. NYS: number of younger siblings. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects. The sample is restricted families with two children (regardless of age) at the time of the survey.

girl-boy subsample, boy-boy subsample, and girl-girl subsample are inconsistent with strong son preference within the household.

In the appendix, we provide further tests of the presence of son preference within the household based on gender composition within siblings, following approaches similar to Jayachandran and Pande (2017). Although the results are generally imprecise (see Tables A10–A14), the sign and magnitude of estimates are not consistent with the birth order effects following the pattern predicted by son preference within households. Overall, although we do not rule out the presence of son preference within the household, the role of son preference in explaining children's outcomes in the household seems weaker compared to those in other countries such as India (Jayachandran & Pande, 2017), where the pattern of son preference closely aligns with birth order effects.

**Table A12**  
Effects of the fraction of sisters among siblings.

	(1)	(2)	(3)	(4)	(5)
Panel A	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
Fraction of sisters	0.394 (0.305)	0.142 (0.292)	-0.468 (0.531)	0.109 (0.163)	-0.048 (0.276)
NYS	0.127 (0.123)	0.063 (0.142)	0.354 (0.264)	-0.036 (0.052)	0.036 (0.110)
N	988	988	952	996	987
adj. R <sup>2</sup>	0.293	0.211	0.409	-0.172	0.419
Panel B	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
Fraction of sisters	0.455 (0.295)	0.224 (0.274)	-0.071 (0.414)	0.163 (0.198)	0.165 (0.346)
Male	-0.108 (0.072)	-0.034 (0.079)	-0.169 (0.159)	-0.015 (0.029)	0.010 (0.065)
NYS	0.170** (0.084)	0.117 (0.087)	0.465*** (0.173)	-0.073** (0.034)	0.001 (0.068)
N	751	751	723	756	747
adj. R <sup>2</sup>	0.327	0.167	0.415	0.126	0.450

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Sample for Panel A is restricted to sons. Sample for Panel B is restricted to those in the households whose firstborn child is a son. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, year fixed effects, and family fixed effects.

**Table A13**  
Birth order effects by the presence of ancestral temples.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	-0.084 (0.055)	-0.012 (0.059)	-0.214* (0.115)	0.043** (0.021)	-0.051 (0.047)
BirthOrder3	-0.219* (0.117)	-0.014 (0.120)	-0.565** (0.224)	0.123** (0.059)	-0.227** (0.089)
BO2 × temple	0.094 (0.062)	0.044 (0.069)	-0.102 (0.115)	-0.000 (0.017)	0.025 (0.056)
BO3 × temple	-0.093 (0.151)	-0.033 (0.165)	0.100 (0.283)	0.006 (0.080)	0.083 (0.139)
N	2028	2028	1936	2042	2029
adj. R <sup>2</sup>	0.275	0.204	0.399	0.121	0.409
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
NYS	0.104** (0.051)	0.018 (0.054)	0.241** (0.101)	-0.057*** (0.022)	0.102** (0.042)
NYS × temple	-0.039 (0.052)	-0.054 (0.054)	0.074 (0.086)	0.009 (0.015)	-0.078 (0.051)
N	2028	2028	1936	2042	2029
adj. R <sup>2</sup>	0.272	0.207	0.400	0.120	0.410

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Control variables include father's education level, mother's education level, rural hukou status, number of siblings, household income, child's age, gender, year fixed effects, and family fixed effects.

#### 4.3. Reinforcing parenting behaviors

In this section, we investigate whether the negative birth order effects are observed throughout the skill distribution of children, or whether the pattern is driven by the "outlying" performance of the firstborn children. If negative birth order effects are observed only when the firstborn children show good performance compared to their peers, then the birth order effects may have been generated by parents' responding to observed outcomes of children, and reinforcing those who show academic promise. Other scholars also reported that parents tend to reinforce advantages in academic achievements among siblings (Dizon-Ross, 2019; Yi et al., 2015).

To examine this possibility, we categorize children based on their Chinese, Math and Cognitive skill achievements. If a student's performance is better than the sample median in at least two of these outcomes, then the student is categorized as "high-achieving", and as "low-achieving" otherwise. We divide the sample based on the performance of the first child in each household and conduct subsample analysis. If parents reinforced investments on children that seemed to perform well academically, we would see that birth order effects are stronger in the subsample with high-achieving first children.

**Table A14**  
Birth order effects by One Child Policy.

	(1)	(2)	(3)	(4)	(5)
	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
BirthOrder2	-0.095 (0.063)	0.007 (0.064)	-0.231* (0.122)	0.053** (0.023)	-0.059 (0.050)
BirthOrder3	-0.205 (0.143)	0.064 (0.144)	-0.473* (0.278)	0.172** (0.080)	-0.295*** (0.099)
BO2 × high fine	0.085* (0.049)	-0.002 (0.055)	-0.023 (0.097)	-0.024 (0.017)	0.021 (0.044)
BO3 × high fine	-0.027 (0.150)	-0.119 (0.152)	-0.133 (0.281)	-0.088 (0.084)	0.138 (0.108)
N	2020	2020	1928	2034	2021
adj. R <sup>2</sup>	0.278	0.206	0.400	0.125	0.409

	Chinese	Math	Cog.Skill	Corp.Punish	Check HW
NYS	0.101* (0.057)	-0.014 (0.057)	0.244** (0.107)	-0.062** (0.025)	0.099** (0.045)
NYS × high fine	-0.031 (0.041)	0.018 (0.043)	0.034 (0.075)	0.017 (0.015)	-0.021 (0.044)
N	2020	2020	1928	2034	2021
adj. R <sup>2</sup>	0.274	0.207	0.401	0.121	0.407

Notes: \*\*\*/\*\*/\*: significant at the 1/5/10% level. Control variables include father’s education level, mother’s education level, rural hukou status, number of siblings, household income, child’s age, gender, year fixed effects, and family fixed effects.

These results are shown in Tables 5 and 6. For the households with high-achieving first children, shown in the first panel of Table 5, we observe sizable and significant negative birth order effects for all outcomes we consider. Significantly, we observe negative birth order effects for Math achievement, for which birth order effects were insignificant using the overall sample. The second panel of Table 5 shows more interesting findings: birth order effects on Chinese and Math are now positive, while birth order effects on other outcomes are negative but smaller or absent. Table 6 show that this pattern persists when the sample is restricted to two-child families or three-child families. The positive birth order effects for Math is comparable to the magnitude of negative birth order effects in the sample with high-achieving firstborn children, explaining lack of birth order effects on Math in the overall sample.

Significant negative birth order effects on academic outcomes and parenting behaviors such as “checking homework” only for high-achieving first child subsample are consistent with the parents’ investment behaviors that reinforce siblings with better initial academic achievements (Dizon-Ross, 2019; Yi et al., 2015). Corporal punishment, which is not a parental investment but a responses to children’s misbehavior, does not follow this pattern (Kim et al., 2018). These findings are consistent with parents providing reinforcing investment to earlier-born children who show high level of academic achievement may be a source of negative birth order effects. Note, however, that these results are based on the outcomes of the firstborn children, not baseline characteristics. More research is needed to be certain of this conclusion.

#### 4.4. Parental reputation

In this section, we examine the reputation model proposed by Hao et al. (2008). In their model, parents provide more investment and implement more strict discipline to older children to establish reputation as a stricter parent to the younger siblings. This incentive generates negative birth order effects on parenting behaviors and children’s outcomes. This mechanism was tested using adolescents’ academic achievements, delinquent behaviors, and parents’ parenting behaviors on the US data (Hao et al., 2008; Hotz & Pantano, 2015) but, to our knowledge, not on Chinese data. We test this hypothesis with the following equation:

$$Y_{it} = \beta_0 + \beta_1 AgeGap_{it} + \beta_2 BirthOrder_{it} + \gamma X + \epsilon_{it}, \tag{8}$$

where  $AgeGap_{it}$  is the age difference of a child with the nearest younger sibling and  $BirthOrder_{it}$  is a vector of birth order variables. An implication of the reputation model is that the outcomes of older children will be decreasing in the age gap with the nearest younger sibling. This is because the impact of reputation will be stronger when children are closer in age.

According to the results in Table 7, we find no evidence in support of the reputation model in our sample. The coefficients are close to zero and the signs are positive, contrary to the implications of the reputation model. We do not include family FE because sample size will be only around 200 if we include it (age gap is defined only for younger siblings).

### 5. Discussion and conclusion

We use multiple waves of CFPS to investigate birth order effects on children’s academic achievement and parenting behaviors, and explore potential mechanisms. We find negative birth order effects on academic achievement and cognitive skill outcome. We also find negative birth order effects on the parents’ use of corporal punishment and supervision of child’s homework. We highlight parents’ use

of harsh parenting as a novel channel that may lead to negative birth order effects. Parents were less likely to use corporal punishment to earlier-born children, which has known harmful effects on children's development (Fiorini & Keane, 2014; Kim et al., 2018).

We explore several potential mechanisms underlying birth order effects, including resource dilution, son preference, parent's reinforcing behaviors, and reputation concerns. Resource dilution and son preference do not seem to be primary mechanisms underlying the negative birth order effects, although we do not rule out their roles entirely. We find little support for reputation concern mechanism. We find suggestive evidence that parents may have chosen to reinforce academic advantages of earlier-born children, generating strong negative birth order effects in academic achievements and parenting behaviors among households with better-performing firstborn children. More research is needed, however, to clearly understand the mechanisms underlying birth order effects.

Our estimates of birth order effects are in contrast to positive birth order effects reported by Weng et al. (2019). An important difference between our study and theirs may be that ours is based on a sample of adolescents in contemporary China, while the sample in Weng et al. (2019) is from earlier generations of Chinese siblings (average age is 47.55 in 2014; see Table 1 in Weng et al. (2019)). Furthermore, studies showing evidence consistent with strong presence of son preference, such as Lei et al. (2017) and Chen (2020), use sample of Chinese adults, also belonging to earlier generation of Chinese compared to those in our sample. These findings are consistent with projections made by other researchers that the effects of son preference in China would grow weaker over time (Murphy et al., 2011). Taken together, our results suggest that family dynamics in contemporary China has evolved over time and is closer to those found in other countries in the developed world also showing negative birth order effects.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Data availability

Data will be made available on request.

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### Appendix

#### Appendix A. Tests of son preference

In this section, we conduct a series of tests to look for the evidence that son preference drives the birth order effects in our sample. If the son preference is the key determinant of birth order effect, then the negative birth order effect would be weaker in daughter-son family than in daughter-daughter family. Another test is to examine whether the negative birth order effect is stronger in son-daughter family than in son-son family. In this case, however, parent's preference over gender diversity may divert some resources to the later-born daughter even if son preference is present. Finally, we use proxies that predict stronger effects of son preference, and examine whether birth order effects are strengthened when such proxies are present.

##### A.1. Tests based on the presence of older brother

In Table A10, we restrict the sample to households who had a son as the youngest-born child, and examine the "effect" of having a brother as the eldest sibling. Son preference mechanism predicts that later-born son would receive greater allocation of household resources if the earlier-born siblings are daughters. Then, the indicator for the firstborn sibling being a son would have negative coefficient estimates. The results in Table A10 are inconsistent with the strong effects of son preference as the explanation for child outcomes and parenting among siblings. The coefficient estimates are relatively small in magnitude and inconsistent in sign across outcomes. In fact, positive and significant coefficient for the Chinese grade outcome contradicts the implications of son preference. Table A11 in the Appendix further restricts the sample to two-child families, whose results confirm those in Table A10.

##### A.2. Tests based on the presence of younger sisters

In Table A12, we test whether the increase in the fraction of sisters among siblings lead to better outcomes. We follow the strategy of Lei et al. (2017) who found that an increase in the fraction of sisters lead to an increase in the educational attainment of men and women, using a sample of Chinese aged between 25 and 65. Chen (2020) also found that having a younger sister reduces parental

educational aspirations and educational expenditures for firstborn daughters but not for firstborn sons. If the negative birth order effects is driven by worse outcomes for later-born daughters, perhaps due to household resource allocation motivated by son preference, we expect positive coefficient estimates on the variable for the proportion of sisters among siblings.

To clarify the interpretation of the results, we apply two sample restrictions: to sons (Panel A), and to children in the households whose firstborn child is a son (Panel B). Further sample restriction would greatly reduce statistical power so that meaningful interpretation of results is difficult.<sup>4</sup>

Estimates in Table A12 are not significantly different from zero in any of the specifications, making it difficult to draw strong conclusions on whether the fraction of sisters among siblings affect children's outcomes of interest. The coefficients for the fraction of sisters for Chinese and Math are positive in both sample restrictions, consistent with the presence of son preference. However, the signs of the coefficients for cognitive skill, corporal punishment, and parents' checking homework do not consistently support the presence of son preference. The magnitudes of the NYS coefficient are not smaller compared to those in Table 2, suggesting that the presence of younger sisters likely does not explain negative birth order effects.

### A.3. Test based on strong patrilineal culture

Zhang (2019) showed that clan culture in rural China is positively associated with a set of individual values that emphasize the children's duty to support their parents in old age. The author used the presence of ancestral temple as a proxy for strong clan culture and showed that the residents were more likely to agree that the purpose of raising children was to receive help in old age if there was an ancestral temple in the village. Because expectation of old age support is one of the important determinants of son preference in China, son preference may be stronger in places with an ancestral temple. Consistent with this hypothesis, Zhang found that the presence of an ancestral temple predicted more children, higher likelihood of having a son, higher likelihood of parents living with their son, and smaller likelihood of the parents being enrolled in social pension programs. Similarly, Jayachandran and Pande (2017) found shallower negative birth order gradient in subsamples with weaker son preference in India and interpreted them as evidence that the birth order effects were driven by son preference.

In Table A13, we use Zhang's data on the presence of ancestral temples and interacted the presence of temples with birth order indicators or NYS. If the presence of an ancestral temple is associated with stronger son preference and son preference drives negative birth order effects, then we would expect negative birth order effects to be stronger in areas with ancestral temples. The results, however, shows that the interaction term coefficients are not significantly different from zero and do not share the same signs as the coefficients for the birth order variables. The evidence does not reject the null hypothesis that birth order effects remain the same in areas with ancestral temples and in areas without ancestral temples, which proxy strong local patrilineal culture.

### A.4. Test based on One Child Policy

Ebenstein (2010) showed that the severity of OCP, as measured by the amount of fine required to pay in case of violating OCP, is associated with higher son-to-daughter ratio and smaller family size. OCP may have provided extra incentive for families with son preference to use sex-selective abortion, or to allocate relatively more resources to sons, because the cost of having more children to have another son would be prohibitively high for many. Then, if son preference drives birth order effects, the effects would be stronger in areas with high OCP fine rate, to the extent that OCP reinforces household behavior based on son preference.

We use the data collected by Ebenstein on provincial fine rate in units of average worker's annual wages and calculate province-specific fine averages.<sup>5</sup> Then, we create indicators for being above sample median in the value of average OCP fines, interacted with birth order effects variables. The results in Table A14 do not show stronger birth order effects in areas with higher OCP fine rate. The magnitudes of interaction coefficients are generally small and insignificant.

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<sup>4</sup> There are 428 firstborn sons in the sample. Estimates on this subsample are imprecise.

<sup>5</sup> We do this because the range of years covered by Ebenstein's data does not fully overlap with the range of years in our sample.

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