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Outlier or Not? The Birth Order Effects on Educational Attainment in China

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Abstract: This study examines birth order effects in China using sibling fixed-effect models and cohort analysis. It reveals that birth order's net effect is negative when adjusting for educational expansion and gendered sibling structures. The findings resonate with Western patterns but challenge earlier positive birth order effects documented in China. Notably, gender plays a significant role, as negative birth order effects are more pronounced in females due to gender preference in fertility and parenting. These complex findings highlight the necessity to explore the mechanisms behind birth order effects amid evolving societal norms and parental behaviors. Moreover, this study contributes novel insights by disentangling macro-level trends from birth order effects and deal with bias from sibling size and sibling gender structures by introducing newly designed adjusted birth order indices.

Keywords: birth order; sibling design; educational inequality; China

Reproducibility Package: Stata replication code is available at the link: https://doi.org/10.7910/DVN/RZVEMI. The data used in this article can be achieved via application through the CFPS website: https://cfpsdata.pku.edu.cn/.

Birth order is a crucial, sibling-specific characteristic that significantly shapes the parental investment children receive. Researchers have long delved into its multifaceted impact on various conceivable outcomes of well-beings, encompassing educational achievement, health, intelligence, and personality (Gini 1915; Blau and Duncan 1967; Ernst and Angst 1983; Conley 2004). Recent studies, utilizing large-scale survey data and rigorous research designs, come to convergence to underscore negative effects of birth order on educational outcomes such as school attainments and cognitive skills, indicating systematic disadvantages for later-born children (Black, Devereux, and Salvanes 2005; Kantarevic and Mechoulan 2006; Booth and Kee 2009; Barclay 2018).

However, the Western-centric narratives exhibit a notable divergence when applied to China. In contrast to established Western patterns, later-born siblings in China demonstrate relative advantages, suggesting positive birth order effects (Luo and Zhou 2010; Tao, Wang, and Zhang 2017; Weng et al. 2019; Xiong et al. 2020). Is China an outlier in this sense? Explanations for this anomaly include preferential resource allocation toward later borns (Xiong et al. 2020) and gender-biased intra-generational resources reallocation (Chu et al. 2007). Nevertheless, previous studies on China face methodological limitations: they inadequately incorporate the macro-level educational expansion trends into the micro-level analysis of within-family birth order differences and insufficiently leverage household data to control for both observed and unobserved factors at the parental level. This article addresses these gaps by investigating China's distinctive birth order effect pattern and its

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divergence from Western contexts. Utilizing sibling fixed-effect models and cohort analysis, this study challenges the presumption of inherent positive birth order effects in China, demonstrating that the apparent later-born advantages primarily stem from the macro trend of educational expansion rather than simple explicit parental preferences.

Isolating the net effects of birth order presents methodological complexity due to its high collinearity with sibling size. Children with earlier birth order positions typically belong to smaller families, whereas later orders intrinsically require larger sibship groups. Consequently, sibling size effects may confound birth order estimates in observational studies. Methodological innovations address this challenge. For instance, Black et al. (2005) utilized the entire population registry data set of Norway to conduct separate regressions for every particular family size, revealing significant educational penalties for later-born siblings. However, this approach relies on sample sizes and yields unstable estimates with small subsamples. Alternatively, Booth and Kee (2009) developed an adjusted birth order index (ABOI) for British families, calculated by deflating the absolute birth order by the average birth order of siblings. This reduced the correlation between sibling size and birth order from 0.705 to 0.066, demonstrating declining parental educational resource shares with increasing birth order.

Another prominent methodological approach utilizes sibling fixed-effect models to conduct rigorous within-family comparisons that isolate birth order effects. Because siblings within the same household share familial environment and genetic background—factors that often introduce confounding in birth order studies—these models have been claimed advantageous for identifying causal relationships between birth order and educational outcomes. Despite this potential, their application in Chinese contexts remains limited due to two key constraints: (1) historical scarcity of household-level data with complete sibling information prior to 2010 and (2) comparative neglect of within-family birth order dynamics in favor of sibship size effects. Crucially, as sibling size operates between families, prior studies failed to leverage the within-family comparison enabled by sibling fixed-effect models for birth order effects. Addressing this gap, this study harnesses genealogical records from the China Family Panel Survey (CFPS) to demonstrate the unique analytical value of sibling fixed-effect models in the Chinese context. By systematically controlling for all time-invariant familial characteristics through within-family comparisons across birth orders, this approach provides precision in identifying birth order effects net of familial confounders.

China's distinct sociocultural context confers unique analytical complexity and significance on birth order effects research through three key dimensions. First, the profound cultural emphasis on education in China motivates families across socioeconomic strata to prioritize their children's educational pursuits, even under resource constraints. Crucially, in multi-child households, parents typically avoid sacrificing educational attainment when either sufficient household resources or supportive policies exist. This unwavering cultural commitment creates an ideal empirical setting conducive for comparing educational attainment between siblings of different birth orders, minimizing confounding from non-educational compensatory strategies. Second, China's rapid demographic transition—marked by the 2016 universal two-child policy and its 2021 expansion to three children after decades of strict birth control—necessitates re-examining sibling educational disparities within evolving family structures. In fact, even during the strict policy period, rural exceptions permitting second children existed under specific conditions. Analyzing these dynamics of birth order effects offers critical insights for aligning educational equity measures with demographic governance. Third, examining cohort trends in birth order effects provides a lens to investigate how China's late-twentieth-century socioeconomic transformations—particularly the mass educational expansion that elevated national average schooling—reconfigured intrahousehold inequality mechanisms. Collectively, these dimensions establish China as both a crucial case study for testing universal theories of birth order effects and a strategic site for developing context-sensitive models of educational stratification.

This article contributes in several aspects. First, this article proposes a novel explanation for the positive correlation between birth order and educational attainment observed in China. In contrast to simplistic attributions to parental preferences or other familial factors, this study posits that the seeming association between later birth order and higher education attainment is primarily driven by the overarching trend of educational expansion. Without accounting for educational expansion, China appears as an outlier exhibiting positive birth order effects. However, after controlling for the effects of educational expansion, the birth order effects revert to negative, aligning China with the pattern observed in Western cases. This explanation may extend to other nations experiencing mass expansion of education. Furthermore, this article employs sibling fixed-effect models to account for the effects of both observed and unobserved time-invariant family characteristics, yielding a more nuanced perspective and precise estimation of birth order effects. By exploring cohort trends in birth order effects spinning from 1940 to 1985, this article advances historical understanding of how societal transformations—from the foundation of socialist China through the Reform and Opening-up period—shaped intrahousehold educational differences, thereby complementing the previous studies on within-family inequality. Additionally, this article introduces innovative indices—the gender-adjusted birth order index (GABOI) and ABOI—designed to isolate the true effect of birth order from the influences of gender and sibling size. These analytical tools hold significant potential for enriching future research in this field.

Literature Background

Theoretical Mechanisms of Birth Order Effects

Educational disparities among siblings are predominantly explained around two theoretical frameworks: the resource dilution theory (Blake 1981) and the confluence theory (Zajonc 1976). Resource dilution theory posits that parental resources every child receives (e.g., time, finances, and attention) diminish with each additional child, disadvantaging later-born siblings who receive a smaller share than early borns, assuming no parental preference between birth orders. On the other hand, confluence theory emphasizes intellectual development through intrahousehold interaction. It argues that the cognitive development depends on the average degree of intellectual stimulation within the family. Firstborns initially benefit from exclusive adult interaction, whereas later borns experience diluted parental attention and potentially less stimulating peer interactions with older siblings. Besides, in the long run, older siblings may gain cognitively from tutoring younger ones (Zajonc, Markus, and Markus 1979). Empirical support for the negative educational impact of later birth order is robust across Western contexts, including the United States (Conley et al., 2007), Norway (Black et al. 2005), Germany (Härkönen 2014; Grätz 2018), and Sweden (Barclay 2018).

Studies in China present a counter narrative. Utilizing the ABOI introduced by Booth and Kee (2009) on China Health and Nutrition Survey data, Luo and Zhou (2010) identified a positive birth order effect—later-born children attaining higher education. This finding is corroborated by Tao et al. (2017), Weng et al. (2019), and Xiong et al. (2020) using national representative surveys (CFPS, China Household Income Project, and Chinese General Social Survey). Notably, Xiong et al. (2020) observed parental preferences favoring both eldest and youngest siblings, yet still found net advantage for the later borns. Despite this empirical consistency, the reasons behind China's positive birth order−education relationship remain inadequately theorised. Prevailing explanations often invoke cultural traditions favoring later borns or, more compellingly, son preference manifesting through gendered resource allocation.

The male-preferring behaviors intersect with birth order through two key mechanisms. On the one hand, resource allocation is skewed by gender and birth order, with later-born males often receiving preferential investment. East Asian studies document that first-born females are traditionally expected to sacrifice education for paid work in their early life to support younger brothers' schooling (Chu et al. 2007; Zheng 2015). On the other hand, the son targeting fertility strategy creates systematic imbalances. Referred to in the literature as **differential stopping behaviors (DSBs)**, this strategy describes parental reproductive behavior where couples persistently pursue subsequent pregnancies conditional on offspring gender—the practice of continuing reproduction until a son is born. Such sex-selective fertility patterns, deeply rooted in patriarchal kinship systems and intensified by China's patrilineal traditions, create distinctive sibship structures. This strategy would result in girls concentrated in not only relatively larger families (sibling size effect) but also in earlier birth order than boys within the family (birth order effect), as theoretically suggested and empirically tested by Basu and De Jong (2010) across developing countries, including China. Consequently, females exhibit systematically earlier (smaller in number) birth orders on average. Given historically significant gender gaps in educational attainment in China (Yu and Su 2006; Wang et al. 2020), observed birth order effects may partially capture underlying discrimination against females, as parental gender-biased investment behavior occurs independently of birth order awareness. Therefore, rigorous analysis of birth order effects in China necessitates explicit control for sibling gender composition and sibling size. Furthermore, methodological limitations in prior studies—notably the insufficient use of sibling fixed-effect models to control for unobserved family heterogeneity and the inadequate adjustment for sibling size/gender confounds—may contribute to biased estimates of birth order effects.

This article introduces an alternative explanation: China's macro-level educational expansion during the latter half of the twentieth century significantly influences the educational attainments of later borns, obscuring the underlying negative birth order effects. Parallel to documented by Barclay (2018) in Sweden, where later-borns' longer education amidst twentieth-century expansion masked a persistent negative net birth order effect, this article posits that China's substantial educational growth similarly contributes to the observed positive correlation. The net disadvantage of later birth order may be obscured amid the overall increase in years of schooling. Later borns, entering the system during periods of greater access, benefit more from the expansion, creating a spurious positive association when years of schooling is compared. This reframes China not as a unique outlier, but as a case where powerful macro trends interact with birth order.

Characteristics of the Chinese Context

National trajectory of educational expansion

Analyzing within-family educational differences in China requires situating them within the nation's transformative educational development. China has experienced a profound educational expansion over the past 70 years, marked by dramatic increase in average years of schooling, significant narrowing of gender gaps in enrollment and attainment, and mass expansion of higher education (Hannum and Park 2007). The scale of change is stark: in 1949, urban illiteracy stood at approximately 80 percent, rising to near 95 percent in rural areas, with fewer than 20 percent of school-age children enrolled (Deng and Treiman 1997; Hannum 1999; Lu and Treiman 2008). Making universal basic education accessible became the paramount priority of national educational policy.

Early efforts focused on restoring the basic education system post-1949. The promulgation of the Provisional Regulations for Primary Schools (Draft) and Provisional Regulations for Secondary Schools (Draft) in 1952 standardized the pedagogical practices nationwide. By 1965, concerted policies focused on expanding basic education had successfully restored primary and secondary school networks (Hannum 1999; Tsang 2000), achieving an 85 percent enrollment rate. However, the Cultural Revolution from 1966 profoundly disrupted education development. Pathways for progression from middle school to high school and high school to university were almost destroyed, while university admissions basically ceased. This interruption in higher education expansion persisted until the inception of the Reform and Opening-up in 1978. Notwithstanding with the broader turmoil, policies aiming at promoting basic education for underserved groups in rural areas demonstrated relative effectiveness. As Hannum (1999) documented, enrollment rates increased significantly despite concerns about education quality. Numerous primary and especially secondary schools were established in rural areas and rendered financially affordable (Lu and Treiman 2008).

The post-1978 era witnessed education's prioritization, catalyzed by Deng Xiaoping's declaration that "science and technology as the first productive force" at the March 1978 National Conference on Science. This momentum culminated in the pivotal Compulsory Education Act in 1986. As Ministry of Education statistics illustrate, this legislative framework—supplemented by departmental implementation efforts—drove extraordinary progress: primary net enrollment rate surged from 20 percent (1949) to 99.95 percent (2018), whereas junior secondary gross enrollment rate (GER) leapt from 3 percent to 100.9 percent over the same period. Senior secondary enrollment exhibited similar dynamism, rising from 1.1 percent (1949) to 91.8 percent (2023). Higher education experienced transformative expansion post-1999, with the aim of popularization of higher education. The Ministry of Education's Action Plan for Educational Revitalisation Facing the twenty-first century (1999) targeted a 15 percent tertiary enrollment rate by 2010, leading to a rapid increase in higher education enrollments and significantly improved overall educational opportunities. Tertiary entrants increased from 1.08 million (1998) to 4.47 million (2004), reaching 10.42 million by 2023. Cumulatively, total higher education enrollment ballooned from 117,000 students (1949, GER: 0.26 percent) to 47.63 million (2023, GER: 60.2 percent), achieving massification.

China's non-linear educational progression necessitates historicized analysis of birth order effects. Within this dynamic context, recognizing how macro-level educational expansion mediates the relationship between birth order and intrafamilial disparities becomes essential. Crucially, this expansion manifests not as linear advancement but through distinct policy regimes characterizing key historical eras. The cohort analysis in subsequent sections demonstrates how shifting institutional architectures differentially moderate birth order effects across China's educational modernization timeline, revealing period-specific patterns obscured by aggregate approaches.

Family planning policy

The family planning policy, which significantly impacted sibling size and gender composition, continues to influence family dynamics and educational outcomes. Family planning policies in China can be broadly defined by the regulation of the birth quotas (Weng et al. 2019). The first phase of these policies lasted from 1949 to 1962, a period characterized by an absence of birth control. The second phase, from 1963 to 1970, was marked by limited birth control measures, involving only guidance and encouragement. However, implementation was rather ineffective and was interrupted by the onset of the Cultural Revolution in 1966. Consequently, China's population growth rate remained very high during this time. The third phase spanned from 1971 to 1979, when the government officially implemented birth control. These policies were effectively enforced in both urban and rural areas, resulting in a total fertility rate below 3, although the target for population growth was lower for urban (10‰) than for rural areas (15‰). Similar to the previous phase, the regulating policies primarily applied to individuals of Han ethnicity, though birth control services were made available in areas populated by non-Han people. In 1978, the principle of family planning was incorporated into the Constitution for the first time. The fourth phase extended from 1979 to 2013, during which the strict one-child policy was implemented, albeit with some exceptions. The strict one-child policy commenced in 1979 and was formally introduced in 1980. Its effective enforcement was ensured through comprehensive legal, economic, and administrative measures. Legally, more provisions concerning family planning were added to the amended Constitution of 1982, and China's Population and Family Planning Law came into effect in 2002. Due to significant resistance, particularly in rural areas where son preference was stronger, the policy was relaxed in 1982 and again in 1984. This relaxation permitted couples to have a second child if certain criteria were met, most notably if the first child was a daughter and the couple resided in a designated poor area. The fifth phase began in 2014 and continues to the present. In November 2013, couples in which at least one partner was an only child were permitted to have two children, rendering approximately 11 million couples eligible. Following this initial relaxation, the policy was further eased with the introduction of a universal two-child policy, allowing every couple to have two children effective on January 1, 2016. The two-child policy was implemented primarily to address the problem of population aging. Nevertheless, the birthrate continued to decline. Consequently, the family planning policy was further extended to a universal three-child policy in May 2021.

Within the analytic sample of this study, which encompasses individuals born between 1940 and 1985, those born between 1971 and 1985 were subject to birth control policies. This exposure potentially introduces selection bias. Under the strict one-child policy era, families with multiple children predominantly comprised two types: first, families meeting specific exceptional criteria (primarily rural families whose firstborn was a daughter); second, families actively violating the policy, typically characterized by greater financial capacity (to afford fines) and non-employment within state sectors (thus avoiding job-related penalties). It is possible that multi-sibling families emerging during this period differ in socioeconomic strata from those existing before the implementation of birth control policies due to this selection effect. However, beyond socioeconomic backgrounds, these families generally exhibit distinct behavioral traits, such as specific parenting styles and pronounced gender preferences. Regardless of the specific circumstances leading to multiple births, families opting for additional children under strict policy regulations overwhelmingly exhibit strong son preference. Policy violation results in gender-disproportionate birth order distributions, analogous to those arising from DSB. These families exhibit intensified son preference in their fertility decisions, with reinforced DSB persisting even through policy violation, leading to a male-dominated skew among later-born children. In such contexts, as argued earlier, observed birth order inequalities fundamentally mirror entrenched gender inequality: under the parental investment preference hypothesis, these families disproportionately invest resources toward sons, who often occupy later birth positions. Thus, controlling for gender preferences embedded within fertility decisions—an issue addressed later in this study using a newly designed index—could partially mitigate the sample bias induced by the policy. The reduction in sibling size facilitated by birth control represents another methodological concern, as it diminishes the extent of resource dilution among siblings. This study will apply statistical methods to control for the effects of both gender preference and sibling size. Furthermore, cohort analysis will facilitate better isolation of period-specific effects attributable to the policy regulations. By comparing results from periods before and after the implementation of significant policy regulations, the study can demonstrate the extent to which the policy itself is a significant factor. Critically, fertility decisions—encompassing both offspring quantity and gender composition—are inherently reflective of parental self-selection. The birth control

Table 1: Sample exclusion process.

Exclusion Criteria	N (Obs)	Excluded (Obs)	N (Sibling Groups)	Excluded (Sibling Groups)
Total sample	127,782		33,598	
Exclude only-child	124,388	3,394	30,204	3,394
Keep siblings with same biological parents	104,348	20,040	24,453	5,751
Keep siblings born in 1940-1985	81,551	22,797	18,838	5,615
Exclude multiple births	78,604	2,947	18,318	520
Limit mother's age at birth to [15,49]	56,944	21,660	13,829	4,489
No missing values for education	47,046	9,898	11,890	1,939
No missing hukou status or non-Chinese	46,996	50	11,879	11

policy primarily intensified and formalized pre-existing self-selection mechanisms rather than acting as a wholly exogenous shock.

Data and Methods

Data

Data sources and sample restriction

This study utilized the first wave of the CFPS conducted in 2010. The CFPS covers 25 provinces and is widely acknowledged as the most reliable and comprehensive longitudinal survey in China. For detailed information regarding sampling, interviewing, and quality assurances, refer to Xie and Hu (2014).

The 2010 CFPS first wave surveyed 14,960 households and collected personal information from 33,598 adult respondents. Specifically, respondents were asked to provide basic demographic information about all their siblings, regardless of whether these siblings were co-resident or alive at the interview date. This approach establishes precise sibling structures for each respondent, enabling the application of sibling fixed-effect models to analyze sibling variations. The original data set was restructured into a long-format panel containing every sibling nested in families as a single observation. This transformation yielded a final analytical sample of 127,782 observations nested in 33,598 sibling groups.

The analytical sample was constructed, as summarized in Table 1. As sibling fixed-effect models will be applied, all siblings within the family were excluded if any member of them did not meet the selection criteria.

First, only-child respondents (3,394 individuals) were excluded from the analytical sample for investigating birth order effects, though retained as a comparison group. Second, adopting definition from Barclay (2018) of sibling groups as children sharing the same biological mother and father, individuals not meeting this criterion were excluded. This included those with missing biological relationship information and step or half siblings. This exclusion ensures accurate birth order sequencing and sibling size calculation while avoiding potential confounding mechanisms in birth order effects that may differ in non-biological sibling relationships.

Table 2: Distribution of birth orders.

Birth Order	Full		Female		Male	
	N	%	N	%	N	%
Only-child	1,615		953		662	
1	11,879	25.28	6,089	25.94	5,790	24.62
2	11,879	25.28	5,900	25.14	5,979	25.42
3	9,558	20.34	4,707	20.05	4,851	20.62
4	6,675	14.20	3,304	14.08	3,371	14.33
5	3,998	8.51	1,945	8.29	2,053	8.73
6	1,923	4.09	996	4.24	927	3.94
7	756	1.61	357	1.52	399	1.70
8+	327	0.70	175	0.75	152	0.65
Total	46,996	100	23,473	100	23,522	100
Average birth order	2.78		2.76		2.79 ($p = 0.054$)	

[1]The average birth order is for the analytical multi-sibling sample.
[2]The p-value in parenthesis is the result of two-sample t-test for birth order by gender.

Third, respondents and their siblings were restricted to those aged 25−70 in 2010 (i.e., born 1940−1985). The lower age bound ensures near-complete educational attainment by the survey date[1], whereas the upper bound mitigates selection bias from differential mortality and ensures all respondents received formal education post-1949. Fourth, siblings from multiple births were excluded due to indeterminate birth order[2]. Fifth, individuals whose mothers were aged below 15 or above 49 at their birth were excluded. This aims to reduce the potential influence of genetic disadvantages associated with births outside the standard fertile age range. Finally, siblings with missing educational attainment data or missing/non-Chinese hukou status were excluded, retaining only Chinese citizens with complete documentation.

The final analytical sample comprises 11,879 sibling groups and 46,996 observations, with an average sibling group size of 3.96. For the only-child comparison group, identical exclusion criteria (age, maternal age at birth, and hukou status) were applied.

Table 2 shows the distribution of birth orders within the sample. The analytical sample exhibits a relatively balanced gender ratio, contrasting with the only-child sample's pronounced female skew. However, an examination of the gender distribution across different birth orders reveals a subtle yet significant pattern: males tend to have larger birth orders, while first borns demonstrate a higher probability of being female. This pattern serves as evidence for male-preferring fertility-stopping behaviors among Chinese parents: a factor potentially affecting birth order estimations.

Educational attainment

Years of schooling serves as the primary dependent variable in this study. To standardize educational levels, each qualification is assigned its corresponding ideal-typical years of schooling within the Chinese education system. The conversion scheme provided by the CFPS is employed, where illiteracy/semi-literacy corresponds to 0 years, primary school to 6 years, junior high school to 9 years, senior high school to 12 years, 3-year college to 15 years, bachelor's degree to 16 years, master's degree to 19 years, and doctoral degree to 23 years. This standardization ensures a consistent metric for assessing educational attainment across different levels.

Birth order and adjustments for sibling size and gender

Research on birth order effects conventionally employs absolute birth order as the primary variable of interest. However, a significant methodological challenge arises from the high correlation between absolute birth order and sibling size (Iacovou 2008). Children with earlier birth orders typically belong to smaller sibling groups, whereas those with later birth orders originate from larger families. Because sibling size exhibits its own dilution effects on educational attainment, this dependency potentially biases birth order effect estimates. Previous studies typically control for sibling size by including it as a separate covariate, though this approach fails to fully disentangle the two factors.

Introduced by Booth and Kee (2009), the ABOI effectively mitigates the bias introduced by sibling size and improves the accuracy of estimation. This study incorporates the ABOI to mitigate the sibling size bias. Let N_j denotes the sibling size of family (sibling group) j, n_{ij} denotes the absolute birth order of sibling i in family j, and A_j denotes the average absolute birth order in the family j, which is $(N_{j+1})/2$ by definition. The ABOI is defined as

$$ABOI_{ij} = \frac{n_{ij}}{A_j} = \frac{2n_{ij}}{N_j + 1}. \tag{1}$$

The ABOI applies a standardization of absolute birth order by deflating it by the average birth order within the family, hence establishing independence of birth order from sibling size. The average of ABOI within any sibling group is constant at 1, making the ABOI independent from sibling size. The correlation between ABOI and sibling size is reduced to 0.00 versus 0.51 for absolute birth order and sibling size (see Table 4).

Another methodological concern about absolute birth order is its potential endogeneity with gender composition due to the DSBs manifesting as male-preferring stopping strategy in China. To address this bias, I introduce the average within-family birth order (AWFBO) proposed by Basu and De Jong (2010)[3]. The AWFBO for each gender is defined as

$$AWFBO_j^{male} = \frac{1}{N_j^{male}} \sum_{i \in male\ in\ j} n_{ij} \tag{2}$$

$$AWFBO_j^{female} = \frac{1}{N_j^{female}} \sum_{i \in female\ in\ j} n_{ij}, \tag{3}$$

Table 3: Example of calculation of GABOI.

Absolute Birth Order	Gender	AWFBO	GABOI
1	Female	2.67	0.38
2	Male	3.50	0.57
3	Female	2.67	1.13
4	Female	2.67	1.50
5	Male	3.50	1.43

where $N_j^{male/female}$ denotes the number of males (or females, respectively) in family j and n_{ij} represents the absolute birth order for sibling i, regardless of gender. An example could better explain the calculation (see Table 3). For a sibling group with the birth order and gender composition of FMFFM (F refers to female, M refers to male, and the time order goes from left to right), the AWFBO for females would be $8/3 = (1+3+4)/3$, and the AWFBO for males would be $7/2 = (2+5)/2$. This metric effectively mitigates DSB-related bias in birth order estimation. Crucially, the AWFBO addresses gender composition distortions but does not account for sibling size effects, which require complementary adjustments as detailed previously.

To leverage the combined advantages of both the ABOI and the AWFBO, this study introduces the GABOI. The GABOI further refines birth order measurement by deflating absolute birth order with the AWFBO of gender groups within each family:

$$GABOI_{ij} = \begin{cases} \frac{n_{ij}}{AWFBO_j^{male}} = \frac{n_{ij}N_j^{male}}{\sum_{k \in male\ in\ j} n_{kj}} & i \in male \\ \frac{n_{ij}}{AWFBO_j^{female}} = \frac{n_{ij}N_j^{female}}{\sum_{k \in female\ in\ j} n_{kj}} & i \in female\ . \end{cases} \quad (4)$$

The strength of the GABOI lies in its property to maintain an average of 1 within each sibling group, ensuring its independence from both sibling size and gender structure. In the example above of a sibling group of FMFFM, the GABOI for the last-born male (1.43) is adjusted to be smaller than that of the female sibling with absolute birth order of 4 (1.50). This adjustment effectively neutralizes the gendered structure of birth order.

Table 4 shows that GABOI successfully reduces the correlation between birth order measurements and gender. It is crucial to note that AWFBO exclusively applies to mixed-gender families. Single-gender male families lack an AWFBO for females and single-gender female families lack an AWFBO for males. Consequently, GABOI is exclusively applicable for mixed-gender families. In analytical models employing GABOI, only mixed-gender families are considered . This constraint aligns analytically with sibling fixed-effect models, which naturally exclude single-gender families when estimating gender-related coefficients.

Specification of birth cohorts in China

This article examines cohort trends in birth order effects across China's educational development since the establishment of the People's Republic of China, spanning the latter half of the twentieth century. To effectively capture these trends, sibling

Table 4: Correlation between variables.

	Absolute Birth Order	ABOI	GABOI	Gender	Sibling Size
Absolute birth order	1				
ABOI	0.83†	1			
GABOI	0.73†	0.81†	1		
Gender, male = 1	0.01	0.04†	0	1	
Sibling size	0.51†	0	0	−0.04†	1
Years of schooling	0	0.09†	0.07†	0.16†	−0.16†

†: p<0.01. *: p<0.05.

groups are categorized into specific birth cohorts based on their mean year of birth. This approach maintains intact sibling groups during cohort assignment. The cohort delineation covers the period from 1940 to 1985, with four cohorts identified to represent distinct historical phases and educational policy contexts in China. These cohorts properly encapsulate different stages of China's educational policy evolution. Given that educational expansion cannot be fully characterized as a simple linear progression, cohort analysis aligned with educational policy transformations better demonstrates how expansion relates to birth order effects during distinct phases of this historical trajectory. Although finer distinctions would be preferable, the sample size is insufficient for more detailed cohort categorization, such as year-by-year analysis.

The first cohort, termed the "Early Republic Cohort," encompasses siblings born between 1940 and 1954. This cohort predominantly completed their education during the early years of the People's Republic and before the Cultural Revolution—a period marked by educational system restoration. The second cohort, referred to as the "Cultural Revolution Cohort," consists of siblings born between 1955 and 1964. Their educational journey unfolded during the tumultuous Cultural Revolution, characterized by educational policies emphasizing egalitarianism and the abolition of academic selectivity. The "Early Reform Cohort" comprises siblings born between 1965 and 1974. This cohort experienced their formative education during the initial stage of economic and educational reforms initiated in 1978. Marketization in both economic and educational spheres accompanied these reforms, strengthening the influence of family background on educational attainment. The final cohort, termed the "Late Reform Cohort," includes siblings born between 1975 and 1985. This group witnessed the full implementation of the 9-year compulsory education law in 1986 and benefited from expanded access to higher education during the late 1990s and early 2000s. Moreover, this cohort was entirely subjected to the strict one-child policy.

Table 5 presents the demographic characteristics of these distinct cohorts, revealing several noteworthy patterns. Educational attainment demonstrates a consistent upward trajectory across cohorts, reflecting the continuous expansion of educational opportunities over this historical period. Concurrently, the gender ratio exhibits a declining trend, potentially influenced by evolving societal dynamics including reduced fertility rates. The Early Republic Cohort (1940−1954), born

Table 5: Descriptive statistics of analytic sample across birth cohorts.

	Full	Early Republic	Cultural Revolution	Early Reform	Late Reform
Birth order	2.78	2.83	3.11	2.67	2.02
Sibling group size	4.54	4.66	5.19	4.34	3.03
Gender, male = 1	0.50	0.52	0.51	0.49	0.46
Age	45.41	58.78	49.75	40.75	31.86
Hukou, rural = 1	0.71	0.63	0.68	0.76	0.75
Mother's age when giving birth	27.87	29.16	28.86	27.12	25.79
Educational attainment					
Years of schooling	7.35	6.24	7.27	7.48	8.46
Primary	0.81	0.71	0.80	0.83	0.88
Junior high school	0.56	0.45	0.57	0.57	0.67
Senior high school	0.20	0.16	0.21	0.19	0.25
3-year college	0.06	0.04	0.04	0.07	0.12
Bachelor	0.03	0.02	0.02	0.03	0.05
Master's	0.00	0.00	0.00	0.00	0.00
Doctoral	0.00	0.00	0.00	0.00	0.00
Number of observations	46996	6333	16957	18298	5408

during wartime conditions, displays smaller average birth orders and sibling group sizes compared with the Cultural Revolution Cohort. This pattern likely stems from economic constraints affecting child-rearing capacity during this era, and potential sibling mortality resulting from wartime conditions. Conversely, the Cultural Revolution Cohort (1955−1964)—benefiting from post-war stability—displays the largest average birth orders and sibling group sizes within the study period. Subsequent cohorts show a progressive decline in average sibling size, influenced by the implementation of family planning policies. This trend culminates in the Late Reform Cohort (1975−1985), which exhibits the smallest sibling group sizes consistent with the strict enforcement of the one-child policy.

The average years of schooling show sustained increases across cohorts, mirroring educational expansion patterns. During the Early Republic Cohort period, the establishment of primary schools elevated average educational attainment to 6.24 years—equivalent to primary school completion. The Cultural Revolution Cohort experienced more substantial educational expansion, with average years of schooling increasing by approximately one year relative to the previous cohort. The Early Reform Cohort showed a comparatively modest increase, whereas the most significant educational improvements emerged in the Late Reform Cohort as the 1986 compulsory education policy yielded pronounced impacts.

Analytic Strategy

This study employs sibling fixed-effect regression to identify birth order effects through within-family comparisons of siblings sharing biological parents. This approach eliminates bias from all time-invariant family characteristics (observed and unobserved), crucially, including the sibling size. The estimated coefficients

(β) thus capture variations in educational attainment attributable to (1) birth-order-specific parental resource allocation, (2) biological endowment differences, and (3) cohort-specific contextual factors.

The baseline sibling fixed-effect model is specified as follows:

$$y_{ij} = \alpha_j + \beta_1 BirthOrder_{ij} + \beta_2 BirthYear_{ij} + \beta_3 Gender_{ij} + \varepsilon_{ij}, \tag{5}$$

where y_{ij} denotes the educational attainment of individual i in family (sibling group) j. Sibling fixed effects are captured by α_j. $BirthOrder_{ij}$ represents the absolute birth order for individual i. The inclusion of $BirthYear_{ij}$ controls for macro trends, enabling a comparison of birth order effects with and without accounting for the expansion of education.

To enhance the precision of estimation and disentangle birth order effects from sibling size and gender composition biases, two extended regression models introduce the ABOI and GABOI:

$$y_{ij} = \alpha_j + \beta_1 ABOI_{ij} + \beta_2 BirthYear_{ij} + \beta_3 Gender_{ij} + \varepsilon_{ij} \tag{6}$$

$$y_{ij} = \alpha_j + \beta_1 GABOI_{ij} + \beta_2 BirthYear_{ij} + \beta_3 Gender_{ij} + \varepsilon_{ij}. \tag{7}$$

Building on these regression models, the analyses are extended to explore birth order effects within specific birth cohorts, enabling a further examination of cohort trends. Inclusion of birth year and cohort analyses serves to discern whether the apparent positive birth order effects in China can be attributed to the broader development and expansion of education. Separate regressions for different genders delve into potential parental preferences for males, contributing to a comprehensive understanding of birth order effects in the Chinese context. Mixed-gender sibling groups will be considered for separate regressions for each gender, as single-gender sibling groups are automatically excluded by sibling fixed effects.

Results

Birth Order Effects, Educational Expansion, and Gender

Table 6 provides a comprehensive overview of average years of schooling by birth order and cohort in China. The table's organization facilitates explicit comparison of educational attainment across birth orders within discrete cohorts. Overall, educational attainment demonstrates relative stability across ascending birth orders, with birth orders 3 and 5 exhibiting the highest values. The data suggest a positive association between increasing birth order and educational attainment through birth orders $1-5$, beyond which later birth orders manifest negative effects.

Distinct cohort patterns emerge from the analysis. The Early Republic cohort displays a pronounced increasing trajectory in educational attainment with later birth orders. Conversely, both Early Reform and Late Reform cohorts demonstrate an inverse relationship between birth order and years of schooling. Critically, when statistically isolating the effects of continuous educational expansion, more pronounced negative birth order effects might be revealed in post-reform cohorts.

Table 6: Average years of schooling and gender ratio by birth order and cohort.

Birth Order	Full Sample		Early Republic		Cultural Revolution		Early Reform		Late Reform	
	YoS	GR	YoS	GR	YoS	GR	YoS	GR	YoS	GR
1	7.31	0.49	5.77	0.51	6.67	0.52	7.77	0.48	8.59	0.42
2	7.36	0.50	5.46	0.53	7.10	0.53	7.59	0.49	8.78	0.46
3	7.40	0.51	6.24	0.53	7.60	0.51	7.40	0.50	8.15	0.52
4	7.37	0.51	6.83	0.52	7.59	0.51	7.30	0.50	7.59	0.51
5	7.40	0.51	7.49	0.52	7.67	0.51	7.09	0.52	6.17	0.48
6	7.28	0.48	7.83	0.50	7.41	0.49	6.79	0.46	6.17	0.38
7	7.23	0.53	8.07	0.49	7.17	0.53	6.87	0.53	6.00	0.67
8+	6.91	0.46	7.23	0.46	6.86	0.46	7.09	0.46	2.00	0.67
Total	7.35	0.50	6.24	0.52	7.27	0.51	7.48	0.49	8.46	0.46

YoS represents the average years of schooling and GR represents the gender ratio (1 = male).

Results further document an imbalanced gender ratio across birth orders. Males progressively outnumber females as birth order increases (see Table 2), indicating that later-born children are disproportionately male. This finding substantiates the operational presence of DSB and illustrates how birth control policies intensified DSB-driven selection mechanisms, particularly among later cohorts.

Table 7 presents results derived from sibling fixed-effect models, dissecting the complex interplay of birth order, sibling size, gender, and educational expansion in China. These models, employing various birth order indices, provide insights into the multifaceted dynamics of birth order effects with families. Parallel analyses including birth year controls were conducted separately for each gender, with outcomes reported in models 3, 4, 7, 8, 11, and 12.

Preliminary specifications (models 1, 5, and 9) suggest seemingly positive birth order effects. However, introducing birth year controls in models 2, 6, and 10 fundamentally alters this pattern: positive birth order effects transform into negative effects, revealing potential upward bias in initial estimates. This shift indicates that educational expansion introduced systematic bias into birth order effect estimation. The increase in educational attainment attributable to educational expansion may have been erroneously attributed to birth order. Critically, this pattern persists following adjustments for sibling size and gender structure via the ABOI and GABOI.

Gender-stratified regressions reveal distinct patterns. For females, model 3 initially shows no significant birth order effects. However, employing ABOI to control for sibling size reveals negative birth order effects, indicating later-born females receive less education than earlier-born females. For males, negative birth order effects emerge upon controlling for birth year, signifying later-born males attain less education than their elder brothers. These results align with Western findings.

A noteworthy aspect lies in the gender-based distinctive patterns. Analysis of absolute birth order and ABOI reveals more pronounced negative birth order effects among males. However, the GABOI in models 11 and 12 introduces a counter-intuitive dynamic: stronger negative birth order effects for females. Designed to

Table 7: Results of sibling fixed-effect models on years of schooling (YoS).

	Absolute Birth Order			
	(1) Baseline	(2) Birth Year Adjusted	(3) Female	(4) Male
Birth order	0.27†	-0.12†	-0.03	-0.20†
	(0.01)	(0.03)	(0.05)	(0.05)
Birth year		0.12†	0.15†	0.10†
		(0.01)	(0.01)	(0.01)
Gender, male = 1	1.54†	1.54†		
	(0.03)	(0.03)		
Constant	5.82†	-234.80†	-287.05†	-179.63†
	(0.04)	(17.18)	(26.95)	(26.86)
Observations	46,995	46,995	23,473	23,522
R-squared	0.09	0.10	0.08	0.01
Number of groups	11,879	11,879	10,697	11,093
	Adjusted Birth Order Index (ABOI)			
	(5) Baseline	(6) Birth Year Adjusted	(7) Female	(8) Male
ABOI	0.78†	-0.58†	-0.53†	-0.65†
	(0.03)	(0.08)	(0.13)	(0.13)
Birth year		0.14†	0.19†	0.10†
		(0.01)	(0.01)	(0.01)
Gender, male = 1	1.54†	1.55†		
	(0.03)	(0.03)		
Constant	5.80†	-270.52†	-360.27†	-182.13†
	(0.04)	(15.82)	(25.04)	(24.82)
Observations	46,995	46,995	23,473	23,522
R-squared	0.09	0.10	0.08	0.01
Number of groups	11,879	11,879	10,697	11,093
	Gender-Adjusted Birth Order Index (GABOI)			
	(9) Baseline	(10) Birth Year Adjusted	(11) Female	(12) Male
GABOI	0.79†	-0.19†	-0.72†	-0.52†
	(0.04)	(0.06)	(0.12)	(0.14)
Birth year		0.10†	0.21†	0.08†
		(0.01)	(0.01)	(0.01)
Gender, male = 1	1.57†	1.54†		
	(0.03)	(0.03)		
Constant	5.71†	-195.41†	-400.38†	-154.87†
	(0.04)	(10.86)	(24.89)	(26.62)
Observations	41,399	41,399	21,224	20,175
R-squared	0.09	0.10	0.08	0.01
Number of groups	9,911	9,911	9,911	9,911

Robust standard errors in parentheses. †: p<0.01, *: p<0.05.

mitigate bias from gender-skewed fertility stopping rules preferring males, GABOI produces more accurate gender-specific birth order effect estimates. The influence of male-preferring stopping rules manifests in larger average birth orders and sibling sizes for males (Table 2). This structural imbalance obscures negative effects for females, who typically occupy earlier birth orders in smaller families. Although ABOI adjustment reveals adverse effects for females, GABOI further adjusts for gendered birth order structures, demonstrating that educational disparities between later-born females and their earlier-born sisters exceed those between later-born males and their earlier-born brothers.

Persistent birth order differences—remaining significant after accounting for educational expansion and potential male-preferring fertility behaviors via GABOI—provide substantial evidence for parental gender-preferred nurturing behaviors in China. Under gender-neutral parenting, birth order effects should be consistent across genders. Given females' systematically smaller birth orders resulting from son-preferring fertility behaviors, GABOI normalizes female birth order positions upward to align with male distribution, thereby better capturing the comparative disadvantage due to birth order experienced by females relative to males at equivalent positions. This resilience of birth order differentials suggests resource allocation reflecting son preference across or within generations. This finding partially aligns with Chu et al. (2007), suggesting females sacrifice education for male siblings' benefit. Moreover, it underscores that females derive greater advantages from educational expansion than males despite experiencing stronger intra-family birth order penalties. Even amid stronger negative effects for later-born sisters, women achieve higher average educational attainment than men in later cohorts. This counterintuitive outcome indicates females leverage educational opportunities more effectively from societal expansion, potentially due to evolving policies and attitudes favoring female education.

Insights from Cohort Analysis

Figure 1 shows birth order effects across cohorts using sibling fixed-effect models and three birth order measures: absolute birth order, ABOI, and GABOI. Plots in the left column (1, 3, and 5) present results without birth year controls, whereas right-column plots (2, 4, and 6) incorporate birth year to account for macro trends. This comparative framework highlights the substantial influence of educational expansion on birth order effect estimates.

Left-column plots initially suggest positive birth order effects across all cohorts. However, after controlling for birth year in right-column plots, these effects dissipate or become negative, demonstrating how educational expansion confounds birth order estimates. Consistent patterns emerge across all three birth order measures. Before accounting for macro trends, birth order effects appear more pronounced in the Early Republic and Cultural Revolution cohorts. The substantial attenuation of these effects following adjustment for educational expansion strongly suggests that expanded educational access primarily drives the higher achievement observed among later-born siblings, particularly during these two periods when basic education underwent rapid restoration.

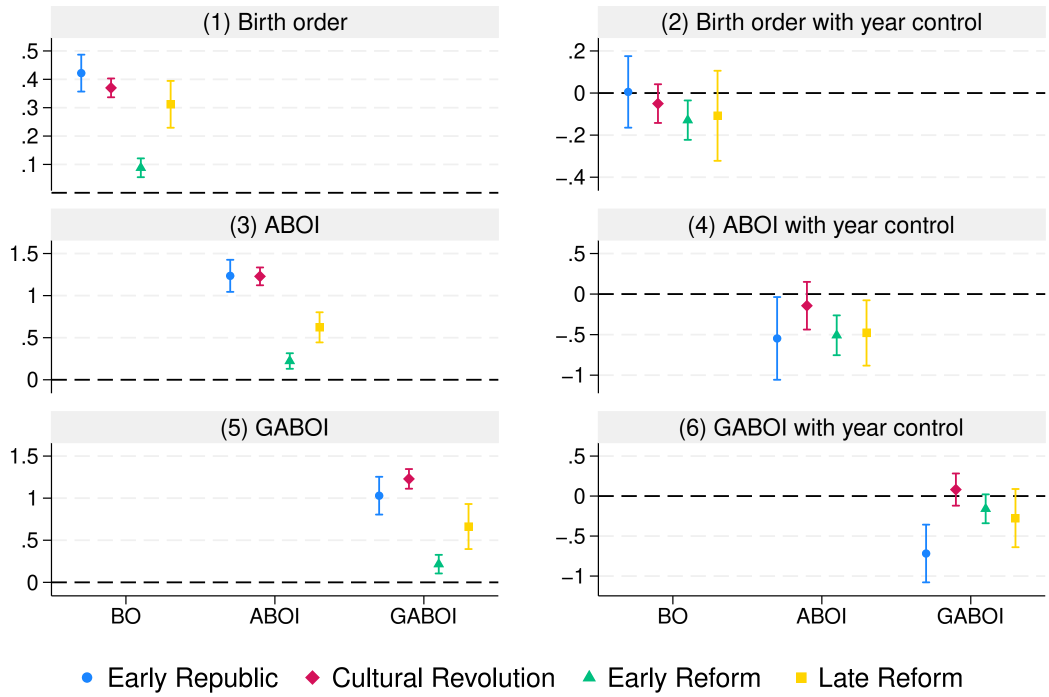

Figure 1: Birth order effects across cohorts.

Furthermore, plots (5) and (6) indicate that the high correlation between birth order and educational attainment may also be associated with sibling gender structures. Figure 2 examines gender-specific birth order effects through separate subsamples for each gender, incorporating birth year controls. After adjusting for educational expansion, significant positive birth order effects disappear. Notably, applying GABOI to correct for gendered birth order structures reveals stronger negative birth order effects for females, showing significant results in the Early Republic, Early Reform, and Late Reform cohorts (plot 5). Conversely, plot (6) demonstrates negative effects for males only in the Early Reform cohort. This aligns with Table 7 findings, confirming that negative birth order effects become more pronounced for females following gender-structure adjustments.

A critical methodological consideration involves birth control policy-induced selection bias, particularly influential for Early Reform and Late Reform cohorts. This bias likely amplifies observed positive birth order effects through two mechanisms: (1) systematic overrepresentation of males in later birth orders due to DSB and (2) reduced resource dilution through constrained sibling sizes. Both mechanisms are statistically controlled for in the models. Crucially, the attenuation or reversal of birth order effects upon controlling for educational expansion robustly demonstrates that apparent positive associations represent statistical artifacts rather than causal relationships. Foundational negative net birth order effects persist, with observed positive correlations attributable to confounding factors—particularly educational expansion and gendered fertility decisions within parenting strategies.

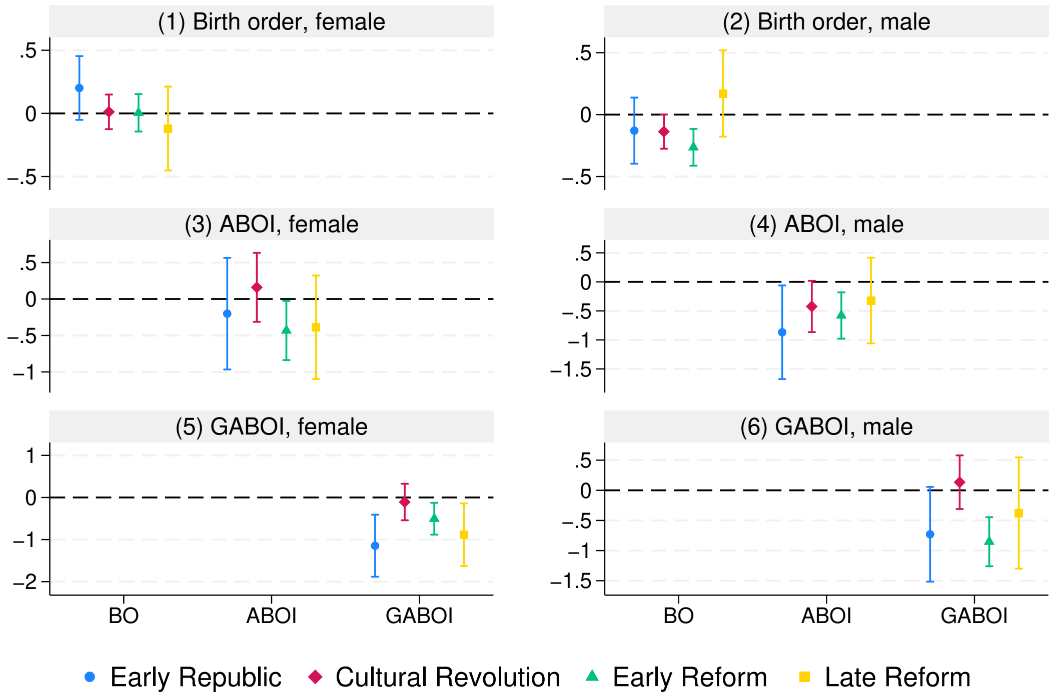

Figure 2: Gender differences in birth order effects across cohorts.

Moreover, Figures 1 and 2 collectively indicate null birth order effects for both genders during the Cultural Revolution cohort following birth year adjustment. Considering the class-based educational inequality was at a particularly low level during the Cultural Revolution (Deng and Treiman, 1997; Zhou et al., 1998), birth order differences also appear constrained after macro trend adjustment in this period. This may reflect relative stability in parental investment behaviors across siblings of different birth orders during this historical interval.

Evidence from Birth Interval

When examining how educational expansion influences birth order effects, the role of birth intervals calls for methodological consideration. Analysis of the relationship between birth intervals and educational attainment reveals operational mechanisms through which birth order impacts outcomes. Smaller birth intervals indicate siblings experience comparable family resource constraints and macro-social educational environments. Consequently, if parental preference exists for later-born children (no matter in what terms), such younger siblings with minimal birth spacing should demonstrate systematically higher educational attainment than their earlier-born counterparts. This framework implies that educational differences among narrowly spaced siblings more directly reflect birth order effects rather than external environmental factors. Conversely, siblings with larger birth intervals face divergent contexts: while potentially benefiting from parental wealth accumulation, they experience substantially different macro-conditions—particularly

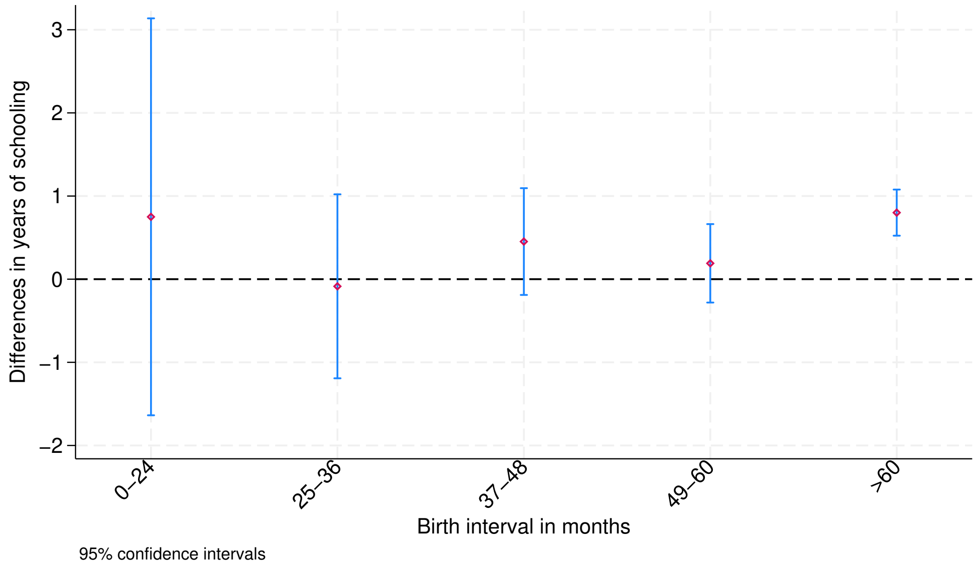

Figure 3: Differences in years of schooling for siblings with different birth intervals (two-sibling groups).

educational expansion and economic development—which disproportionately advantage later-born children through enhanced educational opportunities. Given that some research suggests birth intervals themselves lack direct causal effects on long-term outcomes (Barclay and Kolk, 2017), observed educational disparities may largely reflect educational expansion influences.

To isolate how educational expansion affects birth order differences, this study analyzes educational attainment gaps between last-born and first-born children within families. Figure 3 shows these differentials in two-sibling families[4]. Findings reveal no significant educational disparity among siblings born within 24-month intervals. Positive differences emerge exclusively among siblings separated by more than 60 months. This pattern persists in larger families (Fig. 4), where educational advantages for later-born children appear only when birth spacing exceeds five years. Crucially, families with limited birth intervals show minimal educational differences, whereas those with extended intervals demonstrate pronounced differentials. This pattern highlights how external social factors—particularly educational expansion—shape sibling educational disparities.

These results substantiate the conclusion that observed positive associations between later birth positions and educational attainment principally reflect macro-level factors inherent in educational expansion, rather than genuine birth order effects. The absence of educational advantages in narrowly spaced siblings—where environmental shifts carry less weight—further undermines explanations based on preferential parental investment favoring later-born children.

Discussions

Utilizing sibling fixed-effect models alongside the ABOI, GABOI, and cohort analysis, this study reveals a significant finding: net birth order effects in China become

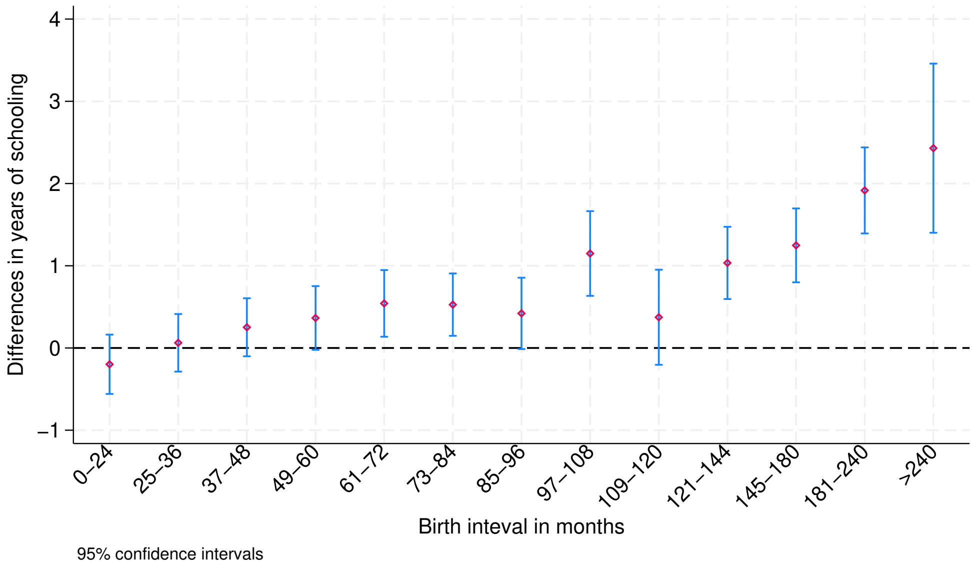

Figure 4: Differences in years of schooling for siblings with different birth intervals (all groups).

substantially negative when accounting for educational expansion and gendered sibling structures. This indicates that, contrary to earlier assumptions regarding Chinese birth order effects, later-born children tend to achieve lower educational attainment when birth order is the only factors accounted for. These findings align with theoretical frameworks and empirical patterns observed in Western contexts. Crucially, however, this study contradicts previously documented positive birth order effects in China. The primary contribution of this study lies in isolating net birth order effects from educational expansion, demonstrating that previously observed positive associations primarily reflected macro-level educational trends rather than distinct within-family behaviors favoring later births. Cohort analyses substantiate that across all four examined cohorts, the seemingly positive relationship between birth order and educational attainment diminishes or reverses upon controlling for macro trends. Furthermore, this study examines how sibling gender structures modulate birth order effects. It identifies gender-specific variations in these effects, particularly within contexts characterized by son-preferring fertility behaviors. After correcting gender-imbalanced birth order distributions through GABOI adjustment, results reveal stronger negative birth order effects among females. This suggests that, beyond gender preferences in fertility decisions, gender-biased parenting practices during offspring development place females at a comparative disadvantage in intra-familial resource allocation. The confluence of these factors positions females unfavorably within familial resource competitions. Additionally, birth interval analyses provide robust evidence for macro-social progress's positive impact on later-born siblings' educational attainment.

This study makes multifaceted contributions to existing literature. First, it presents a novel empirical case and methodological perspective for birth order research, illuminating how macro-level factors like educational expansion reshape sibling inequalities within micro-family contexts. The findings demonstrate that resource dilution theory (predicated on finite resources) and confluence theory (rooted in developmental psychology) remain applicable frameworks for explaining Chinese birth order effects. They also reaffirm the cross-cultural relevance of negative birth order effects documented in Western societies, indicating that China does not represent an outlier in this regard. However, interpretations of positive birth order correlations warrant caution given the substantial influence of educational expansion. This study's empirical demonstration of how educational expansion distorts birth order effects offers an example case for understanding macro-level impacts on intra-household inequalities. Historical processes appear instrumental in driving the evolution of such disparities. Further studies across developing economies experiencing educational advancement and complex family formations are expected.

Moreover, this study identifies the significant impact of gender on birth order effects, differentiating between two distinct mechanisms: gender-imbalanced birth order structures resulting from parental fertility decisions, and birth order effect variations arising from gender-biased nurturing practices. This gendered dimension distinguishes China's birth order pattern from Western contexts—a uniqueness that makes China an outlier in this sense. It contributes to a better understanding of family and gender culture in China and even other traditional East Asian countries, offering a reference for further research in this domain.

Methodologically, this study employs sibling fixed-effect models to rigorously control for shared family characteristics as much as possible. ABOI adjustments address potential bias from sibling size effects. Notably, this study innovatively accounts for son-preferring DSBs influence on sibling structures through GABOI—an original metric designed to neutralize gender composition biases in birth order effect estimation. This approach opens new avenues for gender-focused research. Additionally, the article highlights the analytical importance of birth spacing for future studies of Chinese sibling differences.

Despite these strengths, limitations merit consideration. Data constraints restricted measurement of educational expansion, necessitating future research to develop sibling-level indicators capturing regional educational development in fixed-effect models. More precise expansion metrics, alongside larger samples enabling year-by-year analyses, would address educational progression's non-linear nature. Furthermore, while this study does not directly measure intra-household investment strategies, alternative mechanisms call for exploration. For example, is there a compensatory strategy that generates the birth order differences? As the economic wealth of the family is inherited to the eldest, parents may decide some compensation in terms of better education opportunities to be given to children born later, resulting the later-born siblings have better education attainment. However, such explanations appear improbable given traditional Chinese emphases on educational attainment: even parents feel guilty for the younger siblings that most of the inheritance has been passed to the eldest and act compensatory for the younger siblings, it is not likely that they would sacrifice the eldest's education. Nevertheless, richer data sets are required to fully investigate this hypothesis.

In conclusion, this article underscores the complexity of Chinese birth order effects, demonstrating the necessity for nuanced analytical frameworks incorporating both macro-social trends and intra-familial gender dynamics. The observed association between later birth orders and higher educational attainment represents a multifaceted phenomenon involving educational expansion and gendered resource allocation. Future research should investigate specific mechanisms underlying birth order effects, accounting for evolving societal norms and parental behaviors.

Notes

1 In the final analytical sample, only 40 observations are still pursuing education.

2 Given the absence of direct survey questions regarding multiple births among siblings, identification relied upon birth year coincidence within sibling groups. This operational approach may yield oversight, as siblings born within the same calendar year could possess non-simultaneous birth timings. This methodological constraint necessitated positioning multiple birth exclusions after age restrictions in the sampling sequence.

3 See Basu and De Jong (2010) for a detailed mathematical proof and empirical evidence for how AWFBO captures the DSB in gender.

4 Sample size is 2,658 observations nested in 1,329 sibling groups after making sure all observations have specific birth months for calculation of birth interval.

References

Barclay, Kieron J. 2018. "The Birth Order Paradox: Sibling Differences in Educational Attainment." *Research in Social Stratification and Mobility* 54:56–65. https://doi.org/10.1016/j.rssm.2018.02.001

Barclay, Kieron J. and Martin Kolk. 2017. "The Long-Term Cognitive and Socioeconomic Consequences of Birth Intervals: A Within-Family Sibling Comparison Using Swedish Register Data." *Demography* 54:459–84. https://doi.org/10.1007/s13524-017-0550-x

Basu, Deepankar and Robert De Jong. 2010. "Son Targeting Fertility Behavior: Some Consequences and Determinants." *Demography* 47:521–36. https://doi.org/10.1353/dem.0.0110

Black, Sandra E., Paul J. Devereux, and Kjell G. Salvanes. 2005. "The More the Merrier? The Effect of Family Size and Birth Order on Children's Education." *The Quarterly Journal of Economics* 120:669–700. https://doi.org/10.1162/0033553053970179

Blake, Judith. 1981. "Family Size and the Quality of Children." *Demography* 18:421–42. https://doi.org/10.2307/2060941

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

Booth, Alison L. and Hiau Joo Kee. 2009. "Birth Order Matters: The Effect of Family Size and Birth Order on Educational Attainment." *Journal of Population Economics* 22:367–97. https://doi.org/10.1007/s00148-007-0181-4

Chu, C. Y. Cyrus, Yu Xie, and Ruoh-rong Yu. 2007. "Effects of Sibship Structure Revisited: Evidence from Intrafamily Resource Transfer in Taiwan." *Sociology of Education* 80:91–113. https://doi.org/10.1177/003804070708000201

Conley, Dalton. 2004. *The Peking Order: Which Sibling Succeed and Why*. New York: Pantheon.

Conley, Dalton, Kathryn M. Pfeiffer, and Melissa Velez. 2007. "Explaining Sibling Differences in Achievement and Behavioral Outcomes: The Importance of Within- and Between-Family Factors." *Social Science Research* 36:1087–104. https://doi.org/10.1016/j.ssresearch.2006.09.002

Deng, Zhong and Donald J. Treiman. 1997. "The Impact of the Cultural Revolution on Trends in Educational Attainment in the People's Republic of China." *American Journal of Sociology* 103:391–428. https://doi.org/10.1086/231212

Ernst, Cécile and Jules Angst. 1983. *Birth Order: Its Influence on Personality*. Berlin: Springer - Verlag. https://doi.org/10.1007/978-3-642-68399-2_4

Gini, Corrado. 1915. "Superiority of the Eldest: Investigation Among Professors in Italian Universities Shows that the First-born Are Most Frequent Among Them, While Children Born Late in the Generation Are the Rarest." *Journal of Heredity* 6:37–9. https://doi.org/10.1093/jhered/6.1.37

Grätz, Michael. 2018. "Competition in the Family: Inequality between Siblings and the Intergenerational Transmission of Educational Advantage." *Sociological Science* 5:246–69. https://doi.org/10.15195/v5.a11

Hannum, Emily. 1999. "Political Change and the Urban-Rural Gap in Basic Education in China, 1949-1990." *Comparative Education Review* 43:193–211. https://doi.org/10.1086/447554

Hannum, Emily and Albert Park. 2007. *Education and Reform in China*. London: Routledge.

Härkönen, Juho. 2014. "Birth Order Effects on Educational Attainment and Educational Transitions in West Germany." *European Sociological Review* 30:166–179. https://doi.org/10.1093/esr/jct027

Iacovou, Maria. 2008. "Family Size, Birth Order, and Educational Attainment." *Marriage and Family Review* 42:35–57. https://doi.org/10.1300/J002v42n03_03

Kantarevic, Jasmin and Stéphane Mechoulan. 2006. "Birth Order, Educational Attainment, and Earnings: An Investigation Using the PSID." *Journal of Human Resources* XLI:755–77. https://doi.org/10.3368/jhr.XLI.4.755

Lu, Yao and Donald J. Treiman. 2008. "The Effect of Sibship Size on Educational Attainment in China: Period Variations." *American Sociological Review* 73:813–34. https://doi.org/10.1177/000312240807300506

Luo, Kai and Li'An Zhou. 2010. "The Effects of Birth Order and Gender on Educational Human Capital: from the Perspective of Family Economics [in Chinese]." *Economic Science* 107–19.

Tao, Dongjie, Junpeng Wang, and Kezhong Zhang. 2017. "Family Size, Resource Budget and Distribution of Siblings' Education: Based on CFPS [in Chinese]." *Journal of Huazhong University of Science and Techonology (Social Science Edition)* 31:45–54.

Tsang, Mun C. 2000. "Education and National Development in China since 1949: Oscillating Policies and Enduring Dilemmas." *China Review* 579–618.

Wang, Weidong, Xiaohong Liu, Yongqing Dong, Yunli Bai, Shukun Wang, and Linxiu Zhang. 2020. "Son Preference, Eldest Son Preference, and Educational Attainment: Evidence from Chinese Families." *Journal of Family Issues* 41:636–66. https://doi.org/10.1177/0192513X19874091

Weng, Qian, Xia Gao, Haoran He, and Shi Li. 2019. "Family Size, Birth Order and Educational Attainment_ Evidence from China." *China Economic Review* 57:1–23. https://doi.org/10.1016/j.chieco.2019.101346

Xie, Yu and Jingwei Hu. 2014. "An Introduction to the China Family Panel Studies (CFPS)." *Chinese Sociological Review* 47:3–29.

Xiong, Feng, Leizhen Zang, Ling Zhou, and Fei Liu. 2020. "The Effect of Number of Siblings and Birth Order on Educational Attainment: Empirical Evidence from Chinese General Social Survey." *International Journal of Educational Development* 78:102270. https://doi.org/10.1016/j.ijedudev.2020.102270

Yu, Wei-hsin and Kuo-hsien Su. 2006. "Gender, Sibship Structure, and Educational Inequality in Taiwan: Son Preference Revisited." *Journal of Marriage and Family* 68:1057–68. https://doi.org/10.1111/j.1741-3737.2006.00313.x

Zajonc, R. B. 1976. "Family Configuration and Intelligence." *Science* 192:227–36. https://doi.org/10.1126/science.192.4236.227

Zajonc, R. B., Hazel Markus, and B. Gregory Markus. 1979. "The Birth Order Puzzle." *Journal of Personality and Social Psychology* 37:1325–41. https://doi.org/10.1037/0022-3514.37.8.1325

Zheng, Lei. 2015. "Sibling Sex Composition, Intrahousehold Resource Allocation, and Educational Attainment in China." *The Journal of Chinese Sociology* 2:2. https://doi.org/10.1186/s40711-015-0004-z

Zhou, Xueguang, Phyllis Moen, and Nancy Brandon Tuma. 1998. "Educational Stratification in Urban China: 1949-94." *Sociology of Education* 71:199. https://doi.org/10.2307/2673202

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