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Five-Year Plans and Adolescents' Cognitive Ability in China

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Article

Keywords: Five-Year Plan, Cognitive ability, Human capital

Posted Date: November 10th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11224150/v1

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Additional Declarations: No competing interests reported.

Abstract

This study investigates the impact of China's macroeconomic planning on adolescent cognitive development by comparing cohorts born under the Ninth Five-Year Plan (1996–2000) and the Tenth Five-Year Plan (2001–2005). Using data from the 2014–2015 wave of the China Education Panel Survey (CEPS), we employ OLS and instrumental variable estimations to identify the effects of policy environment shifts on adolescents' cognitive outcomes. The results show that adolescents born during the Tenth Five-Year Plan exhibit significantly higher cognitive scores than those born during the Ninth Five-Year Plan, indicating that generational changes in macro-institutional settings leave a clear imprint on individual development. Mediation analysis reveals that household economic status and maternal occupational type partly account for these differences, suggesting that improved family resources and greater maternal participation in non-agricultural occupations during the Tenth Five-Year Plan served as important indirect pathways. Furthermore, heterogeneity analysis demonstrates that the positive effects are more pronounced among adolescents with local hukou, while those with migrant hukou benefit less, underscoring the amplifying role of institutional stratification. These findings enrich the literature on macro policy and human capital formation and highlight the importance of sustained educational and labor market policies that improve household economic conditions, support women's occupational advancement, and reduce inequalities between local and migrant families.

1. Introduction

Since 1953, China's Five-Year Plans have served as the central strategic instrument for macroeconomic management and the allocation of social resources, and their evolution has profoundly shaped the developmental environment and life opportunities of successive generations. Adolescents, as the foundation of the nation's future, represent a critical group in this context: their physical and mental development—particularly their cognitive ability, constitutes not only a key indicator of social policy effectiveness but also a cornerstone of long-term human capital accumulation. The late 1990s and early 2000s marked a pivotal stage in China's transition from a planned economy to a socialist market economy. Within this period, the Ninth Five-Year Plan (1996–2000) and the Tenth Five-Year Plan (2001–2005) were implemented, yet they differed markedly in policy priorities, growth models, and welfare orientations. Specifically, the Ninth Plan unfolded amid complex domestic and international challenges, with emphasis on responding to the Asian financial crisis, deepening state-owned enterprise reforms, and advancing institutional restructuring. Economic growth during this period relied heavily on government-led investment and domestic demand, while the traditional welfare system collapsed and a new system had yet to take shape, generating substantial social dislocation. By contrast, the Tenth Plan coincided with China's accession to the WTO and a broader strategy of integration into the global economy. Growth dynamics shifted toward a dual engine of exports and investment, while "coordinated development" was introduced as a central theme, accompanied by the initial establishment of a social security system to buffer market risks. These profound macro-level transformations inevitably transmitted through micro-level family channels, exerting heterogeneous effects on adolescents during this critical stage of development.

Existing research has largely focused on the broader effects of macro-level policy reforms, while comparatively little attention has been paid to how successive Five-Year Plans have shaped individual educational opportunities and cognitive development through family and social environments. This gap is particularly salient during the critical transition between the Ninth and Tenth Five-Year Plans, a period marked by deepening economic reforms, accelerated changes in the education system, and the restructuring of the social security framework. These macro-level transformations not only altered household resource endowments and occupational structures but also intensified or, in some cases, mitigated urban–rural disparities in access to education. Against this backdrop, examining differences in adolescents' cognitive abilities across cohorts born under different Five-Year Plans provides valuable insights into the long-term mechanisms through which macro-institutions shape individual outcomes, while also offering a novel perspective on the intergenerational formation of human capital in the context of China's social transformation.

Drawing on data from the China Education Panel Survey (CEPS), this study provides an empirical analysis of differences in cognitive ability among adolescents born during the Ninth and Tenth Five-Year Plan periods. It further examines the mediating roles of household economic status and maternal occupational type, while also exploring the heterogeneity associated with local versus migrant household registration status. The contributions of this paper are threefold. First, it bridges the macro-level framework of the Five-Year Plans with the micro-level outcomes of individual cognitive ability, thereby extending our understanding of the relationship between macroeconomic policy and human capital formation. Second, it identifies the mediating mechanisms of household economic conditions and maternal occupational type, highlighting the role of socioeconomic status in the intergenerational transmission of advantage. Third, it investigates heterogeneity by household registration, underscoring the potential impact of institutional barriers on cognitive development. Taken together, these findings enrich the empirical literature on education and inequality in China and provide evidence to inform more targeted educational and social policies.

2. Literature review

A large body of research has shown that macroeconomic policies and institutional environments are not only instruments for resource allocation and growth management at the national level but also powerful forces in shaping social structures and individual developmental trajectories. Currie and Almond (2011) demonstrate that early life stages are highly sensitive to environmental shocks, and that public interventions in nutrition, health, and education can determine the long-term pathways of both cognitive and non-cognitive development. The development economics literature similarly emphasizes the critical role of institutional arrangements and public policies in the formation of human capital. Cunha and Heckman's (2007) "technology of skill formation" model further highlights that the interplay of early childhood environments, family investments, and public resources is both cumulative and dynamically complementary, with enduring effects on the development of cognitive and non-cognitive abilities.

Classic research in the sociology of education has likewise emphasized the interaction between public policy and family background. The Coleman Report (1966) was the first to demonstrate that educational outcomes are highly dependent on family background, and that access to state support directly shapes children's developmental opportunities. Subsequent studies have provided extensive evidence on the interplay between public education policies, welfare regimes, and family socioeconomic status (SES). For instance, Esping-Andersen (2009) shows that universalistic welfare systems in Western Europe have, to some extent, mitigated the disadvantages faced by children from low-income families in their cognitive development. Currie and Moretti (2003) find that improvements in maternal education significantly enhance the health and educational outcomes of the next generation, highlighting the combined effects of welfare and education policies. Similarly, Hoynes, Schanzenbach, and Almond (2016), using a quasi-experimental design of the U.S. Food Stamp Program, demonstrate that children from low-SES households experience substantial long-term gains in health and economic well-being. Aizer and Currie (2014) further show that maternal socioeconomic disadvantage is transmitted intergenerationally, but welfare programs can partially buffer these adverse effects.

Macroeconomic fluctuations have also been shown to exert profound effects on children's education and health. Thomas and Frankenberg (2000, 2001) find that during economic crises, household expenditures on education and healthcare decline, leading some children to drop out of school and resulting in deteriorated health and nutritional outcomes. Cameron's research(2001) further demonstrates that crises significantly increase the likelihood of child labor participation, thereby undermining educational attainment. The 2008 global financial crisis and the subsequent Great Recession provided additional evidence in this regard. Ananat et al. (2011) show that large-scale layoffs in the United States reduced eighth-grade students' math achievement, with spillover effects extending beyond directly affected families. Ruiz-Valenzuela (2020) documents that parental unemployment substantially lowered academic performance among students in Spain. Bradbury et al. (2013) reveal that foreclosure waves disrupted students' educational stability and achievement. Meanwhile, Schneider, Waldfogel, and Brooks-Gunn (2017), highlight adverse impacts on children's psychological well-being, showing that the recession was associated with increased behavioral problems as well as higher risks of child neglect and abuse.

In the Chinese context, macro-institutional transformations have likewise had profound implications for human capital formation. Brandt and Rawski (2008) argue that the reform and opening-up era spurred educational investment and upgraded the structure of human capital. Chen and Zhou (2007) document the long-term adverse effects of the Great Famine, offering a benchmark for understanding subsequent improvements in education and health following reform. Zhang et al. (2005) find that the expansion of compulsory education increased the returns to schooling for the urban labor force, while Park, Wang, and Wu (2002) show that regional poverty alleviation policies effectively promoted human capital accumulation. At the same time, international evidence provides important comparative insights into the long-term effects of policy interventions. Studies on the U.S. Head Start Program (Currie & Thomas, 1993; Deming, 2009) demonstrate its enduring benefits for children's educational and socioeconomic outcomes, and research on compulsory schooling laws (Angrist & Krueger, 1991; Oreopoulos, 2006)

identifies significant gains in years of education and labor market returns. Nevertheless, most existing studies focus on single policies or short-term shocks, while relatively little attention has been devoted to how China's distinctive, comprehensive, and long-term national strategies—such as the Five-Year Plans—systematically shape the developmental trajectories of an entire generation.

At the micro level, family socioeconomic status (SES) has long been recognized as a central determinant of children's and adolescents' cognitive development. The literature has primarily developed two theoretical frameworks. The first is the Family Investment Model (FIM), which emphasizes that higher-SES families can enhance children's academic performance through greater material investments such as books, tutoring, and nutrition (Bradley & Corwyn, 2002; Duncan & Magnuson, 2012). The second is the Family Stress Model (FSM), which posits that economic hardship increases parental psychological distress and negative parenting practices, thereby undermining child development (Conger et al., 1992; Conger & Donnellan, 2007). A large body of empirical research supports these mechanisms. For instance, Dahl and Lochner (2012) find that increases in household income improve children's academic achievement; Evans et al. (2010) show that the number of books in the home significantly predicts years of schooling; and Adolphus et al. (2013), in a systematic review, demonstrate that regular breakfast consumption is associated with improved attention and memory. Gibson-Davis and Percheski (2022) further highlight the independent role of household wealth in sustaining educational investment. Beyond income and wealth, parental occupational characteristics, particularly maternal employment, which represents another crucial dimension of SES. In addition to influencing household resources, maternal occupation shapes children's development through educational values, cognitive stimulation, time allocation, and job stability (Lareau, 2003; Guryan et al., 2008; Stevens & Schaller, 2011).

In addition, since its establishment in the 1950s, China's household registration (hukou) system has gradually evolved into a stratification mechanism that profoundly shapes individual life opportunities. Research consistently shows that the rural–urban hukou divide determines access to education, healthcare, and social welfare, and creates substantial inequalities in the labor market (Wang, 2005; Hannum & Wang, 2006.) In the field of education, migrant children have long faced disadvantages in terms of school access and social integration (Wang, L. 2008.; Goodburn, C. 2009.), while left-behind children experience additional risks to both academic performance and mental health. Even under the expansion of higher education and ongoing equity-oriented reforms, hukou-based stratification continues to undermine the effectiveness of educational reforms (Li, et al., 2015).

Overall, although the existing literature has produced a substantial body of findings, several important gaps remain. At the conceptual level, most studies tend to treat macro-level policies and micro-level family factors in isolation, lacking a systematic analytical framework that integrates national economic planning as a top-level design with household-level mediating mechanisms. At the mechanistic level, there is limited empirical evidence on the specific pathways through which macro policies shape individual development, such as changes in maternal occupational status—with much of the existing work remaining largely theoretical, leaving the mediating processes a "black box". At the heterogeneity

level, insufficient attention has been paid to the stratifying role of institutional identities such as hukou status, making it difficult to capture the full picture of policy effects.

Building on these gaps, this study seeks to make several contributions. First, by comparing adolescents born during the Ninth and Tenth Five-Year Plan periods, it places national economic planning at the core of the analysis and systematically examines its impact on cognitive development. Second, at the mechanistic level, it investigates the mediating roles of household economic conditions and maternal occupational status. Third, at the heterogeneity level, it explores how hukou-based identity differences shape the distributional effects of policy. Taken together, the study aims to construct a transmission chain linking macro-level policy, family environment, and individual development, thereby providing new empirical evidence from China's transitional era.

3. Hypotheses development

Since 1953, China's Five-Year Plans have served as a central instrument of macroeconomic management and resource allocation. Across different stages, these plans have exhibited notable variation in development strategies, educational investment, and social welfare policies. Such differences have not only shaped the broader socioeconomic environment but also profoundly influenced individuals' developmental contexts and life opportunities. For adolescents in particular, cognitive development is highly contingent on the availability of educational resources, the surrounding social environment, and the degree of policy support during their formative years. The Ninth and Tenth Five-Year Plans correspond to distinct phases of China's development trajectory, with divergent orientations in education and social policy that may have systematically shaped adolescent cognitive outcomes.

Hypothesis H1

Adolescents born under different Five-Year Plans exhibit significant differences in cognitive ability.

Household economic conditions have long been recognized as a crucial mechanism shaping children's cognitive development. According to the Family Investment Model, economically advantaged families are able to provide their children with enriched developmental resources, such as access to higher-quality schools, extracurricular tutoring, educational materials, nutritious diets, and a culturally stimulating environment, all of which directly enhance cognitive ability. In contrast, the Family Stress Model suggests that financial hardship can intensify parental stress and anxiety, diminish educational expectations and emotional engagement, and potentially lead to harsher or more neglectful parenting styles, thereby indirectly constraining children's cognitive growth.Within the Chinese institutional context, household economic status is deeply influenced by national macroeconomic strategies and policy orientations. The disparities across different Five-Year Plan periods, such as variations in economic growth rates, industrial restructuring, job creation, and welfare provision, shaped household income levels and financial security, thus affecting parental capacity to invest in children's education and development. For instance, during the Ninth Five-Year Plan, China was undergoing accelerated

industrialization and market reforms, with rapid growth but widening income inequality, which limited educational investment for certain families. By contrast, the Tenth Five-Year Plan placed greater emphasis on social welfare and educational equity, thereby enabling households to increase spending on education, nutrition, and cultural resources for their children.Consequently, the policy environment of each Five-Year Plan shaped adolescents' developmental opportunities through its impact on household economic conditions. This macro–micro transmission mechanism underscores that the effect of Five-Year Plan periods on cognitive outcomes is not only direct but also operates indirectly through changes in family economic resources. Based on this reasoning, we propose:

Hypothesis H2

the influence of different Five-Year Plan periods on adolescents' cognitive ability is partly mediated by household economic conditions.

Mothers play a unique and central role in family education and child development. Their occupational type not only serves as an indicator of the family's socioeconomic status but also directly shapes maternal time allocation, educational beliefs, and the level of support provided for children's learning. From a resource and status perspective, mothers engaged in high-skilled or high-status occupations typically enjoy more stable incomes and broader social capital networks. These advantages enhance families' capacity to invest in education and allow for the transmission of greater cultural capital, thereby fostering children's cognitive development. From a time allocation and parenting perspective, the stability and autonomy associated with different occupations determine the extent of mothers' involvement in their children's learning and emotional support. Mothers in more autonomous or flexible occupations can more effectively balance work and family responsibilities, devoting additional energy to childrearing. From a cognitive stimulation and educational expectation perspective, occupational type shapes the knowledge environment and social networks mothers are embedded in, as well as their expectations for their children's education. For instance, mothers in higher-status positions may emphasize independent learning and creativity, offering richer cognitive stimulation to their children.Within the specific institutional and historical context of China, maternal occupational types have been closely linked to macroeconomic policies. During the Ninth Five-Year Plan, the labor market was still undergoing rapid industrialization and market-oriented reforms, with relatively limited employment opportunities for women and pronounced occupational divides across regions and sectors. By the Tenth Five-Year Plan, however, the expansion of the service sector and the rise in female educational attainment had significantly increased women's employment opportunities, enabling more mothers to enter non-agricultural and skill-intensive occupations. This macro-level transformation implies that adolescents born in different Five-Year Plan periods were systematically exposed to different maternal occupational environments, which in turn affected their cognitive development through income, educational beliefs, and parenting practices.In sum, differences in labor market opportunities and occupational structures across Five-Year Plan periods are expected to influence adolescents' cognitive outcomes through the mediating role of mothers' occupational types. Based on this theoretical logic and contextual background, we propose:

Hypothesis H3

the influence of different Five-Year Plan periods on adolescents' cognitive ability is partly mediated by mothers' occupational types.

China's household registration system (hukou) has long functioned as a stratification mechanism, shaping disparities in access to education, employment, healthcare, and social welfare between urban and rural residents, as well as between local and migrant populations. Adolescents with local hukou are generally able to secure access to higher-quality schools, public services, and broader social support networks. In contrast, migrant adolescents often encounter significant barriers due to their mobile status, including restricted access to educational opportunities, obstacles in school enrollment, limited social integration, and heightened psychological stress. These structural disadvantages accumulate over time and may hinder cognitive development.The extent of these disparities is not static but has been shaped by the macro-policy environment of different Five-Year Plan periods. During the Ninth Five-Year Plan, educational investment and social welfare systems were still in their early stages, and hukou status exerted a strong influence on the distribution of educational resources, leaving migrant adolescents at a relative disadvantage. By the Tenth Five-Year Plan, however, the government placed greater emphasis on educational equity, social protection, and urban–rural integration. Policy reforms in some regions expanded access to schooling and welfare benefits for the children of migrant families, thereby potentially narrowing the cognitive development gap between local and migrant adolescents.Thus, differences in the policy orientations of successive Five-Year Plans may not only directly influence the overall developmental environment but also interact with hukou-based stratification to either amplify or reduce inequalities in cognitive outcomes. This suggests that the intergenerational effects of macroeconomic and social policies are mediated by the institutional framework of the hukou system, resulting in heterogeneous impacts across different groups.Based on this reasoning, we propose :

Hypothesis H4

the influence of different Five-Year Plan periods on adolescents' cognitive ability varies by hukou status, with local adolescents benefiting more than their migrant counterparts.

4. Research design

4.1. Data source

This study draws on data from the 2014–2015 wave of the China Education Panel Survey (CEPS), a nationally representative, large-scale longitudinal survey administered by the Institute of Social Science Survey at Peking University. The dataset provides detailed information on students' cognitive test results, family background, parental education and occupation, and hukou status, making it highly suitable for the present research design. Although China's education system regularly conducts surveys and statistics, publicly available micro-level data remain limited. For junior high school students, the most recent publicly released dataset is the 2014–2015 CEPS wave. Importantly, while the dataset does not

disclose detailed regional identifiers, it provides macro-level descriptions across urban and rural areas, as well as different types of schools and communities. The cognitive test in CEPS is primarily designed to assess students' problem-solving and comprehensive analytical abilities, rather than subject-specific academic achievement.The 2014–2015 baseline survey covered first-year (Grade 7) and third-year (Grade 9) junior high school students. Based on stratified sampling using indicators such as the average education level of the population and the proportion of the floating population, 28 county-level units (counties, districts, and cities) were randomly selected nationwide. Within these units, 112 schools and 438 classes were sampled, where students completed questionnaires alongside comprehensive cognitive and personality assessments. CEPS thus provides rich micro-level data at the individual, family, and school levels, offering valuable resources for empirical research and policy evaluation in the field of education.

4.2. Main variables

4.2.1 Cognitive ability

The explained variable used in this paper is a comprehensive analytical ability, measured by scores (0–35). Standardized cognitive ability values are available in the survey database. The student's cognitive ability is measured by a set of approved cognitive ability test questions that do not address specific memorization knowledge taught in the school curriculum but instead measure the student's logical thinking and problem-solving skills. And it has the characteristics of international comparability and national standardization. By standardizing the raw scores obtained from the student's cognitive ability test, we can use the score to measure the comprehensive analytical ability. The higher the score, the stronger the comprehensive analysis ability and the higher the cognitive ability.

4.2.2. Plan

The core independent variable in this study is the Five-Year Plan period. Based on respondents' year of birth, the sample is divided into two cohorts: the Ninth Five-Year Plan group (born 1996–2000) and the Tenth Five-Year Plan group (born 2001–2005). For empirical analysis, a binary variable Plan is constructed, coded as 0 for individuals born during 1996–2000 and 1 for those born during 2001–2005. This classification follows the official timeframes of the national Five-Year Plans and captures differences in the macro-policy environment shaping adolescents' developmental contexts.

4.2.3. Household economic status

In this study, a composite indicator of household economic status is constructed based on multiple survey items in the CEPS database that capture household material resources. Specifically, we use variables such as "whether the student has a private desk," "the number of books at home," and "whether the household has a computer and internet access." These variables are standardized (0-1normalization) and aggregated to form a composite index. This measure provides a more comprehensive reflection of a household's overall economic capacity in terms of the learning environment and the provision of educational resources. Compared with single income measures or subjective self-assessments, it better

captures the actual influence of household economic conditions on adolescents' developmental contexts.

For the robustness check of the mediating role of household economic status, we further employ an alternative measure (economic1), which is based on students' subjective evaluation of their family's economic situation (1 = "very difficult," 5 = "very affluent").

4.2.4. Maternal occupational type

Based on the occupational codes for mothers provided in the CEPS questionnaire (categories 1–14), this study constructs four occupational groups to capture how different socioeconomic positions and job attributes may affect adolescents' cognitive outcomes. The classification is as follows:

White-collar (codes 1–6): Includes government officials, employees in public institutions and enterprises, scientists, teachers, doctors, lawyers, accountants, programmers, and general office staff.

Blue-collar (codes 7, 8, 9, 11): Includes commercial and service workers, technical workers, ordinary laborers, and elementary workers. These occupations are primarily characterized by manual or skill-based labor, typically associated with moderate income levels and limited stability or capacity for investment in children's education.

Agriculture, forestry, animal husbandry, fishery, and water conservancy (code 10): Includes farmers, herders, and fishers engaged in primary-sector occupations.

Other occupations (codes 12–14): Includes self-employed individuals, freelancers, retired or laid-off/unemployed workers, and other occupations not otherwise classified.

For regression analysis, the agriculture/forestry/fishery group serves as the reference category, while in robustness checks, the white-collar group is used as the reference category.

4.2.5. Control variables

This study draws on relevant literature in health and labor economics to control for factors that may influence individual cognitive ability (Guo et al., 2024;Ye, C et al.2025). A close link exists between cognitive endowment and the family environment; therefore, the first set of control variables pertains to family background. Parental education levels are converted into years of schooling based on CEPS survey questions regarding the highest educational attainment of the mother and father: primary school or below (6 years), junior high school (9 years), senior high school/vocational school (12 years), junior college (15 years), bachelor's degree (16 years), and postgraduate or above (19 years). This transformation retains the ordinal information of educational attainment while allowing the variable to be treated as continuous in regression models.

To test Hypothesis 2, we also include measures of physical and mental health. Physical health is assessed using self-rated health status, with five response options: "very poor," "moderately poor,"

“average,” “fairly good,” and “very good,” coded from 5 to 1, respectively. Non-cognitive ability is measured using four survey items. Two items capture social withdrawal: “I sit alone a lot and don’t want to be around other people” and “I don’t often talk when I am with my classmates or peers.” Responses are coded as 4 (“strongly agree”), 3 (“agree”), 2 (“disagree”), and 1 (“strongly disagree”). Two items capture emotional stability and confidence: “I can stay calm even when things are bad” and “I am usually confident about the tasks that need to be done.” Responses are coded in reverse order: 1 (“strongly agree”), 2 (“agree”), 3 (“disagree”), and 4 (“strongly disagree”). Scores from all four items are summed to yield a scale ranging from 4 to 16, where higher values indicate weaker non-cognitive ability.

Finally, gender is included as a binary control variable (Male), coded 1 for male students and 0 for female students. In the regression models, females serve as the reference group, and the coefficient reflects the average difference in cognitive ability between males and females.

4.3. Empirical approach

This paper takes plan as the main explanatory variable to examine differences in adolescents’ cognitive ability between different Five-Year Plan periods, and to clarify the mechanism behind the influence: whether differences in adolescents’ cognitive ability across different Five-Year Plan periods are explained by family economic conditions and mother’s job, or directly by the planning periods; We can not intuitively understand its transmission mechanism, so we need empirical analysis. Using the human observation unit, we set the ordinary least square model:

$$\mathrm{Cognitiveability_i} = \beta_0 + \beta_1 \bullet \mathrm{Plan_i} + \beta_2 Control_i + \epsilon_i$$

1

In Eq. (1), i stands for each individual, stands for the student i’s cognitive ability measured by test scores. $\mathrm{Plan_i}$ is a dummy for the Five-Year Plan period (Ninth Plan = 0, Tenth Plan = 1), and its coefficient captures the cognitive differences between adolescents born in different periods; $Control_i$denotes a vector of control variables, including gender (male), mother’s years of schooling, father’s years of schooling, adolescent health status, and non-cognitive ability. $\epsilon_i$is the random error term. The model is estimated using ordinary least squares (OLS), with clustered robust standard errors at the school level to account for intra-school correlation.

5. Empirical analysis

5.1. Baseline results

Table 1 reports the descriptive statistics of the main variables used in the analysis. The total sample consists of 8,046 students, of whom approximately 47.18% were born during the Ninth Five-Year Plan period and 52.82% during the Tenth Five-Year Plan period, indicating a relatively balanced sample across cohorts and thus allowing for meaningful comparison. With respect to gender, females account for 51.14% and males for 48.86%, suggesting a roughly even gender distribution.For continuous variables,

the average score on the cognitive ability test (cogscores) is 23.22 with a standard deviation of 6.64, ranging from 0 to 35, indicating substantial variation in adolescents' cognitive performance. The average years of schooling for fathers and mothers are 10.53 and 9.93 years, respectively, with standard deviations of 3.18 and 3.54, reflecting considerable heterogeneity in parental educational backgrounds. The health variable (health), measured on a scale from 1 to 5, has a mean of 2.12 and a standard deviation of 0.93, suggesting that most students rate their health at a slightly below-average level. The non-cognitive ability variable (ncog) has a mean of 7.90, a standard deviation of 2.27, and ranges from 1 to 16, pointing to notable individual differences in non-cognitive skills.

Table 1
a Descriptive Statistics

VarName	Obs	Min	Median	Mean	Max	SD
cogscores	8046	0	24	23.2	35	6.6
faedu_yrs	8046	0	9	10.5	19	3.2
maedu_yrs	8046	0	9	9.9	19	3.5
health	8046	1	2	2.1	5	0.9
ncog	8046	1	8	7.9	16	2.3

Table 1
b Distribution of Five-Year Plan

Plan = 0	Obs	pct
	3796	**47.18**
Plan = 1	4250	52.82
Total	8046	100.00

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Plan = 0	Obs	pct
	3796	**47.18**
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[Table 1a **b c]**

Table 2 presents the main results. Model (1), which includes only the birth-period indicator without additional controls, shows that adolescents born during the Tenth Five-Year Plan scored on average 2.71

points higher on the cognitive test compared to those born during the Ninth Five-Year Plan. This positive effect remains robust and statistically significant after sequentially adding controls for gender, parental education, health status, and non-cognitive ability, indicating that adolescents born under the Tenth Plan consistently outperformed their Ninth Plan counterparts. Notably, parental education emerges as a significant determinant of adolescents' cognitive ability. Higher levels of parental schooling likely reflect greater knowledge reserves, stronger educational values, and a higher capacity for household educational investment, all of which contribute to providing learning resources and fostering an academically supportive environment that enhances children's cognitive development.

Table 2
Effects of Plan on cogscores

	(1)	(2)	(3)	(4)	(5)
	cogscores	**cogscores**	**cogscores**	**cogscores**	**cogscores**
plan	2.710***	2.725***	2.065***	2.063***	2.063***
	(0.239)	(0.241)	(0.220)	(0.219)	(0.219)
male		0.176	0.175	0.168	0.168
		(0.159)	(0.163)	(0.164)	(0.164)
Faedu_years			0.298***	0.298***	0.298***
			(0.039)	(0.039)	(0.039)
Maedu_years			0.191***	0.190***	0.190***
			(0.045)	(0.045)	(0.045)
health				-0.068	-0.070
				(0.095)	(0.095)
ncog					0.003
					(0.044)
Constant	21.792***	21.699***	17.010***	17.175***	17.156***
	(0.336)	(0.348)	(0.598)	(0.593)	(0.638)
Observations	8046	8046	8046	8046	8046
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses.					

[Table 2]

5.2. Robustness checks

Although Table 2 indicates significant differences in cognitive ability across cohorts born under different Five-Year Plans, these estimates may be biased due to potential endogeneity. Specifically, omitted variables–such as unobserved family characteristics, school quality, or community-level factors–could simultaneously affect both the policy environment in which individuals were born and their subsequent cognitive outcomes. If such confounding factors are not adequately controlled, the observed associations may not reflect true causal effects but rather spurious correlations. To address this concern, this study employs an instrumental variables (IV) strategy. By introducing external instruments that are correlated with the Five-Year Plan period but plausibly exogenous to adolescents' cognitive outcomes, the IV approach helps to mitigate endogeneity bias and strengthen the credibility of the causal inference.The first stage model of the tool variable is set as follows: u_i is the residual.

$$\mathrm{Plan_i} = \beta_0 + \beta_1 \bullet \mathrm{Children_i} + \beta_2 Control_i + u_i$$

2

The instrumental variable regression results reported in Table 3 show that when using the number of children in the household as an instrument, adolescents born during the Tenth Five-Year Plan still exhibit significantly higher cognitive ability than those born during the Ninth Five-Year Plan. The first-stage results confirm that the number of children is strongly correlated with birth period, with an F-statistic of 31.2, thereby satisfying the relevance condition for instrumental variables. In line with the theoretical context, this study argues that, under the constraints of China's family planning policy, household fertility primarily influences the timing of birth, supporting the validity of the number of children as an instrument.

Table 3
Robustness check using instrumental variables

VARIABLES	(1)	(2)
	plan	cogscores
children	-0.0528***	
	(-5.5921)	
male	-0.0879***	0.8154**
	(-8.4011)	(2.5181)
Faedu_years	0.0140***	0.1742**
	(5.5337)	(2.5556)
Maedu_years	0.0158***	0.0334
	(5.1229)	(0.4913)
health	-0.0050	-0.0175
	(-0.7729)	(-0.1616)
ncog	-0.0041	0.0352
	(-1.6500)	(0.8524)
plan		10.0458***
		(3.0458)
Constant	0.3983***	15.1122***
	(7.3763)	(12.2997)
Observations	8,046	8,046
R-squared	0.063	
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses.		

It is important to note that when using the number of children as an instrument, a potential concern arises: larger sibship size may directly affect educational investment and cognitive development through the “resource dilution effect,” thereby violating the exclusion restriction. To mitigate this issue, two strategies are adopted. First, the regressions control for key family background variables, including parental education, individual health status, and non-cognitive ability, in order to isolate the direct effects of family resources and educational capital. Second, within the institutional context of China’s family planning policy, the number of children was to a large extent shaped by external policy constraints rather than purely by household preferences. As such, fertility in this setting primarily reflects policy-induced variation rather than endogenous family choices, enhancing the plausibility of its exogeneity. In other

words, the number of children in this study is interpreted as capturing differences in fertility imposed by policy, rather than reflecting households' intrinsic resource allocation preferences.

To further assess the robustness of the instrument, an additional estimation was conducted by narrowing the sample window to individuals born around the policy cutoff years 2000–2001. As reported in Table 4, the positive effect of being born during the Tenth Five-Year Plan on cognitive ability remains statistically significant and consistent in direction across different bandwidths, providing strong support for the robustness of the findings.

Table 4
Robustness check using instrumental variables.

VARIABLES	**(1)**	**(2)**
	plan	**cogscores**
children	-0.0417***	
	(-4.4372)	
male	-0.0744***	0.7719**
	(-6.8363)	(2.1325)
Faedu_years	0.0128***	0.1612**
	(4.6831)	(2.0000)
Maedu_years	0.0113***	0.0862
	(3.7337)	(1.3522)
health	-0.0010	0.0188
	(-0.1483)	(0.1667)
ncog	-0.0052**	0.0337
	(-2.0808)	(0.7184)
plan		10.1168**
		(2.2849)
Constant	0.4569***	14.5219***
	(8.9387)	(7.8964)
Observations	7,278	7,278
R-squared	0.039	
*** p < 0.01, ** p < 0.05, * p < 0.1.Standard errors in parentheses.		

[Table 3]

[Table 4]

6. Further analysis

6.1 Mechanism tests

Table 5 reports the regression results examining household economic status as a mediating variable. Model (1) shows that birth period (Plan) has a significantly positive effect on adolescents' cognitive ability, consistent with the baseline regression. In Model (2), being born during the Tenth Five-Year Plan significantly improves household economic status, suggesting that differences in macro-policy environments across periods indeed shaped children's developmental contexts by improving family economic conditions. In Model (3), when both household economic status and birth period are included simultaneously, the coefficient of birth period declines slightly from 2.06 in Model (1) to 1.93, though it remains significant at the 1% level. This indicates that household economic status plays a partial mediating role: adolescents born during the Tenth Five-Year Plan exhibit higher cognitive ability in part because their families experienced improved economic conditions during this period. Taken together, these mechanism analyses support Hypothesis 2, that policy differences across Five-Year Plan periods indirectly promoted cognitive development through enhanced household economic status.

Table 5
Mechanisms-the effects of household economic status

VARIABLES	(1)	(2)	(3)
	cogscores	household economic status	cogscores
household economic status			3.5002***
			(5.0429)
plan	2.0633***	0.0372***	1.9332***
	(9.4325)	(5.8952)	(9.1599)
male	0.1679	-0.0178***	0.2301
	(1.0212)	(-3.8054)	(1.3795)
Faedu_years	0.2980***	0.0124***	0.2547***
	(7.6103)	(10.8592)	(6.3891)
Maedu_years	0.1898***	0.0139***	0.1410***
	(4.2290)	(11.9895)	(3.2874)
health	-0.0702	-0.0233***	0.0113
	(-0.7423)	(-8.1644)	(0.1259)
ncog	0.0026	-0.0052***	0.0207
	(0.0600)	(-4.2654)	(0.4844)
Constant	17.1565***	0.2728***	16.2016***
	(26.8908)	(10.8630)	(23.2422)
Observations	8,046	8,046	8,046
R-squared	0.090	0.191	0.100
*** p < 0.01, ** p < 0.05, * p < 0.1.Standard errors in parentheses.			

To further test the robustness of this mediation pathway, an alternative mediator (economic1) is employed, based on students' subjective evaluations of their household economic status (1 = "very difficult," 5 = "very affluent"). The regression results in Table 6 show that birth period continues to exert a significantly positive effect on household economic status, and that household economic status itself remains a significant positive predictor of cognitive ability. After controlling for household economic status, the effect of birth period decreases but remains significant, indicating once again that household economic status mediates part of the effect. These findings are consistent with the results using the composite economic index, thereby confirming the robustness of the mediation effect.

Table 6
Mechanisms-the effects of economic1

VARIABLES	(1)	(2)	(3)
	cogscores	Economic1	cogscores
economic			0.6015***
			(3.0234)
plan	2.0633***	0.0806***	2.0148***
	(9.4325)	(4.1125)	(9.4912)
male	0.1679	-0.0034	0.1700
	(1.0212)	(-0.2118)	(1.0308)
Faedu_years	0.2980***	0.0224***	0.2846***
	(7.6103)	(7.3173)	(7.2268)
Maedu_years	0.1898***	0.0369***	0.1676***
	(4.2290)	(10.4557)	(3.7842)
health	-0.0702	-0.0826***	-0.0206
	(-0.7423)	(-11.6320)	(-0.2243)
ncog	0.0026	-0.0066*	0.0066
	(0.0600)	(-1.9593)	(0.1522)
Constant	17.1565***	2.5278***	15.6360***
	(26.8908)	(42.6731)	(17.5996)
Observations	8,046	8,046	8,046
R-squared	0.090	0.137	0.092
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses .			

[Table 5]

[Table 6]

Table 7 presents the mediation analysis results for maternal occupational type in the relationship between birth period and adolescents' cognitive ability. In Model (1), without including maternal occupation, the results show that adolescents born during the Tenth Five-Year Plan exhibit significantly higher cognitive ability compared to those born during the Ninth Plan. In Model (2), when dummy variables for maternal occupational type are added (with "agriculture/forestry/fishery" as the reference

category), the findings indicate that children whose mothers are employed in white-collar, blue-collar, or "other" occupations score significantly higher in cognitive ability than those whose mothers work in the primary sector, with differences of 1.61, 1.39, and 1.53 points, respectively—all significant at the 1% level. These results confirm that maternal occupation is closely associated with children's cognitive development. At the same time, the coefficient of birth period (Plan) decreases slightly from 2.06 in Model (1) to 1.98 in Model (2), though it remains significant at the 1% level. This suggests that maternal occupational type plays a partial mediating role. Taken together, these findings support Hypothesis 3: policy differences across Five-Year Plan periods not only directly improved adolescents' cognitive outcomes but also indirectly promoted cognitive development by shaping the distribution of maternal occupational types.

Table 7
Mechanisms-the effects of Maternal occupational type

plan	**(1)**	**(2)**
	2.063***	**1.982*****
	(0.219)	(0.216)
male	0.168	0.145
	(0.164)	(0.165)
Faedu_years	0.298***	0.266***
	(0.039)	(0.039)
Maedu_years	0.190***	0.162***
	(0.045)	(0.045)
health	-0.070	-0.057
	(0.095)	(0.095)
ncog	0.003	-0.006
	(0.044)	(0.043)
White-collar		1.613***
		(0.476)
Blue-collar		1.385***
		(0.425)
Agriculture-related		1E-06
industries		(0.001)
Control Group		1.526***
		(0.460)
Observations	8046	8046
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses		

To further test the robustness of the mediation effect of maternal occupational type, the reference category was changed from “agriculture/forestry/fishery” to “white-collar” in the regression. As reported in Table 8, the results remain consistent with the earlier findings: children whose mothers work in agriculture/forestry/fishery occupations score significantly lower in cognitive ability compared to those with white-collar mothers, while no significant differences are observed between blue-collar or “other”

occupations and white-collar work. Meanwhile, the effect of birth period (Plan) remains robust, indicating that maternal occupation continues to play a partial mediating role regardless of the choice of reference group. These results suggest that the empirical conclusions regarding the mediation mechanism are not dependent on the baseline category and are therefore highly robust.

Table 8
Mechanisms-the effects of motherjob

plan	**(1)**	**(2)**
	2.063***	**1.982*****
	(0.219)	(0.216)
male	0.168	0.145
	(0.164)	(0.165)
Faedu_years	0.298***	0.266***
	(0.039)	(0.039)
Maedu_years	0.190***	0.162***
	(0.045)	(0.045)
health	-0.070	-0.057
	(0.095)	(0.095)
ncog	0.003	-0.006
	(0.044)	(0.043)
White-collar		1E-06
		(0.001)
Blue-collar		-0.228
		(0.283)
Agriculture-related		-1.613***
industries		(0.476)
Control Group		-0.087
		(0.286)
Observations	8046	8046
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses		

[Table 7]

[Table 8]

6.2 Heterogeneity analysis

Table 9 reports the subgroup regression results by household registration (hukou) status. For adolescents with migrant hukou, being born during the Tenth Five-Year Plan is associated with an average increase of approximately 1.54 points in cognitive test scores. Among those with local hukou, however, the effect is larger, at about 2.18 points. The difference-in-coefficients test confirms that the effect differs significantly between the two groups. Overall, the cognitive gains associated with being born during the Tenth Plan are more pronounced for local hukou adolescents, likely reflecting their greater advantages in access to educational resources, social integration, and policy benefits. By contrast, adolescents from migrant households, constrained by hukou-related barriers to educational opportunities and resources, also benefit from improvements in the broader policy environment, but to a comparatively lesser extent.

Table 9
Heterogeneity Analysis of the Impact of hukou on cognitive ability

VARIABLES	(1)	(2)
	cogscores	cogscores
plan	1.5405***	2.1782***
	(4.7643)	(8.7102)
male	-0.1975	0.2310
	(-0.5632)	(1.3225)
Faedu_years	0.2469***	0.3083***
	(3.3352)	(7.0310)
Maedu_years	0.0840	0.2092***
	(0.9461)	(4.3472)
health	-0.0072	-0.0716
	(-0.0362)	(-0.6673)
ncog	-0.0962	0.0192
	(-1.1591)	(0.3973)
Constant	20.1113***	16.5572***
	(15.2899)	(24.2288)
P-value for group coefficient difference test	0.038	
Observations	1,371	6,675
R-squared	0.044	0.102
*** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors in parentheses		

[Table 9]

7. Conclusion

Using data from the 2014–2015 wave of the China Education Panel Survey (CEPS), this study systematically examines differences in cognitive ability among adolescents born under different Five-Year Plans, as well as the mechanisms and group heterogeneity underlying these differences. The main findings are as follows. First, significant disparities in cognitive ability exist between cohorts: adolescents born during the Tenth Five-Year Plan exhibit notably higher cognitive scores than those born during the Ninth Five-Year Plan, suggesting that generational shifts in the macro-institutional

environment have left a clear imprint on individual development. Second, household economic status and maternal occupational type serve as partial mediating mechanisms. During the Tenth Plan, improvements in family economic conditions and greater maternal participation in non-agricultural occupations were important indirect channels enhancing adolescents' cognitive outcomes. Third, heterogeneity by hukou status reveals that these intergenerational differences are uneven across groups. The cognitive gains of adolescents with local hukou are more pronounced, while those with migrant hukou benefit to a lesser extent, highlighting the amplifying effect of the hukou system on intergenerational disparities.

These findings yield several implications. First, policymakers should recognize the long-term effects of different policy periods on individual development, particularly the intergenerational inequalities shaped by differential access to education and social resources. Second, sustained education and labor market policies are needed to improve household economic conditions and promote women's occupational advancement, thereby fostering a positive transmission mechanism for children's cognitive development. Third, narrowing the gaps between local and migrant families in access to education and public services is essential to mitigating intergenerational disparities and promoting equity in educational opportunities.

Declarations

The authors declare no competing interests and received no financial support for the research, authorship, and/or publication of this article.

Author Contribution

Xiao-Hang Guo wrote the main manuscript text and Li-Chen Chou involve the process of empirical estimation. All authors reviewed the manuscript.

Acknowledgement

The authors declare no competing interests and received no financial support for the research, authorship, and/or publication of this article.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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