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IFPRI Discussion Paper 1708

February 2018

It's all in the Stars

The Chinese Zodiac and the Effects of Parental Investments on Offspring's Cognitive and Noncognitive Skill Development

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ABSTRACT

The importance of (early) parental investments in children's cognitive and noncognitive outcomes is a question of deep policy significance. However, because parental investments are arguably endogenous, it is a great challenge to empirically estimate their importance. This paper exploits a rich and novel dataset, the China Family Panel Studies, and proposes a culture-specific instrumental variable based on the Chinese zodiac, in order to address this empirical challenge. By looking at the outcomes of children born just before and just after the cutoff for a "lucky" versus "nonlucky" zodiac sign, we find that parents' investments have significant effects on their offspring's development of both cognitive and noncognitive skills.

Keywords: Cognitive Skills; Noncognitive Skills; Parental Investments; Zodiac Signs; China

JEL Codes: I10; I15; J24; O12; O53

ACKNOWLEDGMENTS

This work was undertaken as part of the CGIAR Research Program on Policies, Institutions, and Markets (PIM), led by the International Food Policy Research Institute. The authors would like to thank the Greg and Cindy Page Faculty Distribution Fund and PIM for their partial financial support.

We are grateful to have access to the national sample of the China Family Panel Studies (CFPS), which is funded by 985 Program of Peking University and carried out by the Institute of Social Science Survey of Peking University.

1. INTRODUCTION

This paper contributes to an extensive literature about the impact of parental investments on children's cognitive and noncognitive skill development. Existing work suggests that the economic returns on cognitive and noncognitive skills are potentially large both for individual well-being (Heckman and Rubinstein 2001; Heckman, Stixrud, and Urzua 2006; Borghans et al. 2008; Chetty et al. 2011; Heckman, Pinto, and Savelyev 2013; Cadena and Keys 2015) and for economic growth (Hanushek and Dennis 2000; Hanushek and Woessmann 2008). Early investments by parents play an important role in shaping cognitive and noncognitive skills in their offspring. It has been postulated that early life investments generate higher returns than investments made later in the child's life (Shonkoff and Phillips 2000; Carneiro and Heckman 2005; Kirchsteiger and Sebald 2010; Anger and Schnitzlein 2017).

A major challenge in the development and labor economics literature is to properly identify the economic returns on early childhood educational investments. A key complication faced by econometricians in estimating the returns on early parental investments is that such investments are endogenous. Parental investment decisions may respond to incentives based on their own private knowledge about their children, which may not be observable by the econometrician. For example, parents may know something about the relative level of innate motivation of their various children and may allocate scarce resources across their children to maximize the children's overall outcomes based on this knowledge.[1] Most previous literature has followed a structural model, which delivers a set of structural equations tying initial conditions and the sequence of parental investments across multiple periods to the evolution of cognitive and noncognitive skills (Cunha and Heckman 2008; Cunha, Heckman, and Schennach 2010).

This paper employs a quasi-experimental approach, which does not need a fully specified model as the structural approach does. Moreover, using China Family Panel Studies (CFPS) data, the paper uses

[1] Heckman and Mosso (2014) explained how parents' decisions to either reinforce or compensate for a child's disadvantages rely critically on both the parents' preference for equality of outcomes across their children and the curvature of the human capital production function.

a particular culture-specific determinant of parental investment behavior as a source of exogenous variation to properly identify and consistently estimate the returns on early investment. Specifically, this analysis employs the child survey component in the recently released 2010 and 2012 waves of the CFPS for our analysis. The CFPS is novel in that it includes direct measures of both cognitive (word recognition and mathematical ability) and noncognitive (curiosity, organization, optimism, mistake tolerance, and anger control) skills for children.

This paper proposes a set of instrumental variables (IVs) for parental investments that is specific to Chinese/Asian culture.[2] There are 12 lunar zodiac signs—Rat, Ox, Tiger, Rabbit, Dragon, Snake, Horse, Sheep, Monkey, Rooster, Dog, and Pig—and it is well known that some parents plan the birth of their child to coincide with the "lucky" signs. For example, because positive characteristics are associated with the Dragon zodiac sign, some parents plan their children's birth to fall in the year of the Dragon (Lim 2012). This phenomenon exists even among Asian immigrants to the United States (Johnson and Nye 2011). Based on established beliefs in Chinese culture, we categorize the zodiac signs into (1) "lucky" signs: Tiger and Dragon, (2) "unlucky" signs: Snake and Sheep, and (3) "neutral" signs: all others.

How can zodiac signs have an impact on parental investments?[3] There are two channels for such an effect. The first is the channel of superstition, a purely cultural mechanism that is specific to the Asian (Chinese, in this case) context, whereby parents potentially assign subjective inherent attributes to children born under lucky signs. Their belief in these attributes then drives their decisions about investment in their children. A parent may decide, for example, "My child is a Dragon and is likely to be successful; I should invest in my child."

[2] Lunar zodiac signs (as opposed to the solar signs common in Western cultures) originated in China and spread to other Asian countries. But there are minor differences in practices across those countries. For example, in Vietnam, zodiac signs are combined with the five essential elements (Do and Phung 2010); people in China generally know and care only about the zodiac signs, not their interactions with other astrological constructs.

[3] Other works in the literature have explored how zodiac-related factors affect economic outcomes, but establishing causality has been a serious issue. For example, Vere (2008) employed variations in fertility across different lunar years as an instrument to estimate the effect of fertility on female labor supply. Do and Phung (2010) and Johnson and Nye (2011) found that children born in the year of the Dragon have longer schooling in Vietnam and among Asian immigrants to the United States. In contrast, Wong and Yung (2005), using Hong Kong census data, found no evidence that children born in the year of the Dragon have better earnings outcomes.

The second way in which a child's sign can influence parental investments is the rational channel. Through this channel, even if parents do not themselves believe in the superstitious powers of the zodiac, they may still be incentivized to alter their investment behavior depending on their child's sign if they believe that there are sufficient superstitious parents in the population. This response is due to social interaction effects (Durlauf and Ioannides 2010; Blume et al. 2011), whereby the actions of some parents (in this case, the rational ones) are dependent upon the optimal choices of other (superstitious) parents. For example, the parents of children born under a neutral or unlucky zodiac sign may realize that their children do not have an advantage, in terms of social preferences or beliefs regarding zodiac characteristics, over the cohort of contemporaries with whom they will compete for educational opportunities, jobs, mates, and so on. Such parents may therefore be incentivized to invest in their children to increase their chances of success if superstitious parents are also doing so. These two channels suggest the potential relevance of zodiac-related IVs in influencing parental investments.

However, the validity of the IV approach relies essentially on these zodiac signs' being randomly assigned across children. The fact that parents may potentially plan to achieve particular zodiac signs for their children would certainly lead to questions regarding the validity of an instrument based on the signs. If there was parental self-selection into children's zodiac signs, then there is likely to be selection bias when comparing children's outcomes. Therefore, we need to exclude the children born to parents who have intentionally planned for their children to be born under a lucky sign.

Our strategy for identifying such children is based on the assumption that parents who are intent on achieving a particular zodiac sign for their children would be very unlikely to plan for their child to be born close to the margins of the targeted lunar year. They would plan ahead so that their child is born somewhere in the middle of a lunar year (away from the margins of the preferred zodiac sign, where there would be a risk of the child's being born in the "wrong" year). We assume that the parents of offspring born within a small window around the end of one lunar year and the beginning of the next lunar year (that is, a window across two signs, one "desirable" and one "less desirable") are therefore not engaging in sign selection. Their child just happens to be born under one sign as opposed to the other, adjacent

sign. Specifically, we define the signs of children born within such a window as "random zodiac signs," and we use this variable as an IV for parental investments. The proposed IV approach is therefore closely related to a "fuzzy" regression discontinuity design approach.[4]

This paper further restricts comparisons between children from a pair of adjacent zodiac signs to the set of children who are in the same schooling cohort and thus would be facing the same market, with the same degree of competition, for jobs and educational opportunities. We assume that children born under lucky signs and those born under adjacent neutral or unlucky signs (together, the "nonlucky" signs) are otherwise exchangeable in terms of their unobserved characteristics. This approach is important because we are not able to control for parental expectations regarding the future condition of such markets and opportunities for their children across the birth cohorts in the sample. The random assignment of zodiac signs across children born within the window between two lunar years thus provides a source of exogenous variation in culturally induced differences in parental investments, allowing us to identify the effects of these investments on children's cognitive and noncognitive outcomes.

In terms of our results, using random zodiac signs to instrument for parental investments, measured as total education costs in the previous year, we find that parental investments are important determinants of the development of children's cognitive and noncognitive skills. Specifically, we find that parental investments have substantial implications for children's word recognition and math test scores (cognitive measures), and for their optimism, organizational skills, ability to cope with or tolerate others' mistakes, ability to control anger or anxiety, and level of curiosity (noncognitive measures).

In terms of its broader contribution, this paper is related to an emerging literature that employs exogenous shocks to initial endowments to investigate the effects of early investments on children's cognitive and noncognitive outcomes. Tan, Tan, and Zhang (2015), for example, examined the impact of in utero famine exposure on later-life cognitive outcomes in the context of the Great Chinese Famine of

[4] Our work is related to Zhang et al. (2014) who employed a different identification strategy; i.e., using dynamic panel methods to control for endogeneity, and a different measure of parental investment in children (parental absence). They found that parental absence reduced children's cognitive achievements in rural China.

1959–1961. Leight, Glewwe, and Park (2015) exploited early rainfall shocks to investigate the evolution of children's cognitive and noncognitive skills, finding evidence that parents invest to reduce the impact of negative shocks. The literature that employs policy experiments to elicit the impact of childhood investment includes Adhvaryu and Nyshadham (2016, pre-birth exposure to iodine), Ludwig and Miller (2007, discontinuity in Head Start funding), and Chetty et al. (2011, random assignment of teachers and students to classrooms).

The rest of the paper is organized as follows. Section 2 describes the data and the details of the methodology. Section 3 discusses the findings, and Section 4 concludes.

2. DATA AND METHODOLOGY

Data

Our main dataset is from the CFPS surveys conducted in 2010 and 2012. The CFPS is "a nationally representative, annual longitudinal survey of Chinese communities, families, and individuals," funded by the Chinese government and conducted by the Institute of Social Science Survey of Peking University, China. The CFPS was formally launched in 2010. All individuals in families surveyed in 2010 are followed up in every subsequent survey, which takes place every two years. The CFPS includes four questionnaires: community, family, adult, and child. Our data were constructed using the child questionnaires for 2010 and 2012, complemented by the corresponding adult survey questionnaires. Because the CFPS provides a unique identification number for each individual, we are able to combine information from the 2010 and 2012 surveys. The CFPS also has the advantage of providing direct measures of children's cognitive and noncognitive skills, parents' investments, and family background information.

Defining Key Variables

This subsection defines measures of cognitive and noncognitive skills, parental investment, children's and parents' characteristics, and most importantly, random zodiac signs.

Cognitive skills

The CFPS 2010 survey includes word recognition and math tests as measures of cognitive skills for children who were born from 1995 through 2000. The word recognition and math tests have 34 and 24 questions, respectively, ordered from the easiest to the most difficult. The starting point from which a respondent answers questions depends on his or her education level. The ultimate test score is the number (rank) of the most difficult question that the respondent is able to answer correctly. If a respondent fails to correctly answer any question among those for his or her education group, the score is the lowest for that education level minus 1. For example, in the word recognition test, children with 7 to 9 years of education start at the 9th question. If the most difficult question a child answers correctly is the 11th, his or her test

score is 11. If the child starts at question 9 but fails to answer questions 9, 10, and 11 correctly, his or her score is 8.

Noncognitive skills

The CFPS also includes questions regarding noncognitive skills for children who were born in 1995, 1999, 2003, and 2007 from the 2010 survey, and in 1997, 2001, 2005, and 2009 from the 2012 survey. We derive five measures corresponding to the "big five" noncognitive skills: openness to experience, conscientiousness, extroversion, agreeableness, and neuroticism versus emotional stability (OCEAN). The proxy variables for OCEAN are the survey questions that ask parents, respectively, whether the child is curious, whether the child is organized, whether the child is optimistic, whether the child can tolerate others' mistakes, and whether the child can control his or her anger. These five noncognitive skill variables, based on parents' survey answers, take values of 1 for "strongly disagree," 2 for "disagree," 3 for "neutral," 4 for "agree," or 5 for "strongly agree."

Parental investment

We measure parental investment as total education expenditures for the child in the previous year.[5] These expenditures are deflated to thousands of 2010 Chinese renminbi (that is, to real values).

Children's and parents' characteristics

Using demographic and household information from the CFPS, we can control for a set of family characteristics including the child's gender, whether the family lives in a city, the father's and mother's age and education, and family income (in thousands of 2010 renminbi).

Random zodiac signs

We identify "random" zodiac signs for certain children based on their birth years and months. There are 12 zodiac signs in Chinese culture: Rat, Ox, Tiger, Rabbit, Dragon, Snake, Horse, Sheep, Money,

[5] Parental investment is measured per child in the survey.

Rooster, Dog, and Pig. We categorize these 12 signs into three groups: the Tiger and Dragon are lucky signs, the Snake and Sheep are unlucky signs, and the others are neutral signs. A new zodiac sign starts on each Lunar New Year and continues throughout the lunar year. As discussed in the Introduction, our key identifying assumption reduces to the argument that parents who truly care about their offspring's zodiac sign should rationally plan on giving birth in the middle of the lucky zodiac sign's year. In this way, parents can guarantee that their children are endowed with the lucky zodiac sign, even should an unforeseen event or health condition arise and alter the delivery date. To rule out this set of parents who select into the zodiac sign of their child, we define a child's zodiac sign as randomly assigned only if his or her birth date falls within the first two or last two months of the sign, as illustrated in Figure 1. Therefore, we keep in the sample only children who were born within the first two or last two months of each lunar year, and we treat these children's zodiac signs as if they were randomly assigned.

Because the CFPS data include cognitive skill measures only for children born from 1995 through 2000 and noncognitive skill measures only for children born in the odd years from 1995 through 2009, we define 11 pairs of late/early ("random") zodiac signs in these birth years. Take children born in 1995 as an example: The Lunar New Year was on January 31. Therefore children born in January 1995 are "late Dogs" and children born in February and March 1995 are "early Pigs," as shown in Figure 2. Similarly, using this nomenclature, the remaining 10 pairs of "random" zodiac signs are late Pig versus early Rat (1996), late Rat versus early Ox (1997), late Ox versus early Tiger (1998), late Tiger versus early Rabbit (1999), late Rabbit versus early Dragon (2000), late Dragon versus early Snake (2001), late Horse versus early Sheep (2003), late Monkey versus early Rooster (2005), late Dog 2 versus early Pig 2 (2007), and late Rat 2 versus early Ox 2 (2009).

Ideally, if we had the exact birth dates of the children, we would be able to accurately identify their zodiac signs. However, the survey collects only children's birth years and months, not their birth dates. We therefore implement the following strategy to solve tiebreaker issues. If the Lunar New Year falls in the first half of a month, we assign children born during this month the zodiac sign associated with

the new lunar year. If the Lunar New Year falls in the second half of a month, then children who were born in this month are assigned the zodiac sign of the previous lunar year.[6]

We note two additional points regarding our definition of random zodiac signs. First, Chinese zodiac signs depend on the lunar year, not the month, of birth. This characteristic helps us avoid any perfect correlation between lucky/unlucky/neutral zodiac signs and particular birth months. This imperfect correlation helps us to identify and isolate the impact on parental investment of zodiac signs apart from that of other factors associated with birth months that have potential influence on children's skills, such as duration of exposure to sunshine. Second, because of the window of months around which our random zodiac is defined, all children in this sample were born in the months of January through April. Because the cutoff birth date in China for primary school entrance is September 1, the children within each pair of late and early zodiac signs are in the same school cohort. Hence, we automatically control for all school cohort fixed effects.

Details regarding the definitions of the above five groups of variables are in Appendix Table A.1, Panel A.

Summary Statistics of the Sample within the "Window"

Panels B and C of Appendix Table A.1 display the summary statistics for the two window samples, respectively: children for whom the dataset contains measures of cognitive skills (those from the 2010 survey born in 1995 through 2000) and children for whom it contains measures of noncognitive skills (those from the 2010 survey born in 1995, 1999, 2003, and 2007, and those from the 2012 survey born in 1997, 2001, 2005, and 2009). Because we employ only observations for which the child's birth month falls in the window around the Lunar New Year, the sample contains, respectively, 935 and 907 observations for cognitive skills (Panel B) and noncognitive skills (Panel C).

[6] Ideally, we would also like to exclude the first and the last weeks in each lunar year in the random Zodiac sign definition, in order to exclude the possibility that parents may choose the child's zodiac sign through induced early or late delivery. However, we cannot exclude these possibly "planned" zodiac births because the dataset has only birth years and months, not exact birth dates.

In the sample for cognitive skills, the average scores on the word recognition and math tests are approximately 22.0 and 11.7, respectively. On average, parents spent 1,689 renminbi (RMB) on each child's education over the previous year, and the average family income is RMB 22,6000; therefore a representative family spent approximately 7.4 percent of its income on each child's education. Approximately 51.4 percent of children were male and 38.1 percent of children lived in an urban area; both statistics indicate that the sample well represents the population data. A typical child's father is 41.0 years old and has 7.2 years of education, whereas his or her mother is 39.1 years old and has 5.7 years of education.

In the sample for noncognitive skills, average scores on the five survey questions for noncognitive skills—curiosity, organization, optimism, mistake tolerance, and anger control—are 3.7, 3.5, 3.9, 3.5, and 3.3, respectively. These values indicate that parents, on average, evaluate their child's noncognitive skills to be between "neutral" (3) and "agree" (4) for these questions. Approximately 54.3 percent of children were male; that is, the gender ratio is slightly higher than in the sample for cognitive skills but still representative of the population. Also, 38.1 percent of children lived in an urban area, consistent with the sample for cognitive skills. Because children for whom we have measures of noncognitive skills are younger than those with measures of cognitive skills, their parents are also younger.

Methodology

We estimate the impact of parental investments on children's cognitive and noncognitive skills using a two-stage model, whereby parental investments are instrumented by the random zodiac signs.

Specifically, the first-stage regression takes the following specification:

$$\boldsymbol{pinv_i = c + \delta^T rzodiac_i + X_i \Gamma + v_i,} \quad (1)$$

where $pinv_i$ is the investments by the parents of child *i*; $rzodiac_i$ is child *i*'s random zodiac sign; X_i is a set of control variables that includes the child's age and gender, the father's and mother's age and educational attainment, family income, and the urban dummy (to control for location fixed effects); and v_i is the residual.

The IVs are the random zodiac signs discussed above. Our identification strategy therefore invokes the regression discontinuity design approach in that we make comparisons between individuals born within the boundaries of lucky and neutral/unlucky zodiac signs. That is, we think of the exact occurrence of a particular zodiac sign as being akin to an arbitrary policy rule, and when forming the treatment and control groups, we consider observations within the neighborhood of the policy threshold to be randomly assigned.

The second-stage regression is given by

$$\boldsymbol{skill_i = \alpha + \beta pinv_i + X_i \theta + \varepsilon_i}, \tag{2}$$

where the dependent variable, $skill_i$, is a measure of the cognitive or noncognitive skills of child *i*, and ε_i is the residual. Standard errors are clustered at the level of the birth year and month.

3. FINDINGS

Simple Ordinary Least Squares Results

Before we present the estimation results for equations (1) and (2), we show simple ordinary least squares (OLS) regression results for equation (2). Specifically, we regress children's cognitive or noncognitive skills on parental investment, after controlling for the children's age, gender, residence location, father's and mother's age and education, and family income. In Panel A of Table 4.1 we find that parental investment (as measured by education cost in the previous year) has statistically significant impacts on children's word recognition and math test scores. In Panel B, we show that parental investments are positively correlated with a child's level of organization and optimism. These OLS results indicate that parental investment affects both the child's cognitive and noncognitive skills. However, these preliminary results do not account for the potential endogeneity of parents' investments.

Benchmark Findings for Cognitive Skills

We next estimate a standard two-stage least squares regression, as described by equations (1) and (2).[7] The control variables include children's gender, the urban dummy, parents' age and education, and family real income. Note that random zodiac sign dummies already contain information on children's age. The sample for cognitive skills includes children that were born between 1995 and 2000. For example, if a child was defined as a late Dog, we know that child was born in 1995 and was 15 years old during the survey. Therefore we exclude children's age from the list of control variables.

Table 4.2 displays the first-stage regression for children whose cognitive skill scores are available. We run the regression of parental investments on random zodiac signs and other control covariates, setting the last random zodiac dummy (early Dragon) as the benchmark. The first-stage standard errors are clustered at the level of children's birth year and month. We also list the category (lucky, neutral, or unlucky) of each random zodiac sign. Almost all random zodiac sign dummies are statistically significant, except late Tiger. We are also able to reject the hypothesis that the coefficients to

[7] Specifically, we employ generalized method of moments (GMM) because the GMM estimator is efficient.

late zodiac signs equal the coefficients to early zodiac signs. This finding implies that parents do, in fact, respond to the zodiac sign of their children when making investment decisions in their offspring. The Kleibergen-Paap Wald *F* statistics show that the random zodiac signs are not weak instruments.

Table 4.3 summarizes the second-stage results on how parental investments affect children's cognitive skills. Increased education expenditure significantly improves children's word recognition and math test scores. The magnitude of the effect of parents' investments on cognitive skill development is quantitatively large. For example, an increase of RMB 1,000in education expenditure raises a child's word recognition test score, on average, by 0.882, or 12.2 percent of the standard deviation of this score (7.256). Similarly, an increase of RMB 1,000 in education expenditure raises the average math test score by 1.133, or 25.4 percent of a standard deviation (4.469).

Benchmark Findings for Noncognitive Skills

Next we examine the two-stage least squares regression results for noncognitive skills. Table 4.4 summarizes the first-stage results. In the first stage, we set the benchmark as late Dog 2 versus early Pig 2 (birth year 2007, from the 2010 survey), and late Rat 2 versus early Ox (birth year 2009, from the 2012 survey). The control variables are the same as Table 4.2. The first-stage regression is clustered at the level of children's birth year and month. Like for the case of cognitive skills, we are again able to reject the hypothesis of no differences between the effects of late zodiac signs and those of early zodiac signs in influencing parental investments. The Kleibergen-Paap Wald *F* statistics confirm that the random zodiac signs are not weak instruments.

In the second-stage regressions, displayed in Table 4.5, we find that for all pairs of random zodiac signs, parental investments (as measured by total education costs in the previous year) improve a child's curiosity, organization, optimism, tolerance of others' mistakes, and anger control. The magnitudes of the impacts are substantial and important. For example, an increase of RMB 1,000 in parents' investment can raise a child's curiosity score by 0.094, or 10.8 percent of the standard deviation (0.868). An increase of RMB 1,000 in parents' investment has an even larger effect on the score for being organized, 0.122, or

13.1 percent of the standard deviation (0.930). Columns 3 through 5 show that a parental investment of RMB 1,000 can increase a child's scores on optimism, mistake tolerance, and anger control, respectively, by 0.034 (4.9 percent of the standard deviation, 0.693), 0.029 (3.2 percent of the standard deviation, 0.894), and 0.090 (9.0 percent of the standard deviation, 1.001).

Robustness Checks

We now consider a range of robustness checks. The first robustness check is on the assumption of the estimation method. The identification strategy relies on the underlying smoothness of the forcing variable (time, in this case) across the threshold. This smoothness may be violated if, for example, parental characteristics that determine offspring's skill formation are systematically different across the zodiac cutoff. In Table 4.6, we check whether control covariates are differentiated across late and early zodiac signs. Among the 63 pairs of control covariates across children in the same birth year, 54 are not significantly different in mean values; the exceptions are late Rat versus early Ox for father's and mother's education, late Tiger versus early Rabbit for mother's age and family income, late Dragon versus early Snake for father's age and education, and late Monkey versus early Rooster for children's gender.

The second robustness check examines whether it is the change in birth months, not the change in zodiac signs, that has explanatory power for parental investment. We design a falsification test in which we shift the birth month window away from the Lunar New Year; this shift causes children's birth dates in each pair to fall into the same lunar year. Specifically, we designate children born in the third and fourth months of each lunar year as the first group and children born in the fifth and sixth months as the second group. Note that children in these two groups of each lunar year have the same zodiac sign. Moreover, all of these children were born before the cutoff date for primary school entry (September 1) and are consequently in the same schooling cohort. We then examine whether parents invest in differentiated ways on children in these groups. Table 4.7 reports the falsification tests for measures of cognitive and noncognitive skills. In both cases, we fail to reject the hypothesis that the coefficients for

the first and second groups in each zodiac sign year are identical. The estimation results suggest that parents do not differentiate their investment in children if they have the same zodiac signs. The results confirm that it is the change in zodiac signs, not the change in birth months, that explains differences in parents' investments.

The third robustness check uses an alternative window period (one month instead of two) to designate the random zodiac signs. In Table 4.8, we designate as random the zodiac signs of children born in the first or last month of the lunar year, and then repeat the two-stage least squares regressions for cognitive and noncognitive skills, as in the benchmark cases. The new results are qualitatively consistent with the benchmark results.

4. CONCLUSION

There is keen interest in the literature in properly identifying the potential impact of parental investment in education on children's cognitive and noncognitive development. A key challenge for consistently estimating this impact is the high likelihood that parental investments may be endogenous. That is, parents may make investment decisions in their children that are based on their own private information about their offspring, which is not observed by the researcher.

This paper proposes a culture-specific IV based on the Chinese zodiac as a source of exogenous variation for identifying the effects of parental investments on their offspring's skill formation. By defining a window around the boundary of a zodiac sign, and assuming that observations are randomly assigned across this boundary, we establish the exogeneity of the IV. Using the "fuzzy" regression discontinuity approach to examine the outcomes of children born just before and just after the cutoff for a lucky versus nonlucky zodiac sign, we find that parental investments have significant effects on children's cognitive and noncognitive skill development. The main results confirm the findings in the literature, which are largely drawn from a structural approach.

Figure 4.1 Lunar Years and Random Zodiac Signs

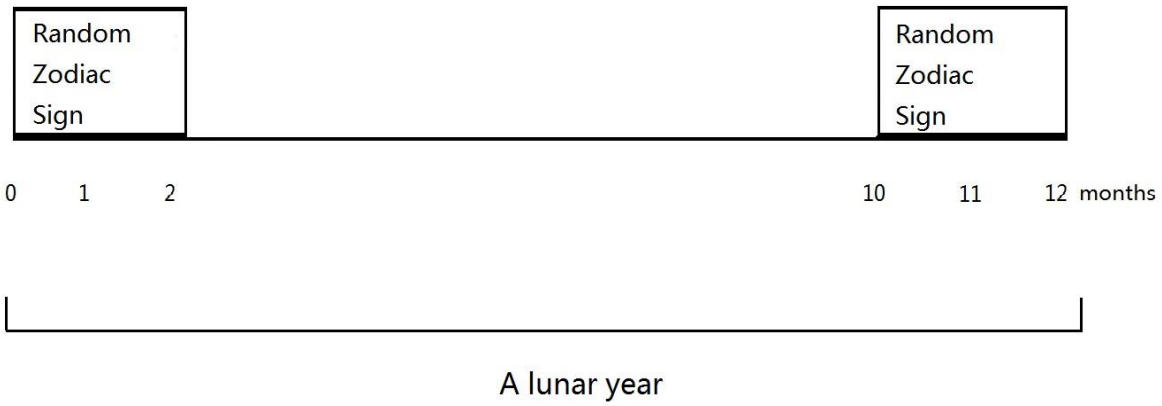

Figure 4.2 Late Dog and Early Pig in 1995

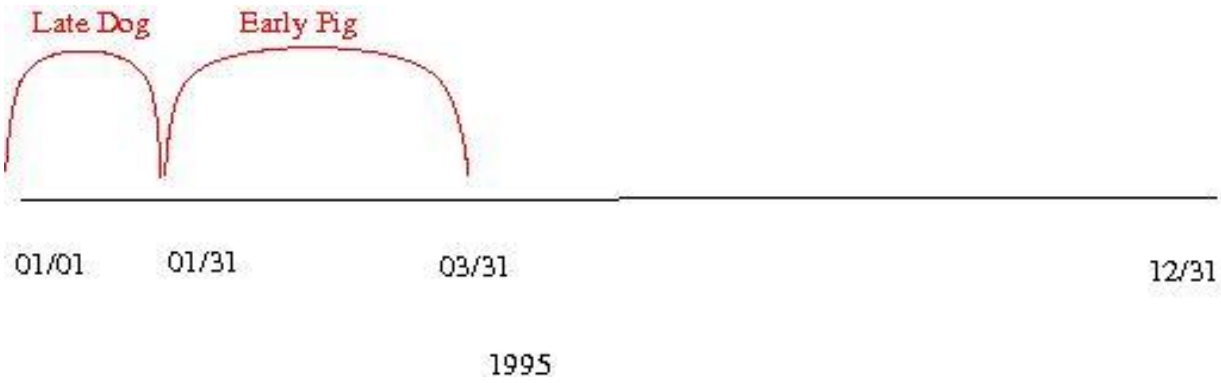

Table 4.1 Impact of parental investment on children's cognitive skills: Ordinary least squares regressions

	Panel A: Cognitive skills		Panel B: Noncognitive skills				
Variable	**Word recognition test**	**Math test**	**Curiosity**	**Organization**	**Optimism**	**Mistake endurance**	**Anger control**
	(1)	**(2)**	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Education cost	0.137**	0.086***	0.011	0.029***	0.025***	0.013	0.015
last year	(0.07)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
Age	1.973***	1.733***	-0.009	-0.003	-0.025***	0.015*	0.019**
	(0.18)	(0.08)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gender	-1.240***	0.315	0.097	-0.069	0.008	0.06	-0.032
	(0.39)	(0.21)	(0.07)	(0.07)	(0.05)	(0.06)	(0.07)
Urban	0.763	0.493**	-0.002	-0.123	-0.018	0.009	-0.059
	(0.62)	(0.24)	(0.05)	(0.08)	(0.05)	(0.07)	(0.08)
Father's age	-0.185***	-0.076***	-0.006	-0.001	0.006	-0.006	-0.024**
	(0.05)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Father's	0.180***	0.074***	0.022**	0.003	0.001	-0.003	-0.007
education	(0.05)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mother's age	0.05	0.029	0.003	0.012	0.003	0.015	0.037***
	(0.05)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mother's	0.314***	0.140***	0.006	-0.007	0.011	-0.006	-0.005
education	(0.06)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Family income	-0.002	0.001	0.001*	-0.002	0.001	0.001	0.001
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
R^2	0.296	0.454	0.037	0.022	0.04	0.023	0.04
Observations	935	935	907	907	907	907	907

Note: Panel A displays preliminary results on the impacts of parental investment on children's cognitive skills, in the sample of children for whom cognitive skill test results are available (birth years 1995 through 2000) and who were born within the last two months or the first two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. Panel B displays preliminary results for the impacts of parental investment on children's noncognitive skills, in the sample of children for whom noncognitive skill test results are available (birth years are the odd years from 1995 through 2009) and whose birth dates fall in the last two months or first two months of a lunar year. All regressions are clustered at birth year-month levels. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.2 Impact of parental investment on children's cognitive skills: First-stage regression

Variable	Education cost last year	Category/year of random zodiac sign
Late Dog	0.881***	Neutral (1995)
	(0.093)	
Early Pig	0.734***	Neutral (1995)
	(0.098)	
Late Pig	0.952***	Neutral (1996)
	(0.157)	
Early Rat	1.093***	Neutral (1996)
	(0.128)	
Late Rat	3.373***	Neutral (1997)
	(0.152)	
Early Ox	2.542***	Neutral (1997)
	(0.181)	
Late Ox	1.061**	Neutral (1998)
	(0.525)	
Early Tiger	0.328***	Lucky (1998)
	(0.125)	
Late Tiger	0.208	Lucky (1999)
	(0.234)	
Early Rabbit	0.765***	Neutral (1999)
	(0.202)	
Late Rabbit	0.104	Neutral (2000)
	(0.072)	
Gender	0.007	
	(0.258)	
Urban	0.533**	
	(0.235)	
Father's age	0.074***	
	(0.028)	
Father's education	0.033*	
	(0.020)	
Mother's age	-0.067**	
	(0.031)	
Mother's education	0.123***	
	(0.029)	
Family income	0.015**	
	(0.006)	
R^2	0.172	
F test for late coef.=early coef.	8.63***	
(Prob. > F)	(0.000)	
Kleibergen-Paap Wald *F*	120.90**	
Hansen's *J* statistic	14.957	
(*p* for Hansen's *J*)	(0.134)	
Observations	935	

Source: Authors' calculations from China Family Panel Studies (ISSS 2017).

Note: This table displays the first-stage regression results for how parental investment can be explained by random zodiac signs and other control variables. The sample includes all children for whom cognitive skill test results are available (birth years 1995 through 2000) and who were born within the last two months or first two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. Early Dragon is used as the benchmark. All regressions are clustered at birth year-month levels. The significance for the Kleibergen-Paap Wald *F* is from the Stock-Yogo weak instrument test. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.3 Impact of parental investment on children's cognitive skills: Second-stage regression

Variable	Word recognition test	Math test
	(1)	(2)
Education cost	0.882***	1.133***
last year	(0.198)	(0.252)
Gender	-1.380***	0.576**
	(0.342)	(0.262)
Urban	0.668	-0.394
	(0.528)	(0.329)
Father's age	-0.237***	-0.184***
	(0.050)	(0.032)
Father's	0.128***	0.050*
education	(0.031)	(0.029)
Mother's age	0.194***	0.183***
	(0.067)	(0.040)
Mother's	0.179***	0.016
education	(0.035)	(0.033)
Family income	-0.010**	-0.009
	(0.004)	(0.006)
R^2	0.029	0.010
Observations	935	935

Note: This table displays the second-stage generalized method of moments regression results for the impacts of parental investment on children's cognitive skills. The sample includes all children for whom cognitive skill test results are available (birth years 1995 through 2000) and who were born within the last two months or the first two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. Early Dragon is used as the benchmark. All regressions are clustered at children's birth year-month levels. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.4 Impact of parental investment on children's noncognitive skills: First-stage regression

Variable	Education cost last year	Category/year of random zodiac sign
Late Dog	0.633***	Neutral (1995)
	(0.238)	
Early Pig	0.702***	Neutral (1995)
	(0.245)	
Late Rat	2.017***	Neutral (1997)
	(0.241)	
Early Ox	3.064***	Neutral (1997)
	(0.242)	
Late Tiger	0.368	Lucky (1999)
	(0.275)	
Early Rabbit	0.173	Neutral (1999)
	(0.237)	
Late Dragon	1.426***	Lucky (2001)
	(0.192)	
Early Snake	0.550***	Unlucky (2001)
	(0.207)	
Late Horse	-0.109	Neutral (2003)
	(0.178)	
Early Sheep	-0.285*	Unlucky (2003)
	(0.165)	
Late Monkey	0.522***	Neutral (2005)
	(0.183)	
Early Rooster	0.727***	Neutral (2005)
	(0.180)	
Gender	-0.160	
	(0.182)	
Urban	0.693***	
	(0.251)	
Father's age	0.017	
	(0.021)	
Father's education	0.012	
	(0.024)	
Mother's age	-0.011	
	(0.027)	
Mother's education	0.106***	
	(0.020)	
Family income	0.012***	
	(0.004)	
R^2	0.196	
F test for late coef.=early coef.	59.01***	
(Prob. > F)	(0.000)	
Kleibergen-Paap Wald *F*	239.912***	
Hansen's *J* statistic	12.442	
(*p* for Hansen's *J*)	(0.331)	
Observations	907	

Note: This table displays the first-stage regression results for how parental investment can be explained by random zodiac signs and other control variables. The sample includes all children for whom cognitive skill test results are available (birth years 1995 through 2000) and whose birth dates fall in the first or last two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. Children born in 2007 (three years old in the 2010 survey, late Dog 2 and early Pig 2) and in 2009 (three years old in the 2012 survey, late Rat 2 and early Ox 2) are used as the benchmark. All regressions are clustered at children's birth year-month levels. The significance of the Kleibergen-Paap Wald *F* is from the Stock-Yogo weak instrument test. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.5 Impact of parental investment on children's noncognitive skills: Second-stage regression

Variable	Curiosity	Organization	Optimism	Mistake tolerance	Anger control
	(1)	(2)	(3)	(4)	(5)
Education cost	0.094**	0.122***	0.034***	0.029***	0.090***
last year	(0.015)	(0.014)	(0.011)	(0.010)	(0.016)
Gender	0.091*	-0.023	0.039	0.089***	-0.041
	(0.054)	(0.043)	(0.032)	(0.031)	(0.054)
Urban	-0.041	-0.118*	-0.062**	0.048	-0.118*
	(0.038)	(0.070)	(0.027)	(0.051)	(0.063)
Father's age	-0.006	-0.009	0.008**	-0.006	-0.025***
	(0.010)	(0.008)	(0.004)	(0.006)	(0.009)
Father's	0.015*	0.005	0.004	0.001	-0.015**
education	(0.008)	(0.011)	(0.008)	(0.007)	(0.007)
Mother's age	-0.007	0.011	-0.007	0.020***	0.043***
	(0.009)	(0.008)	(0.005)	(0.008)	(0.008)
Mother's	0.005	-0.027***	0.012**	-0.013**	-0.014*
education	(0.007)	(0.009)	(0.006)	(0.006)	(0.008)
Family income	0.001	-0.003***	-0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
R^2	0.001	0.001	0.017	0.017	0.001
Observations	907	907	907	907	907

Note: This table displays the second-stage generalized method of moments regression results for the impacts of parental investment on children's noncognitive skills. The sample includes all children for whom noncognitive skill test results are available (born in the odd years from 1995 through 2009) and whose birth dates fall in the last or first two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. All regressions are clustered at children's birth year-month levels. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.6 Falsification tests: Comparisons of control variables between late and early zodiac signs

Birth year / zodiac sign	Gender		Urban		Father's age		Father's education		Mother's age		Mother's education		Family income	
	Mean	*t*	Mean	*t*	Mean	*t*	Mean	*t*	Mean	*t*	Mean	*t*	Mean	*t*
1995														
Late Dog	0.614	1.095	0.386	1.053	42.136	-0.013	7.023	0.550	40.295	-0.327	5.659	0.821	20.788	0.803
Early Pig	0.515		0.297		42.149		6.634		40.534		5.030		17.192	
1996														
Late Pig	0.495	0.354	0.386	0.435	41.604	-0.901	7.307	-0.260	39.851	-0.190	5.584	-0.290	21.722	1.236
Early Rat	0.468		0.354		42.215		7.456		39.949		5.772		17.358	
1997														
Late Rat	0.471	-0.196	0.412	1.505	42.000	-0.391	8.500	1.676*	40.382	-0.416	6.882	2.391**	41.270	1.035
Early Ox	0.492		0.262		42.361		7.230		40.705		4.770		32.115	
1998														
Late Ox	0.556	-0.102	0.356	-0.482	41.611	1.409	6.767	0.030	38.844	-0.513	5.944	0.451	21.786	-0.642
Early Tiger	0.563		0.391		40.437		6.747		39.184		5.643		28.557	
1999														
Late Tiger	0.500	0.162	0.454	0.282	39.939	-0.732	7.939	1.501	37.364	-2.093**	6.136	0.760	27.511	1.930*
Early Rabbit	0.486		0.431		40.542		6.778		38.917		5.486		18.518	
2000														
Late Rabbit	0.500	0.978	0.393	-0.717	39.333	0.015	7.155	-1.011	38.071	1.511	5.893	-0.536	19.352	0.040
Early Dragon	0.423		0.449		39.321		7.782		36.782		6.282		19.219	
2001														
Late Dragon	0.455	0.282	0.361	0.143	38.278	-1.716*	7.611	1.692*	36.944	-1.252	6.861	1.430	38.136	0.493
Early Snake	0.431		0.346		40.154		6.154		38.365		5.423		34.494	
2003														
Late Horse	0.567	0.530	0.337	-0.307	34.500	-1.408	8.100	0.721	32.733	-1.139	7.400	0.671	19.629	0.567
Early Sheep	0.508		0.400		35.970		7.462		34.000		6.785		27.552	
2005														
Late Monkey	0.448	-1.768*	0.448	0.943	35.414	-0.888	8.276	0.077	33.862	-0.488	7.483	-0.153	38.337	0.692
Early Rooster	0.639		0.347		36.528		8.208		34.417		7.625		32.947	

Note: This table reports comparisons in control variables between late and early zodiac sign pairs, in the samples of children for whom cognitive or noncognitive skill test results are available (birth years 1995 through 2000 or the odd years from 1995 through 2005) and who were born within the last or first two months of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.7 Falsification tests: Children born in the same lunar year

Variable	(1) Sample for cognitive skills	(2) Sample for noncognitive skills
	Education cost last year	Education cost last year
F test for first group coefficient = second group coefficient	0.84	0.93
(Prob. > *F*)	(0.521)	(0.475)
Kleibergen-Paap Wald *F*	17.786*	18.307**
Observations	1,392	1,139

Note: This table displays the results of falsification tests. The sample for cognitive skills includes all children for whom cognitive skill test results are available (birth years 1995 through 2000); the sample for noncognitive skills includes all children for whom noncognitive skill test results are available (birth years are the odd years from 1995 through 2009). The two groups in each lunar year are children who were born in the third and fourth months (group 1) and in the fifth and sixth months (group 2) in that lunar year. The *F* test is a joint test for whether coefficients of the first and second groups in the lunar year are equal. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

Table 4.8 Impact of parental investment on children's skills: One-month window

Variable	Panel A: Cognitive skills		Panel B: Noncognitive skills				
	Word recognition test	Math test	Curiosity	Organization	Optimism	Mistake tolerance	Anger control
	(1)	(2)	(1)	(2)	(3)	(4)	(5)
Education cost	0.137**	0.086***	0.011	0.029***	0.025***	0.013	0.015
last year	(0.07)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)
R^2	0.296	0.454	0.037	0.022	0.04	0.023	0.04
Observations	935	935	907	907	907	907	907

Note: This table displays the robustness results for the impacts of parental investment on children's skills. The sample for cognitive skills includes all children for whom cognitive skill test results are available (birth years 1995 through 2000) and who were born within the last month or the first month of a lunar year; the sample for noncognitive skills includes all children for whom noncognitive skill test results are available (birth years are the odd years from 1995 through 2009) and who were born within the last month or the first month of a lunar year. Appendix Table A.1 provides detailed explanations for all variables. All regressions are clustered at children's birth year-month levels. ***, **, and * denote significance at 1%, 5%, and 10%, respectively.

APPENDIX

Table A.1 Summary Statistics

Panel A. Definitions of variables

Variable	Definition
Word recognition test	The child's word recognition test score based on the number of questions answered correctly. Minimum: 0, maximum: 34
Math test	The child's math test score based on the number of questions answered correctly. Minimum: 0, maximum: 24
Curiosity	The parent's answer on whether the child is curious. 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree
Organization	The parent's answer on whether the child is organized. 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree
Optimism	The parent's answer on whether the child is optimistic. 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree
Mistake tolerance	The parent's answer on whether the child can tolerate others' mistakes. 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree
Anger control	The parent's answer on whether the child can control his or her anxiety/anger. 1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree
Total education cost last year	The total real expenditure by parents on the child's education last year (thousand RMB, 2010 as the base year)
Gender	The child's gender: 1 male, 0 female
Urban	If the child lives in the urban area: 1 yes, 0 no
Family income	The total real income of the family last year (thousand RMB, 2010 as the base year)
Father's age	The father's age
Father's education	Education years of the father: 0 for illiteracy/near-illiteracy, 6 years for primary school, 9 years for middle school, 12 years for high school, 14 years for associate's degree, 16 years for bachelor's, 19 years for master's, 22 years for PhD
Mother's age	The mother's age
Mother's education	Education years of the mother; see "Father's education"
Late Dog	1 if child was born in 1995 and in the last two months of the Dog year, 0 otherwise. Cutoff: 01/31/1995
Early Pig	1 if child was born in 1995 and in the first two months of the Pig year, 0 otherwise. Cutoff: 01/31/1995
Late Pig	1 if child was born in 1996 and in the last two months of the Pig year, 0 otherwise. Cutoff: 02/19/1996
Early Rat	1 if child was born in 1996 and in the first two months of the Rat year, 0 otherwise. Cutoff: 02/19/1996
Late Rat	1 if child was born in 1997 and in the last two months of the Rat year, 0 otherwise. Cutoff: 02/07/1997
Early Ox	1 if child was born in 1997 and in the first two months of the Ox year, 0 otherwise. Cutoff: 02/07/1997

Table A.1 Continued

Panel A. Definitions of variables

Variable	Definition
Late Ox	1 if child was born in 1998 and in the last two months of the Ox year, 0 otherwise. Cutoff: 01/28/1998
Early Tiger	1 if child was born in 1998 and in the first two months of the Tiger year, 0 otherwise. Cutoff: 01/28/1998
Late Tiger	1 if child was born in 1999 and in the last two months of the Rat year, 0 otherwise. Cutoff: 02/16/1999
Early Rabbit	1 if child was born in 1999 and in the first two months of the Ox year, 0 otherwise. Cutoff: 02/16/1999
Late Rabbit	1 if child was born in 2000 and in the last two months of the Rabbit year, 0 otherwise. Cutoff: 02/05/2000
Early Dragon	1 if child was born in 2000 and in the first two months of the Dragon year, 0 otherwise. Cutoff: 02/05/2000
Late Dragon	1 if child was born in 2001 and in the last two months of the Dragon year, 0 otherwise. Cutoff: 01/24/2001
Early Snake	1 if child was born in 2001 and in the first two months of the Snake year, 0 otherwise Cutoff: 01/24/2001
Late Horse	1 if child was born in 2003 and in the last two months of the Horse year, 0 otherwise Cutoff: 02/01/2003
Early Sheep	1 if child was born in 2003 and in the first two months of the Sheep year, 0 otherwise. Cutoff: 02/01/2003
Late Monkey	1 if child was born in 2005 and in the last two months of the Monkey year, 0 otherwise. Cutoff: 02/09/2005
Early Rooster	1 if child was born in 2005 and in the first two months of the Rooster year, 0 otherwise. Cutoff: 02/09/2005
Late Dog 2	1 if child was born in 2007 and in the last two months of the Dog year, 0 otherwise. Cutoff: 02/18/2007
Early Pig 2	1 if child was born in 2007 and in the first two months of the Pig year, 0 otherwise. Cutoff: 02/18/2007
Late Rat 2	1 if child was born in 2009 and in the last two months of the Rat year, 0 otherwise. Cutoff: 01/26/2009
Early Ox 2	1 if child was born in 2009 and in the first two months of the Ox year, 0 otherwise. Cutoff: 01/26/2009

Table A.1 Continued

Panel B. Summary statistics: The sample for cognitive skills

Variable	Mean	St. dev.	# of obs.
Word recognition test	21.997	7.256	935
Math test	11.667	4.469	935
Total education cost last year	1.689	3.403	935
Gender	0.514	0.500	935
Urban	0.381	0.486	935
Family income	22.577	39.163	935
Father's age	41.024	5.022	935
Father's education	7.236	3.981	935
Mother's age	39.114	4.385	935
Mother's education	5.749	4.485	935
Late Dog	0.042	0.200	935
Early Pig	0.098	0.298	935
Late Pig	0.108	0.311	935
Early Rat	0.084	0.278	935
Late Rat	0.053	0.225	935
Early Ox	0.086	0.280	935
Late Ox	0.096	0.295	935
Early Tiger	0.093	0.291	935
Late Tiger	0.075	0.263	935
Early Rabbit	0.091	0.288	935
Late Rabbit	0.090	0.286	935
Early Dragon	0.083	0.277	935

Table A.1 Continued

Panel C. Summary statistics: The sample for noncognitive skills

Variable	Mean	St. dev.	# of obs.
Curiosity	3.690	0.868	907
Organization	3.525	0.930	907
Optimism	3.921	0.693	907
Mistake tolerance	3.505	0.894	907
Anger control	3.291	1.001	907
Total education cost last year	1.400	2.669	907
Gender	0.543	0.498	907
Urban	0.381	0.486	907
Family income	29.191	39.392	907
Father's age	37.637	6.287	907
Father's education	7.673	4.008	907
Mother's age	35.656	4.296	907
Mother's education	6.523	4.481	907
Late Dog	0.048	0.214	907
Early Pig	0.110	0.314	907
Late Rat	0.037	0.189	907
Early Ox	0.067	0.250	907
Late Tiger	0.072	0.259	907
Early Rabbit	0.079	0.269	907
Late Dragon	0.039	0.195	907
Early Snake	0.057	0.232	907
Late Horse	0.033	0.178	907
Early Sheep	0.071	0.257	907
Late Monkey	0.032	0.175	907
Early Rooster	0.079	0.269	907
Late Dog 2	0.094	0.292	907
Early Pig 2	0.084	0.028	907
Late Rat 2	0.000	0.000	907
Early Ox 2	0.098	0.298	907

Note: Panel A displays definitions for major variables in the China Family Panel Studies 2010 and 2012 data (ISSS 2017). Children who were born from 1995 to 2000 (from the 2010 survey) took the word recognition and math tests. Children who were born in 1995, 1999, 2003, and 2007 (from the 2010 survey), and in 1997, 2001, 2005, and 2009 (from the 2012 survey) took the noncognitive skill surveys. In order to construct the treatment and control groups, the sample includes only children who took the cognitive or noncognitive skills test and whose birth dates fall in the last two months or the first two months of a lunar year.
Panel B displays the summary statistics for children who took the cognitive skills tests (birth years 1995 through 2000) and whose birth dates fall in the last two months or the first two months of a lunar year.
Panel C displays the summary statistics for children who took the noncognitive skill tests (birth years are the odd years from 1995 through 2009) and whose birth dates fall in the last two months or the first two months of a lunar year.
RMB = Chinese renminbi.

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