The Winter's Tale: Season of Birth Impacts on Children in China*

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Abstract

This paper examines the effect of season of birth on height and cognitive and non-cognitive skills of Chinese children. We find that the child's season of birth has a significant impact on the height of girls aged less than 5 years in agricultural households: girls born in winter are 0.4 standard deviations shorter as compared to girls born in other seasons. We find, however, that this relative height differential does not translate to deficits in cognitive and non-cognitive skills when girls are adolescents aged 10–15 years. We show that compensating investments by parents, manifested through higher parental expectations regarding educational attainment for poorly endowed winter-born girls, may be an explanation for why the initial height disadvantage does not have lasting negative implications when girls are older.

Key Words: Child Health, Cognitive and Non Cognitive Skills, Compensating Investments, Season of Birth, China

JEL Codes: O15, I15, J13

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1 Introduction

This paper examines the effect of season of birth on long-term health, and cognitive and non-cognitive ability of Chinese children. There is now a growing literature that examines the effects of early childhood conditions on outcomes later in life. Specifically, it is argued that the time of the year when a child is born matters. The literature has documented that the time of birth and neonatal health can affect the outcomes of very young children including infant mortality (Breschi and Livi-Bacci, 1997), their health as adults (Weber et al., 1998), susceptibility to diseases and disabilities (Muhuri, 1996), their life span (Doblhammer and Vaupel, 2001), and cognitive ability (McGrath et al., 2006, Venkataramani, 2012, Figlio et al., 2014). The economics literature from both developed and developing countries suggests that the time of the year the child is born impacts human capital development. For example, Angrist and Kruger (1991) finds that in the US, children born during the first quarter of the year have lower average levels of education than children born later in the year. Almond and Mazumder (2011) notes that in-utero exposure to Ramadan (the Islamic month of fasting) results in lower birth weight and a higher probability of long term disability. Using data from India, Lokshin and Radyakin (2012) reports that children born during the monsoon months have lower anthropometric scores compared to children born in the post-monsoon and winter months. Shah and Steinberg (2017) finds that more early-life rainfall is associated with higher test scores in both math and reading.

We examine the impact of season of birth on children born in agricultural and non-agricultural households in China, after ruling out selection into season of birth (i.e., after ensuring that births are not timed). Much of the literature on the effect of season of birth on child outcomes has focused on the effect of the monsoon (for example Maccini and Yang, 2009, Tiwari et al., 2017).[1] However, depending on the context, births in other seasons of the year may also have adverse implications for children. For instance in environments where food cannot be stored easily,

[1] In developing countries like China where agriculture is an important source of livelihood, the monsoon season is crucial and can affect child outcomes in multiple ways. By influencing agricultural production, the timing of the monsoon is correlated with resource availability within the household, which can positively influence the health of children. However, the monsoon is also associated with an enhanced disease environment, which can have a negative effect on the health of children in agricultural households.

winter is often a season of shortages, and this is particularly true in China.[2] Brown et al. (2011) argues that during specific events and festivals, poor households in China engage in status seeking behavior by increasing their spending on socially observable goods. The Lunar New Year, which is typically in winter, is one such event. By limiting liquidity, such spending could further exacerbate resource constraints within households with adverse effects on child health and development. In an important exception to the expectation that winter-born children will be adversely affected, Bai et al. (2018) analyzes the influence of season of birth on health outcomes of children aged 8–10 months and find that those born in winter have an advantage as compared to those born in the summer months. This is because winter-born children reach 6 months of age (a critical threshold when food intake patterns change) during the summer when there are more varieties of food available, the food is of greater nutritional value, and parents spend more time with their children outside, all of which are beneficial to child health outcomes such as anemia and cognitive and psychomotor development. However, their sample is restricted to a poor rural Northwestern region of China, and the children they examine are evaluated at very young ages of 8–10 months which are close to the important developmental threshold of 6 months. Given growth trajectories and other rapid changes at these early ages, it is hard to be sure that the documented patterns will be long-lasting.

We examine a nationally representative sample of children focusing on differences by gender and socio-economic status at comparable and older ages where plausibly, growth is still positive but relatively more stable due to gradients that are less steep.[3] We find that relative to girls born in winter in agricultural households, girls born in the non-winter seasons (pre-monsoon, monsoon and post-monsoon) have significantly higher HAZ, the widely accepted proxy for long-term health.[4] The relative effect is the strongest and most persistent for children born in the post-monsoon season. There is no effect of season of birth on birth weight, which indicates that the season of birth effect on health is not due to what happens *in-utero*; rather it may be the result of circumstances the household faces *after* the child is born. An explanation is that the

[2]Figure A1 presents the crop calendar for China. This shows that there is very little agricultural production/activity during the winter months.

[3] Currie (2009) and Currie and Vogl (2013) note that two-thirds of adult height is decided by the age of 5 years, often by 2–3 years.

[4]See discussion in Section 3 on the use of HAZ as a measure of long term health of children.

early nutritional deprivation that girls may face (in the period after being born) is exacerbated in winter months when households are particularly resource-constrained.

We further investigate whether such initial disadvantages have lasting impacts. This is in light of the evidence that height disadvantages in early life can have resonating impacts in terms of cognition as these children age through adolescence and adulthood (Martorell et al., 2005, Case and Paxson, 2008). Such impacts are also evident when considering non-cognitive skills (Heckman, 2000, Persico et al., 2004, Schick and Steckel, 2010). We find that there is little effect of season of birth on the cognitive and non-cognitive ability of these children in adolescence. In particular, while girls in agricultural households born in winter have lower relative HAZ as of age 5, this disadvantage does not translate to lower cognitive or non-cognitive development in a sample of 10–15 year old winter-born girls. We hypothesize that this is because conditional on observed health, there are compensating investments on the part of parents so that early childhood disadvantages do not have persisting consequences.[5] We find that such compensating investments take the form of parents investing additional time and resources in girls born in winter. These results corroborate the findings of Leight et al. (2015) which uses the Gansu Survey of Children and Families (GSCF) data and shows that the effect of early life shocks on cognitive skills of children declines over time. This study argues that compensatory strategies by parents contribute to this decline in the impact of early life shocks. Our results are consistent with an income equalization hypothesis and with the notion of dynamic compensatory investments on the part of parents, who, as demonstrated in other contexts, spend more inputs on their relatively underprivileged children (Behrman and Rosenzweig, 2004, Almond and Mazumder, 2013, Adhvaryu et al., 2018, Leight and Liu, 2018).

We use parental expectations on the educational attainment of children conditional on observed health and other individual and household characteristics as a proxy measure for why parents may engage in compensating behaviour. Parental expectations can be a key indicator of parents' involvement and investments in children's education (Fan and Chen, 2001), and can potentially be a crucial determinant in forming children's attitudes towards education (Wood et al., 2007).

[5] See Cunha et al. (2010) and the references cited therein for more on compensating investments by parents.

The existing literature posits a significant positive correlation between parent's expectations and children's educational achievement through provision of a supportive and emotionally inspiring environment (Neuenschwander et al., 2007). Leight (2017) examines allocation of educational expenditures to children and finds that these expenditures are directed to the child with relatively lower physical endowments.[6] There is pre-existing evidence therefore that Chinese parents use educational funding to compensate for differences in their children's health.

We find that parents from agricultural households hold higher educational expectations for daughters born in the winter as compared to those born in the non-winter seasons. A reason may be that parents believe that because of their relative initial health advantage, girls born in the non-winter seasons are better off when it comes to physically intensive labor market work. But daughters born in winter who are seen to be relatively disadvantaged in terms of health are encouraged to invest in education so that they may gain remuneration from more mentally demanding tasks when adults. This is in the spirit of the *brain* vs *brawn* hypothesis, but *within* children of the same gender (Pitt et al., 2012). We find that parental expectations are positively correlated with educational expenditure and negatively correlated with hours of housework for winter-born girls in agricultural households. We hypothesize that such differential investments lead to catch-up (of winter-born girls to girls born in other seasons), and is an explanation for why the relative height deficiency in early childhood does not translate into statistically measurable differentials in cognitive and non-cognitive skills in adolescence.

Our research adds to the growing literature on the effect of conditions *in-utero* and at birth on child health in developing countries in several ways. First, we find that the season of birth matters: being born in the winter is a disadvantage for girls in agricultural households as compared to girls in similar households born in other seasons. We synchronize this to agricultural cycles in China which are strongly influenced by rainfall patterns, and note that the winter disadvantage may be linked to shortages that rural households face at this time of the year. This winter birth disadvantage has also been observed elsewhere, typically in developed countries, and is often due to the imposition of exogenous rules such as those that govern school enrollment. In our study, the

[6] Leight (2017) uses data from the GSCF survey, i.e., from a specific province of China.

winter birth disadvantage arises in response to environmental circumstances that shape household resources and the resulting investments in children. Second, our study is unique in that we are able to identify channels by which the initial health disadvantage at younger ages does not manifest itself in long-term cognitive and non-cognitive shortages. Specifically, we show that parental expectations play a key role in directing educational and time resources to girls born in winter. Finally, we demonstrate the robustness of our results using a range of alternative specifications including different ways of categorizing the year into seasons. Amongst other things, this allows us to cast light on the potential *nature versus nurture* origins of the results that we document.

We set the context for the findings of our paper by discussing child height and nutritional challenges in China. We begin this discussion by focusing first on relevant studies that use the same source of data as we do – the nationally representative China Family Panel Studies (CFPS) data (Zheng et al., 2019, Cui et al., 2019). Zheng et al. (2019) uses the 2012 and 2014 rounds of the CFPS data to study the impact of the National Rural Pension Scheme on child health (measured by child height-for-age z-scores) and finds that the scheme has a positive effect on the health of *left behind* boys.[7] Cui et al. (2019) uses all four rounds of the CFPS data (as we do) to analyze the impact of maternal education on children's human capital and finds that the compulsory schooling laws in China (used as an instrument) that influenced maternal education improved children's school enrollment, test scores in Mathematics, general health (measured by child HAZ scores), mental health, and the incidence of being underweight. The mechanism for these results was better mental health and parenting by educated mothers.[8] A final recent relevant study that uses a different source of data (RUMiC) to investigate Chinese children's human capital is Meng and Yamauchi (2017), who evaluate the impact of parental migration on children's education and health and finds significant negative consequences on children who are thus exposed.[9] Other recent studies that have considered child height and stunting in China include Luo et al. (2014), Ouyang et al. (2019) and Wang et al. (2019). While HAZ is higher in these studies (rates of stunting are lower), their context is quite specific in nature in focusing on certain provinces (Shanghai,

[7]The boys are *left behind* due to parental migration. Zheng et al. (2019) report height-for-age z-scores (HAZ) for children aged 0–15 years that are similar to those in our study. In our sample, the approximate national average of HAZ is -0.54 for children aged 0–5 years and 10–15 years. For children age 0–5 years, the average HAZ is -0.68.

[8]This study also reports average HAZ for children aged > 9 years that are similar to those in our study.

[9]The average HAZ in the rural sample of this study is -1.487, which is lower than in our case.

Anhui, Guangdong, Shaanxi), children born to healthy and educated mothers (as in Ouyang et al. (2019)), in tight age-groups (6–11 months as in Luo et al. (2014)), or in not constituting a representative sample: for example, Wang et al. (2019) use data from four sub-populations of rural China that comprise less than half of all children nationally.

The rest of the paper is organized as follows. Section 2 presents the estimation framework. Section 3 presents details on the data sets used and provides an overview of the key variables in our analysis. Section 4 presents the empirical results: Section 4.1 presents the results for the effects of season of birth on height-for-age z-scores (sample includes children aged 0–5 years); Section 4.2 presents the corresponding results on cognitive and non-cognitive test scores of children aged 10–15 years. We also present evidence on the channels through with the effects of initial conditions are mitigated in this section. Finally Section 5 concludes.

2 Estimation Framework

Given the sheer size of China as a country, there are vast differences in environmental conditions across the country. These include differences in terms of temperature, humidity, precipitation (and hence agricultural activities), sometimes even within the same calendar month (Song et al., 2011). A specific month therefore might not have equal significance in different parts of the country. For example, while the average temperature in Guangdong can reach 26 degree Celsius and the average rainfall is more than 200 millimeters in May, in the same month, average temperature in Shanxi is less than 17 degree Celsius and the average rainfall is around 50 millimeters. Not surprisingly, these two provinces also differ in terms of the main crops cultivated and the key months of the year for agriculture (for example, rice is the main crop in Guangdong where the key month is March/April, while wheat is the main crop of Shanxi where the important month is June).

In order to examine the effect of season of birth on children's outcomes, we consider similarities in patterns across climate zones in China in terms of their influence on agricultural production. The factor we focus on is rainfall, given that most agricultural regions of China are impacted by the Asian monsoon. The monsoon affects provinces in China at different time periods during the year however. The summer monsoon advances to southern China in mid-May and reaches the Yangtze River valley in mid-June when the *mei-yu* (or the plum rain) begins. The monsoon then progresses northward for the next three weeks to cover the remaining parts of China. The monsoon starts withdrawing in early September, and retreats across mainland China over the next months. Please see Zeng and Lu (2004) for more details. The regional variation in the onset of monsoon in China is illustrated in Figure 1 which shows that the southern provinces experience the onset of monsoons in May, provinces in the middle portion of the country experience the monsoons in June, and the rest of the country is impacted in July.

We construct seasons using these patterns to categorize time of birth of Chinese children as opposed to using their Gregorian month of birth. We sub-divide the year into four quarters: pre-monsoon, monsoon, post-monsoon and winter (reference season). For each province in the country, using data on average monthly rainfall over the period 1982–2012, the monsoon season is defined as the three consecutive months in a year with the highest average rainfall.[10] The three months immediately preceding the monsoon months are categorized as pre-monsoon; the three month immediately succeeding the monsoon months are categorized as post-monsoon. The remaining three months are the winter months. Constructing seasons based on this method implies that the months that make up each season varies across provinces. In other estimations, we use long run data on rainfall, thus allowing for richer variation in the timing of the monsoon's arrival across the country. For significant parts of the analysis, we combine the pre-monsoon, monsoon and post-monsoon seasons into a non-winter season in order to improve clarity.

Figure 2 presents the seasons across the different provinces of China. It is clear that the time of the onset of monsoon, and thus which months are categorized as particular seasons, varies considerably across provinces. For example, the provinces of Shanxi, Gansu and the Ningxia Hui Autonomous region are characterized by the relatively late onset of monsoons (starts in July), whereas Guangdong and Guangxi Zhuang Autonomous region are characterized by the relatively early onset of monsoons (the monsoons arrive in May). Agriculture in much of China is heavily rain-dependent; Figure A1 presents the crop calendar of the country with the regional

[10] The relevant rainfall data is available from http://https://en.climate-data.org/info/sources/.

distribution of where crops are grown predominantly. This shows that with the exception of winter wheat and rapeseed, there is very little agricultural production/activity during the winter months of December, January and February. These patterns provide evidence that agricultural households may be especially resource-constrained in winter.

Our main specification is given by

$$Z_{ih} = \mathbf{X}^{'}\beta + \sum_{s=1}^{3} \gamma_s \text{Season}_{ihs} + \delta_y + \varepsilon_{ih} \tag{1}$$

where $\text{Season}_{ihs} = 1$ if child i in household h is born in season s (pre-monsoon, monsoon, post-monsoon); the reference category is that the child is born in winter. **X** denotes a vector of child, household, parental and community characteristics that affect child outcomes and that are discussed in detail below; δ_y is a set of survey year fixed-effects, and ε_{ih} denotes idiosyncratic error.

In order to improve the cogency of presentation of results, we also estimate a modified version of equation (1):

$$Z_{ih} = \mathbf{X}^{'}\beta + \xi \text{ Non-winter}_{ih} + \delta_y + \varepsilon_{ih} \tag{2}$$

where $\text{Non-winter}_{ih} = 1$ if child i in household h is born in a non-winter (pre-monsoon, monsoon or post-monsoon) season. In this framework, ξ measures the effect of non-winter birth relative to winter birth. All other parameters in equation (2) are as in equation (1). In this (baseline) specification, given the rain data, there is no variation in the timing of seasons in each province over the relevant period. Consequently we are unable to control for province or year of birth fixed-effects in equations (1) and (2). In the alternative specifications that follow, we categorize seasons differently. That allows us to control for province fixed-effects (μ_p), year of birth fixed-effects (λ_b), and their interactions ($\mu_p \times \lambda_b$). Please see discussion in Section 4 for more details. We report results from weighted regressions with standard errors clustered at the household level in all estimations of equations (1) and (2) that follow.

3 Data

Our analysis primarily uses four waves of China Family Panel Studies (CFPS) data collected in 2010, 2012, 2014 and 2016.[11] The CFPS is a nationally representative longitudinal survey covering 25 provinces or equivalent administrative units that represents 94.5% of the Chinese population (Xie and Hu, 2014). The survey collected information on a range of individual (separate modules for adults and children), household and community characteristics. The 2010 wave consists of 14,798 households (33,600 adults and 8990 children), the 2012 wave consists of 13,315 households (35,719 adults and 8,620 children), the 2014 wave consists of 13,946 households, and finally the 2016 wave consists of 14,019 households (36,892 adults and 8427 children). A benefit of using the CFPS comes from the design of the household roster. The CFPS household roster provides basic information on all core (defined as those members who share one kitchen and have blood/marriage or adoption relations) and non-core family members (who share one kitchen and live in the family for 6 months or more in a year, but do not have blood/marriage or adoption relations), even when they are not at home at the time of survey. The availability of anthropometric measurements of children aged 0–5 years, and cognitive and non-cognitive test scores of children aged 10–15 years, are the other advantages.

Our health outcome variable is the height-for-age z-score (HAZ), the age- and gender-adjusted measure of height in standard deviations, which reflects a child's development relative to a reference population.[12] To avoid outliers and observations that are likely to be mis-measured, we restrict the sample to children whose HAZ $\in [-6, 6]$ as is usually done.[13] We use information on

[11] Data were also collected in 2011, however, the main purpose of the 2011 wave was to clarify the information collected in the 2010 wave and prepare for the 2012 wave.

[12] In the Early Childhood Development (ECD) literature specific to the developing world, height-for-age, which reflects health and nutrition conditions in the long run, is the most widely used measure of child health and well-being. See discussion in Strauss and Thomas (1998), Currie and Vogl (2013), Huang et al. (2013), and Meng and Yamauchi (2017), and the references cited there-in. We do not use weight-for-height or body mass index (BMI) as outcomes because they are likely to reflect temporary changes in nutrition and ambient conditions. This is because these measures fluctuate in the short-run in response to sickness and temporary nutritional deficiencies, and so are often very noisy.

[13] This is similar to the restriction used by Zheng et al. (2019) who also use the CFPS data. Figure A2 in the Appendix presents the distribution of the HAZ scores for the sample of children aged 0–5 years. The mean of the distribution is about -0.68 and the standard deviation is 2.2 (similar to that in Zheng et al., 2019). WHO guidelines suggest that inaccurate age reporting may be an issue in the data if the standard deviation of the z-scores exceeds 1.3 approximately. The age in months variable in the CFPS may indeed be over-estimated as the CFPS surveys calculate this variable by computing differences between the year and month of the survey and the year and month

children aged 0–5 years with complete data to study the influence of season of birth, yielding a sample of 8,046 children across the four survey rounds.

We use two modules of cognitive tests developed in CFPS as our measure of cognitive development. The first one (from the 2010 and 2014 waves) includes 34 vocabulary recognition questions and 24 standardized mathematics questions from topics covered in the standard curriculum in primary and secondary schools. These tests measure *crystallized intelligence* which is related to the knowledge acquired from education and experience. The second module (from the 2012 and 2016 waves) consists of a numerical reasoning test, and immediate and delayed word recalls. These tests are measures of *fluid intelligence* which is associated with the ability to memorize, analyze, and make reasoned decisions.[14] We use data from 15 self-evaluation questions administered to children aged 10–15 years to measure non-cognitive skills. We construct three indices determined by the first three factors obtained from a principle component analysis of these 15 questions. The score of each factor is the average of the scores of the item loadings of that factor. The items used to construct the three non-cognitive skill factors are similar to those in papers that measure the importance of this type of skill.[15] Details of the items and principal component analysis are presented in Table A2 in the Appendix. We label the three loaded factors as confidence, diligence and self-discipline (henceforth, *diligence*), and attitude towards teachers and schools (henceforth *attitude*). Our sample of adolescents consists of 10,923 children.

Given the time span covered by the 2010, 2012, 2014 and 2016 rounds of the CFPS data, we have only limited information on the same set of children when they are aged 0–5 years and when

of birth of the child: no information on the date of birth or the date of the survey is taken into account (these data are not collected). If age in months is over-estimated, then given a certain height, children may appear to be shorter for their age than they truly are; that is, HAZ scores may be lower on average. We ran several sensitivity checks based on recalibrating the age in months variable in the CFPS. Although the HAZ scores do appear to increase consequently, the standard deviation of the distribution remains more than 2. Given this and the evidence in other recently published papers that have also used the CFPS surveys and report HAZ scores for young and older children that are similar to what we report in this paper (Zheng et al. (2019) and Cui et al. (2019)), we leave our original HAZ measure unchanged.

[14] See Huang et al. (2015) for further details on these tests and what they imply for cognitive development.

[15] Heckman (2000) was the first and most path breaking in this realm. The non-cognitive test scores (see Table 9 in Heckman (2000)) include questions related to attitude towards schooling and education (10^{th} grade GPA, 11^{th} grade GPA, percent attending college 1 year after high school) etc.), diligence (skipped class, skipped day of school) and attitude and confidence (trust in parent, lying to parent, peer emotional support). Hence, the items we use to construct our non-cognitive skill factors (confidence, diligence and self-confidence, attitude towards school) are similar to those used in Heckman (2000). However, we are constrained by the data available in the CFPS and cannot use the exact survey measures in Heckman (2000).

they are aged 10–15 years. For the most part, we have height data for very young children but not their cognitive and non-cognitive test scores in adolescence; similarly, we have test scores for adolescents but not their height when very young. To ensure that older girls in agricultural households also suffered from relative height disadvantages in early childhood if born in winter, we use the fourth wave of the CFPS data collected in 2016. For a small sample, we have HAZ data when children are aged 4 or 5 years (using the 2010 wave), and information on cognitive and non-cognitive scores when they are 10 or 11 years (using the 2016 wave). As we detail below, in this sample, girls aged 10 or 11 in the 2016 wave experienced relative height deficits when younger if they were winter-born. We present these results in Section 4.2.2.

Descriptive statistics (means and standard errors) for the key outcome variables for children aged 0–5 and 10–15 are presented in Table 1, panels A and B respectively. The samples are organized into non-agricultural and agricultural households, and within these, by gender of the child. Households are classified as agricultural if they replied "Yes" to the survey question *Did your household gain income from agricultural activities?* All households replying 'Yes" own farm land and cultivate their land.[16] Either rice or wheat is the main crop grown by the majority of these households. Focusing first on the younger age group in Table 1, although variation by gender within non-agricultural or agricultural households are not statistically different for the majority of the variables, they are significantly different when variation across non-agricultural and agricultural households are considered, conditional on gender. Child outcomes in particular are better among non-agricultural households. Among children in the older age-groups (i.e., children aged 10–15), the descriptive statistics presented in Panel B of Table 1 show relatively more statistically discernible variation across genders within the same types of households, and by gender across types of households, especially for the cognitive and non-cognitive test score component of the outcome variables.

[16] We do not consider rural versus urban households *per se*, and choose instead to focus on agricultural and non-agricultural households in order to understand the influence of rainfall patterns. We believe that rainfall has particular relevance to agricultural households, and although there is likely to be substantial overlap between agricultural and rural households, not all households in rural areas are agricultural. Further, although many urban households are likely to be non-agricultural, there need not be one-to-one correspondence between these groupings. To focus the sample to one that is likely to be most impacted by rainfall uncertainty, and because the rural to agricultural and urban to non-agricultural correspondences are not unique, we prefer to use the agricultural/non-agricultural classification as opposed to the rural/urban one.

Table A1 in the Appendix presents the corresponding descriptive statistics for the parents, households and communities of the two sets of children (Panel A for children aged 0–5 and Panel B for children aged 10–15). For both groups of children, parents from non-agricultural households are notably older and more educated than those from agricultural households. Children from non-agricultural households are less likely to experience the absence of either father or mother (for reasons that include migration for work, divorce or death). In general, non-agricultural households are wealthier than their agricultural counterparts. Children from non-agricultural households also experience better living standards compared to children from agricultural households. Their families are more likely to use tap water for cooking whereas more than 50% of children from agricultural households use less hygienic sources of drinking water. Non-agricultural households are smaller, and have fewer school-age children and fewer elderly people. The descriptive statistics presented in Table A1 also reveal children in agricultural households are more likely to have at least one sibling. A comparison between the two age cohorts indicates that parents of children 0–5 years are more educated than parents of the older age cohort (a lower proportion of parents of young children have no education, and a higher proportion have completed senior high school and have college degrees). We control for all the relevant control variables from Table**??** in the estimations that follow.

The key dependent variables for children aged 0–5 years include HAZ and the proportion that is stunted (defined as HAZ < -2); outcomes for older children aged 10–15 years include HAZ and results on vocabulary, mathematics, numerical series, immediate word recall, and delayed word recall tests, and measures of confidence, diligence and self-discipline. Table 2 presents the averages for the outcome variables of interest in agricultural households by gender and season of birth (winter or non-winter birth).[17] The corresponding results for the non-agricultural households are available on request. Girls born in winter suffer a height deficit as compared to those born in the non-winter months, and importantly, the average HAZ is the lowest for winter-born girls. Differences in cognitive and non-cognitive test scores, and in parental expectations regarding average scores this/next semester and the highest level of education parents expect the child to

[17] Statistical differences across gender conditional on season of birth are evident in Table 2. In particular, winter-born boys are up to 0.3 standard deviations taller than winter-born girls in the 0–5 years age-group. There are measurable differences across cognitive and non-cognitive markers for the older 10–15 years age-group as well.

attain appear to be less pronounced across household types, child gender, and season of birth.[18]

4 Results

4.1 Short Run Results: The Effect of Season of Birth on Height-for-Age z-scores

Our primary regression results are presented in Tables 3 and 4 for the HAZ of the child and the likelihood of stunting, respectively. Columns 1–4 present results corresponding to equation (1), while columns 5–8 are the coefficients estimated from equation (2).

The results presented in Panel A Table 3 show that the season of birth has a statistically significant effect on HAZ of girls born in agricultural households. Relative to those born in the winter months (the excluded category), girls in agricultural households born in the pre-monsoon, monsoon and post-monsoon season are 0.11, 0.36 and 0.69 standard deviations taller for their age, respectively. The effect is largest for those born in the post-monsoon season. The results presented in columns 5–8 are consistent with those presented in columns 1–4. Relative to girls in agricultural households born in winter, girls in agricultural households born in non-winter months are 0.42 standard deviations taller for their age.[19] This is *the winter's tale*.

Panel A of Table 4 presents the results for equation (1) where the dependent variable is an indicator for stunting. These results show that as before, estimates are measured significantly in the sample of girls in agricultural households. Relative to girls born in winter, those born in the pre-monsoon, monsoon and post-monsoon season are respectively 4.3 percentage points (or 12.6% given the mean stunting rate of 0.34 for girls in agricultural households born in winter),

[18] The descriptive statistics presented in Table 2 combine children born in pre-monsoon, monsoon or post-monsoon periods into one group (non-winter born). In Figures A3, A4, and A5 we present the average HAZ, cognitive test scores and non-cognitive test scores by gender and season of birth, for each of the non-winter component seasons in agricultural households. The averages in these figures are consistent with those presented in Table 2.

[19] We do not estimate models with mother fixed-effects as we would not be able to condition on mother's height, a measure of genetic endowment, which is important in these models. Instead, we test that mother-specific (and household-specific) unobservables are not driving results. If they were, then a season of birth effect would be evident for all girls born to the same mother in the same household, irrespective of the child's season of birth. We find no evidence that this is the case. These regressions are available on request.

8.7 percentage points (25.3%) and 13.3 percentage points (39%) less likely to be stunted. The results corresponding to the specification given by equation (2) in columns 5–8 show that girls in agricultural households born in the non-winter months are 9.3 percentage points (or 27%) less likely to be stunted.

The rainfall data used in Panel A of Tables 3 and 4 are province level average monthly rainfall over the period 1982–2012. This gives us a single data point per province, which is insufficient to control for province or year of birth fixed-effects that are likely to be important. While rain data with regional and time variation are compiled for all weather stations across the country, the complete data are not publicly available. However, we have alternate rainfall data from 435 weather stations covering all provinces in China for the period 1901–2016.[20] Using this information, we compute province and month and year level average rainfall over the 20 years immediately prior to the birth of the index child. As before, for each province, the monsoon season in a particular year is defined as the three consecutive months with the highest average rainfall. This construction of the rain data allows seasons to differ across provinces and years, thus allowing controls for province and year fixed-effects. We use these alternate rain data to examine the robustness of our results. Figure A6 in the Appendix presents the classification of the monsoon season for a subset of Chinese provinces using these data.

The regression results in Panels B, C and D of Tables 3 and 4 use this alternative measure of seasons and progressively include province fixed-effects (μ_p), year of birth fixed-effects (λ_b), and interactions of province and year of birth fixed-effects ($\mu_p \times \lambda_b$). More specifically, the regression specification in Panel D is given by

$$Z_{ih} = \mathbf{X}'\beta + \sum_{s=1}^{3} \gamma_s \text{Season}_{ihs} + \mu_p + \lambda_b + (\mu_p \times \lambda_b) + \varepsilon_{ih} \tag{3}$$

In Panels B and C of Tables 3 and 4 we present estimates from restricted versions of equation (3) where in Panel C we include only μ_p, and in Panel D we include μ_p and λ_b, but not their interactions.

[20]These data are available from the Climatic Research Unit at the University of East Anglia.

In Tables 3 and 4, the results in Panels B, C and D are similar to those presented in Panel A: relative to girls born in winter, HAZ is significantly higher for girls born in the other three seasons of the year in agricultural households (though the effects are weaker for pre-monsoon births). This disadvantage for winter-born girls remains evident even when seasons are combined (columns 5–8).

Given that our primary results show presence of season of birth effects for girls in agricultural households, the rest of the paper focuses on this sub-group alone. Additionally, for the long run results of season of birth on cognitive and non-cognitive skills that follow, we focus on the comparison between girls born in winter and girls born in other seasons combined in agricultural households, i.e., we estimate the specification given in equation (2) for the sample of girls in agricultural households.[21]

4.1.1 Timing of Births

We check to ensure that season of birth is not endogenous. This may be salient if parents know that children born during specific times of the year are more likely to have lower health endowments. They might then plan to have children in seasons that are more favorable to health, resulting in the fact that children born in specific seasons constitute a non-random sample. Further, if during specific seasons of the year more children are born to richer and better educated households, then the season of birth effect could simply be attributed to differences in resources and information available to parents. For example, Buckles and Hungerman (2013) finds that women giving birth in winter in the US are different on observables from women giving birth in other times of the year: they are likely to be younger, less educated and less likely to be married (i.e., from a low socio-economic background). In the Chinese context, while there is evidence that timing of births may matter, it's labor market and socioeconomic implications are contradictory. For example Lau (2019), using data from Hong Kong, argues that children born in Dragon cohorts spend more time studying and exhibit higher math test scores (with effects being especially pronounced for

[21]Results for the other categories of children and those using the specification in equation (1) are available on request.

girls); however, evidence from Singapore suggests that because of the increased size of cohorts born in Dragon years, such children earn lower labor market incomes on average (Agarwal et al., 2019). Mocan and Yu (2017) notes that while Dragon and non-Dragon Chinese children do not differ in terms of observables (parental, household, or child-specific), the fact that parents expect their Dragon children to succeed leads them to invest more time and money in such children. Expectations thus become self-fulfilling as Dragon children are found to be more likely to have a college education. We address these issues below.

We begin by examining the importance of selection on unobservables in our context. To accomplish this, we follow Altonji et al. (2005) and Oster (2017) and compute δ, a measure of the strength of selection due to unobservables relative to selection due to observables. As is understood, $\delta = 1$ implies that the controls and unobservables are equally important. Alternatively $|\delta| < 1$ indicates that unobservables are relatively less important. The estimated values of δ are presented in Table 5. In twenty-six of the twenty-seven cases we examine, $|\delta| < 1$. There is only one instance where this threshold for $|\delta|$ is not met, underlining that selection on unobservables is not a major driver of results in our study.

Next we rule out differences in observables across seasons. In order to do this, we estimate the relationship between the probability of child i being born in the winter (Prob($S_i = 1$)) and education of the father and mother (E_i^f, E_i^m), age of the mother (Age_i^m), and the wealth quintile of the household (W_i), controlling for other measured individual and household characteristics. The empirical form is

$$Prob(S_i = 1) = f(\beta_1 E_i^f + \beta_2 E_i^m + \beta_3 Age_i^m + \beta_4 (Age_i^m)^2 + \beta_5 W_i + \gamma_s \bar{X}_i + \varepsilon_i); \tag{4}$$

Statistical significance of the coefficients $\beta_j, j = 1 \ldots 5$, would indicate that parental and household characteristics affect the probability of a child being born in winter, that is, the sample is non-random. The marginal effects from a logit regression for girls aged 0–5 years and 10–15 years in agricultural households born in the winter season are presented in Table 6, columns 1 and 2, respectively. These results show that virtually none of the parental and household characteristics are significant determinants of winter births. The set of χ^2 tests reported in the bottom panel of this table indicate that we cannot reject the null hypothesis that the observables are jointly 0. Hence there is little evidence of selection on observables in winter births.

Next, we estimate a modified version of equation (2) where we exclude individual, parental and household characteristics. This is done in order to demonstrate that the season of birth patterns in HAZ are not, either partially or fully, explained by differences in family characteristics. The corresponding regression results are presented in Table 7. A comparison of the result in column 8 of Panel A of Table 3 with that in column 3 of Table 7 shows that the coefficient estimate of the non-winter season of birth is close in magnitude and significance across the two specifications: the estimated coefficient is 0.42 standard deviations in Table 3 and 0.32 standard deviations in Table 7. Column 8 in Panel A of Table 4 reports that winter-born girls in agricultural households are 9.3 percentage points less likely to be stunted. The corresponding effect is 8.1 percentage points in column 4 of Table 7. We conclude that season of birth patterns are not dependent on observed characteristics.

Given the evidence, albeit conflicting, that parents may time births in Dragon years, we check to ensure that this is not the case in our data. The Dragon years relevant to us include 2000 and 2012. We begin by testing whether children born in these years differ systematically from children born in other years on important measurables. While we find weak evidence that HAZ is marginally higher in agricultural households for those born in Dragon years, children in non-Dragon years have slightly better math and vocabulary test scores. Further, on average, Dragon children are younger than non-Dragon children (18 months versus 34 months). However, there is no difference between these cohorts when it comes to numerical series tests, immediate word recall tests, delayed word recall tests, non-cognitive skills, or in parental expectations regarding average scores this/next semester, or in the highest educational level parents expect the child to attain in the future. Most compellingly, results in Table 3 remain virtually the same when children born in the Dragon years of 2000 and 2012 are excluded from the analysis.[22] Hence we find little evidence that our results are affected by selection of this nature.

[22]These results are available on request.

4.1.2 Nature versus Nurture

The next question we investigate is whether nature or nurture underlies our HAZ result. In particular we ask whether children born in specific seasons are inherently weaker (possibly because of what happens *in-utero* and/or genetic factors) at birth, or is the difference due to differential seasonal availability of resources after birth. Addressing this question is important for policy since the answer informs the timing of interventions necessary to effectively mitigate the negative consequences of winter birth. We estimate a variant of equation (1) where the dependent variable is the birth weight of the child in order to shed light on this issue.[23]

The regression results for birth weight are presented in column 1 of Table 8. There is no evidence that winter-born girls in agricultural households are inherently less healthy at birth on the basis of this marker: birth weight is not statistically different across girls born in non-winter seasons relative to those born in winter.[24] It appears therefore that it is allocations to children in the post-birth environment that are responsible for differences in the health of girls in agricultural households.[25] This is corroborated in Figure 3 which presents the smoothed values from a kernel-weighted local polynomial regression of HAZ on age in months of the child by season of birth. The sample is children aged 0–5 years in agricultural households. For boys (the right hand panel of Figure 3), the age-of-child patterns on HAZ are not systematically different by winter/non-winter as the confidence intervals overlap. For girls (the left hand panel of Figure 3), the confidence intervals overlap to begin with indicating that there is no difference in HAZ at birth and at very young ages by season of birth, but the lines diverge for relatively older girls in this age-group with those born in winter exhibiting significantly lower HAZs as compared to those born in the

[23] Unlike data from other developing countries, CFPS data on birth weight is not subjective and is precisely measured as most births happen in formal health facilities.

[24] A reason for this is because winter-born girls were likely in important developmental stages *in utero* in the monsoon and post-monsoon seasons, which are propitious for health as shown above.

[25] In unreported specifications, we include birth weight as an additional explanatory variable in the HAZ regressions. While birth weight is positively correlated with HAZ, the estimated effect of non-winter birth on HAZ remains unaltered, indicating that birth weight does not have additional explanatory power. These results are available on request.

non-winter months.[26]

In sum, the results presented in Tables 3–8 demonstrate that girls in agricultural households suffer from seasonal shortages in winter. Such shortages however do not appear to affect boys in agricultural households. The birth weight results underline that girls born in winter are not inherently weaker at birth; gender differences we document arise post-birth in these households.

4.1.3 Heterogeneity of Effects

Given that the explanation for the winter effect in early childhood is likely to be seasonal variations in resource availability within the household, we examine whether the season of birth effects differ between richer and poorer households. We categorize households as being more (households with less than median wealth) or less (households with at least median wealth) resource-constrained on the basis of wealth. These results are presented in columns 2 and 3 of Table 8. For non-winter born girls in poorer agricultural households, the HAZ is 0.48 standard deviations higher than the value for winter-born girls. The corresponding impact in relatively richer agricultural households is half the size at 0.24 standard deviations (and not statistically significant). This indicates that resource constraints that disproportionately affect poorer agricultural households are an important explanatory channel for our results. We also examine heterogeneity of impacts by geography. Northern China is different from southern China particularly in heating infrastructure; thus the effect of winter births might vary. However, we do not find any evidence for such variation in the impact of winter births on the HAZ of girls.[27]

[26] The reason why the curve for girls born in winter starts slightly later than the curve for girls born in non-winter in Figure 3 is because we do not have observations in that range for winter-born girls, possibly because data collection in these surveys was conducted in July and August (we have relatively more observations on younger girls who are born in non-winter).

[27] Winter-born girls in agricultural households in northern China are 0.56 standard deviations shorter than the non-winter-born girls in agricultural households in the same region. The corresponding effect in southern China is 0.54 standard deviations. These results are available on request.

4.1.4 Onset of Monsoon

Given the importance of the monsoon in agricultural societies, we implement an alternate though related model as a specification check of results obtained above. This model measures initial environmental conditions in months prior to the onset of the monsoon and shortly thereafter in order to unpack seasonal impacts. The estimating equation is given by

$$Z_{ih} = \mathbf{X}^{'}\beta + \sum_{k=-5}^{5} \gamma_k \text{Onset}_{ihk} + \delta_y + \varepsilon_{ih} \tag{5}$$

where $\text{Onset}_{ihk} = 1$ if child i in household h is born k months prior to the month of onset of the monsoon ($k < 0$), or born in the month of onset of the monsoon ($k = 0$), or born k months after the month of onset of the monsoon ($k > 0$). The reference category ($\text{Onset}_{ihk} = 0$) is the child is born 6 months after the month of onset of the monsoon. The month of onset of the monsoon is defined as in Zeng and Lu (2004) and presented in Figure 1.

The corresponding regression results for girls in agricultural households are presented in Table A4 and are consistent with those noted above. Relative to those born in winter (6 months post onset of monsoon), girls in agricultural households born in the month of onset of the monsoon, the month prior to the onset of monsoon or 3, 4 and 5 months post onset of monsoon, have significantly higher HAZ (column 1). The second column of this table presents results for stunting. Relative to girls born in winter, girls born in the month of onset of the monsoon, or 3 and 5 months post onset, are significantly less likely to be stunted. Hence, our result on the height deficit for winter-born girls in agricultural households remains robust irrespective of how we benchmark seasons.[28]

[28] Cummins (2013) and Agarwal et al. (2017) argue that the uneven timing of surveys across the year can induce differential mean age at measurement across months of birth of children, which can then translate into a difference in HAZ because of the HAZ-age profile. In light of this and following Cummins (2013), we examine different specifications of children's age. We use age in months (linear) and age in months and square of age in months (quadratic form), and categorize age of children into 5 groups (1–11 months, 12–23 months, 24–35 months, 36–47 months, and 48–59 months). We find that results with these alternate specifications for child's age remain qualitatively similar to those presented in Panel A of Table 3. These results are available on request.

4.2 Long Run Results: The Effect of Season of Birth on Cognitive and Non-cognitive Skills

A reason to be concerned with low HAZ when a child is young is because of evidence that these are often predictive of poor health and economic outcomes in the long run as discussed above. Health penalties in childhood have been found to significantly influence human capital and economic outcomes including, though not limited to, education, occupations, earnings, and labor supply. While medically possible (for example Emons et al., 2005), evidence of reversals in the context of developing countries is rare. An important reason for this is that environments in such countries that lead to deficiencies in the first place are unlikely to improve dramatically in the future.

Given the importance of cognitive and non-cognitive skills in determining economic outcomes, understanding whether they are affected by shocks in critical periods in early childhood is of value. Additionally, evaluating whether differences in human capital caused by early environmental disadvantages enlarge, persist, or decay as children grow is important for comprehending their evolution over time. There remains a lack of evidence on the potential for catch-up in the formation of cognitive and non-cognitive skills mainly because the detailed data required for such exercises have been missing. In particular, we need information on physical and cognitive controls during both childhood and in adolescence to be able to fully understand causal pathways. Importantly, if we find that negative initial conditions have few lasting implications beyond childhood, additional information on parental actions and expectations is required. A dataset with this level of richness allows us to open the black box of short and long-run impacts of negative shocks on children, and opens up avenues to answer questions on whether parents make compensatory investments so that the impact of such shocks diminish over a child's life. A significant advantage of the CFPS data is that it meets most of these informational requirements.

Table 9 presents the effects of season of birth on cognitive and non-cognitive test scores for girls in agricultural households aged 10–15 years, the adolescent time window in which these children are observed.[29] It is evident that season of birth does not have a significant effect.[30] Hence, while

[29] Details on how cognitive and non-cognitive skills are measured are presented in Section 3.

[30] These results hold even when we condition on girls' height in these models. We also do not find any effect of

season of birth matters for HAZ when girls in agricultural households are very young, there is little evidence that the effects persist over time.[31] Note that the results presented in column 2 of Table 6 and the results in columns 5–8 in Table A3 indicate that as with children aged 0–5 years, for this set of older children, we test and reject that births are timed. Further, as evident from columns 1 - 8 of Table 10, excluding individual, parental and household characteristics does not change the results in Table 9. This confirms that season of birth patterns are not correlated with these observables.

4.2.1 Role of Parental Expectations

A reason why height penalties in early childhood may not translate into cognitive and non-cognitive deficiencies in adolescence may be compensating investments on the part of parents (see, for example Cunha et al., 2010). This could take many forms including increased parental inputs in terms of nutrition, time and expenditures. We have data on time and expenditure investments and on parental expectations that we use to test for this. In particular, parental expectations are likely to be positively correlated with greater investments in children.[32] The descriptive statistics presented in Panel D of Table 2 show that parental expectations regarding the average score the child will achieve that year is slightly higher for winter-born than non-winter born girls in agricultural households. Considering parental expectations regarding the highest level of education the child will achieve in the last panel of Table 2, and focusing on the two highest categories of college/university bachelor or higher, it is clear that parental expectations for winter-born girls are not substantially lower than for non-winter born girls in agricultural households. Indeed, there is evidence that such expectations are slightly higher for girls born in the winter when it comes to the highest category of *higher education*.[33] Consequently, we hypothesize that

season of birth on cognitive and non-cognitive test scores of boys and girls aged 10–15 years in non-agricultural households, or on boys aged 10–15 years in agricultural households. Moreover, there is no evidence that the school starting age cut-off (September 1 in China) impacts these measures. These results are available on request.

[31] The insignificance of the non-winter dummy in Table 9 cannot be the result of all girls being treated less well than boys in agricultural households because as seen in Table 3, girls born in the non-winter season have higher HAZ scores as compared to girls born in the winter.

[32] Evidence from developing countries shows that parents respond to information/expectations on their children's ability (see, for example Dizon-Ross, 2018).

[33] These measures of parental expectations are similar to those in studies such as (Cunha et al., 2013) where mothers form expectations based on a child's health in early-life, and act on these expectations through time

parents form differential expectations across children born in the winter and act on them in a compensatory matter.[34] These actions are such that any initial height disadvantages in early childhood have few lasting consequences for the penalized winter-born child in the long run.[35]

Testing this hypothesis requires us to examine first whether there is a season of birth effect on parental expectations. In order to accomplish this, we estimate a variant of equation (2) where the dependent variables are the parents' expectations regarding the child's average test score that year and their expectations on the highest level of future education the child will achieve. These results are presented in Table 11: Panel A for child's average score and Panel B for the child's highest level of education. Of primary interest is the sample of girls in agricultural households as this is where the seasonal penalty in height for those who are winter-born was most evident (column 2). Here the coefficient estimate of the dummy for non-winter birth is negative and statistically significant indicating that parents in agricultural households hold higher expectations for girls born in winter than girls born in the non-winter season. We show that these higher expectations translate into relatively higher compensatory investments for girls born in winter as compared to girls born in other seasons. This is the mechanism by which initial poor health does not manifest itself in lower cognitive and non-cognitive achievement in the long run among winter-born girls in agricultural households.[36]

The inputs in the CFPS that are likely to be important in the realm of parental actions in this context include expenditures on education and time spent by girls in housework. In order to

investments to increase the formation of child's human capital. In the same manner, parents condition their expectations on the child's height in early life in our framework, and act on these by investing in their human capital.

[34] As the literature on children born in dragon years indicates, these expectations are important in China (see Mocan and Yu, 2017, Lau, 2019).

[35] That this is likely to be the case is clear when we consider HAZ patterns for girls in agricultural households using cross-sectional data over their complete 0–15 years. As seen in Figure 4, winter-born girls catch-up with their non-winter-born counterparts in terms of HAZ by the ages of 11–12 years on average.

[36] We note two things: first, the fact that this behavior on the part of parents when girls are older possibly contrasts their actions when these girls were very young suggests that parents are perhaps unaware of the extent of the health penalty that results for their winter-born daughters in early ages. Second, the mechanism that we outline might not be the only channel. Programs such as midday meals in school, or combinations of nutritional supplementation and psychological stimulation have also been shown to be efficient at fostering children's growth (Singh et al., 2013, Walker et al., 2005). Further, other considerations that might drive targeted parental investments include the expectation that girls born in winter, by virtue of their height disadvantage, may incur a future penalty in the marriage market. As the CFPS does not collect data on parental expectations regarding children's marriage prospects, we are unable to test this latter hypothesis explicitly.

test whether higher educational expectations for girls in agricultural households translate into comparatively higher time and money investments in them as compared to girls born in other seasons, we estimate two versions of equation (2) where the dependent variable is expenditure on education in one case and hours of housework engaged in by girls aged 10–15 years in the other. These regression results are presented in Table 12 and, as before, control for a range of child specific as well as parental and household characteristics. Further, these regressions condition on non-winter births as this was found to be the determinant of parental expectations above.[37] The estimates in columns 1 and 3 underline that parental expectations on average scores this/next semester and the highest level of education the child is expected to attain are positively associated with investments: expenditure on education is significantly higher. Similarly, the results in columns 2 and 4 show that parental expectations are negatively correlated with hours of housework performed by adolescent girls (the effects are estimated imprecisely in both columns; the t-statistic is over 1.0 in column 2 however). Hence, conditional on season of birth, parental expectations are the channel through which compensating inputs primarily in terms of increased education expenditures are operationalized for adolescent girls in agricultural households.

4.2.2 Robustness of Results on Compensating Investments

Given the time-span of the existing CFPS rounds, the sample that considers the same children as of age 5 and when they are adolescents is limited. The fourth wave of the CFPS data collected in 2016 allows us to track a subset of such children over time. We have HAZ data when children are aged 4 or 5 years using the 2010 wave, and data on cognitive and non-cognitive skills for these

[37] We estimated several variants of these models. First, when we exclude expectations, the coefficient on the non-winter dummy remains unaltered (results not reported). Next, we included interactions of the non-winter dummy and parental expectations in order to understand relative levels of compensatory investments made by parents. Results suggest that parental expectations have a relatively larger impact on winter-born girls: parental expectations on average score are associated with a greater increase in educational expenditure for winter-born girls relative to non-winter born girls, while parental expectations on the highest level of education are associated with a relatively larger decrease in time spent in housework for winter-born girls as compared to non-winter born girls. These "difference-in-difference" estimates, while always in the expected direction, are estimated imprecisely in several cases, perhaps due to measurement error in these variables that are collected retrospectively (both education expenditure and hours of housework are as of last year). These results are available on request. We also disaggregated the results in Table 12 by wealth quintiles of the household. This revealed that most of the impacts originate in agricultural households with above median levels of wealth. This is as expected since it is these households that are monetarily able to act on their expectations. Again, results are available on request.

same children when they are aged 10 or 11 years using the appropriate module from the 2016 wave.

Table A5 presents these results.[38] Understandably, this is a relatively small sample of 140 girls. Column 1 shows that very young girls born in winter have lower HAZ compared to girls born in other seasons of the year. The estimate on non-winter birth is in the same direction as before but not significant, possibly because of lack of power due to the small sample size. Columns 2–7 present the effects of season of birth on cognitive and non-cognitive test scores for these girls when they are adolescents. It is clear that our previous results on this front remain unaltered as well. Hence, using the same children who are observed when very young and in adolescence, we find trends that echo our earlier results: lower HAZ scores for winter-born 0–5 year old girls in agricultural households do not have lasting consequences on cognitive and non-cognitive test scores when these girls are older adolescents.

5 Conclusion

This paper uses data from four waves of the CFPS survey to analyze the relationship between conditions in early childhood (season of birth), health outcomes, and cognitive and non-cognitive scores of young children in China. Our results indicate that there is a season of birth effect on height-for-age z-scores of girls aged 0–5 years in agricultural households. Those born in winter suffer along this widely accepted measure of long term development as compared to girls born in other seasons. However, we do not find any evidence of persistence of these season of birth effects in adolescence. Winter-born girls aged 10–15 years are no worse off in terms of cognitive and non-cognitive skills as compared to girls born in other seasons. A possible mechanism to explain this is compensatory investments by parents. Indeed, we find that parents have greater expectations regarding the educational attainment of 10–15 year old girls born in winter relative to those born in other seasons. We find that these higher expectations translate into greater education and time inputs for winter-born girls. We show that such differential investments are

[38] The results in columns 2–7 control for HAZ of these children when they were 0–5 years old.

a reason why the relative height penalty in early childhood does not translate into measurable differentials in cognitive and non-cognitive skills in adolescence.

Although a topic of importance, son preference in resource allocations is not the focus of our study. The comparison that we spotlight is gender-specific in that we consider girls born in different seasons within the same household whose main source of income is agriculture. We do not compare varying allocations due to seasonal shortages to children of different genders resident within the same agricultural household. We also do not consider children of different genders born and resident in heterogeneous household types.

Our paper has several implications for policy in China. We find that among Chinese agricultural households, the relative HAZ disadvantage for girls in early life is larger in poorer households. This is in keeping with the understanding that it is these households that are likely to be the worst off in the winter months. They are thus a clearly delineated group that is most vulnerable and readily identifiable for ameliorative actions on the part of local governments and non-governmental organizations in China. An example of a program that has benefited at-risk children who have been *left behind* by virtue of parental migration in rural areas of China is the National Rural Pension Scheme as evaluated in Zheng et al. (2019). The results of our study underline that the scale-up and effective administration of such programs would be beneficial not just to Chinese children whose parents have migrated, but to all children in agricultural households, especially girls. Further, although we find that Chinese agricultural households take remedial actions on their own to insulate girls who are at most risk such that they do not suffer in the long run, easing the burden for these households may both free up resources and improve the effectiveness of actions that parents adopt. Strategies to assist these households to invest in their winter-born girls particularly in terms of increasing their education is likely to accrue returns inter-generationally (Cui et al., 2019). Moreover, as noted in Wang et al. (2019), resource interventions are likely to be even more productive when paired with training/knowledge to raise rates of interactive parental styles that are low in rural China (and also in other comparable middle-income developing countries). Finally, reducing the vulnerability of Chinese agricultural households to weather patterns by encouraging diversification of income sources and by making it possible for such households to adopt alternative means of sustenance should serve to further shield children from the unpredictable vagaries of weather.

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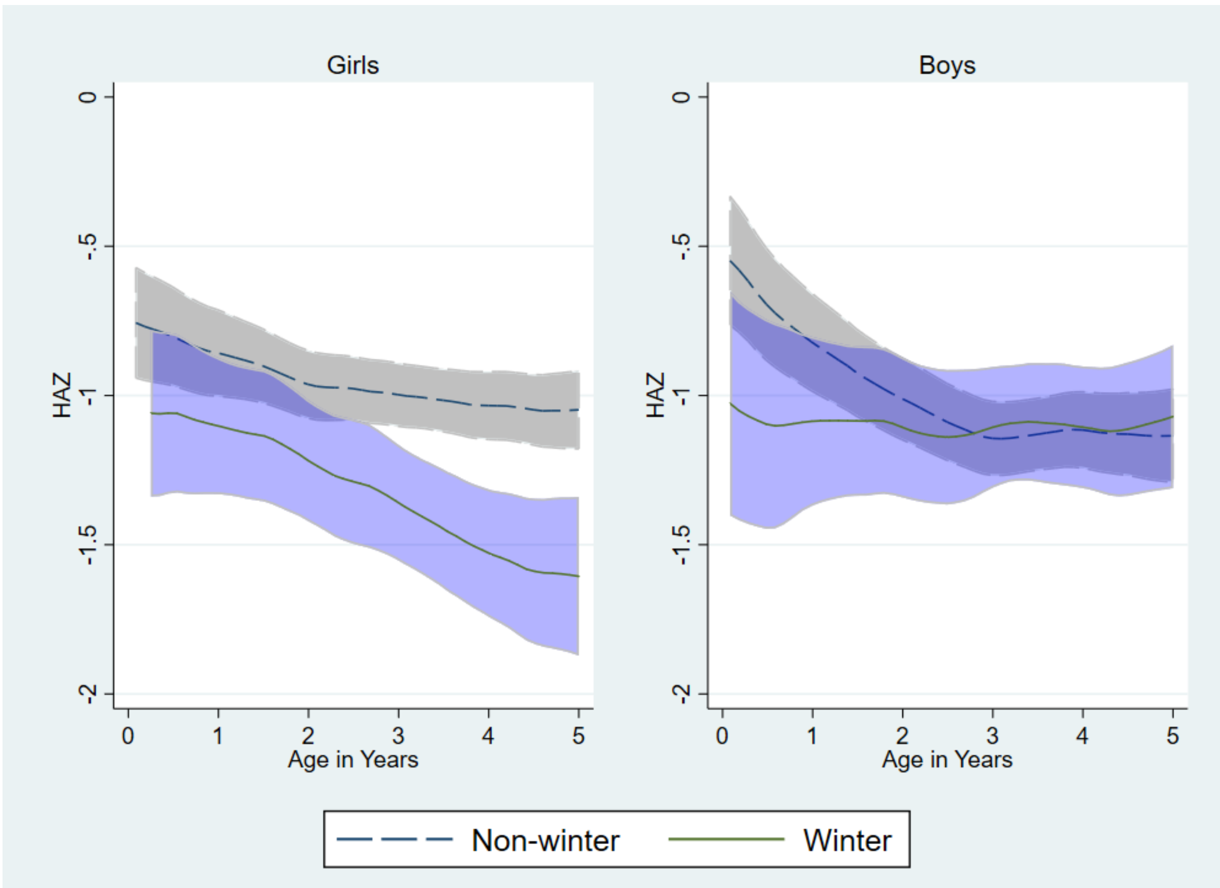
Figure 1: Onset of Monsoon Across Provinces of China

Notes: We follow Zeng and Lu (2004) in defining the onset of the monsoon across provinces of China.

Figure 2: Pre-Monsoon, Monsoon, Post-Monsoon and Winter Months in the Different Provinces of China

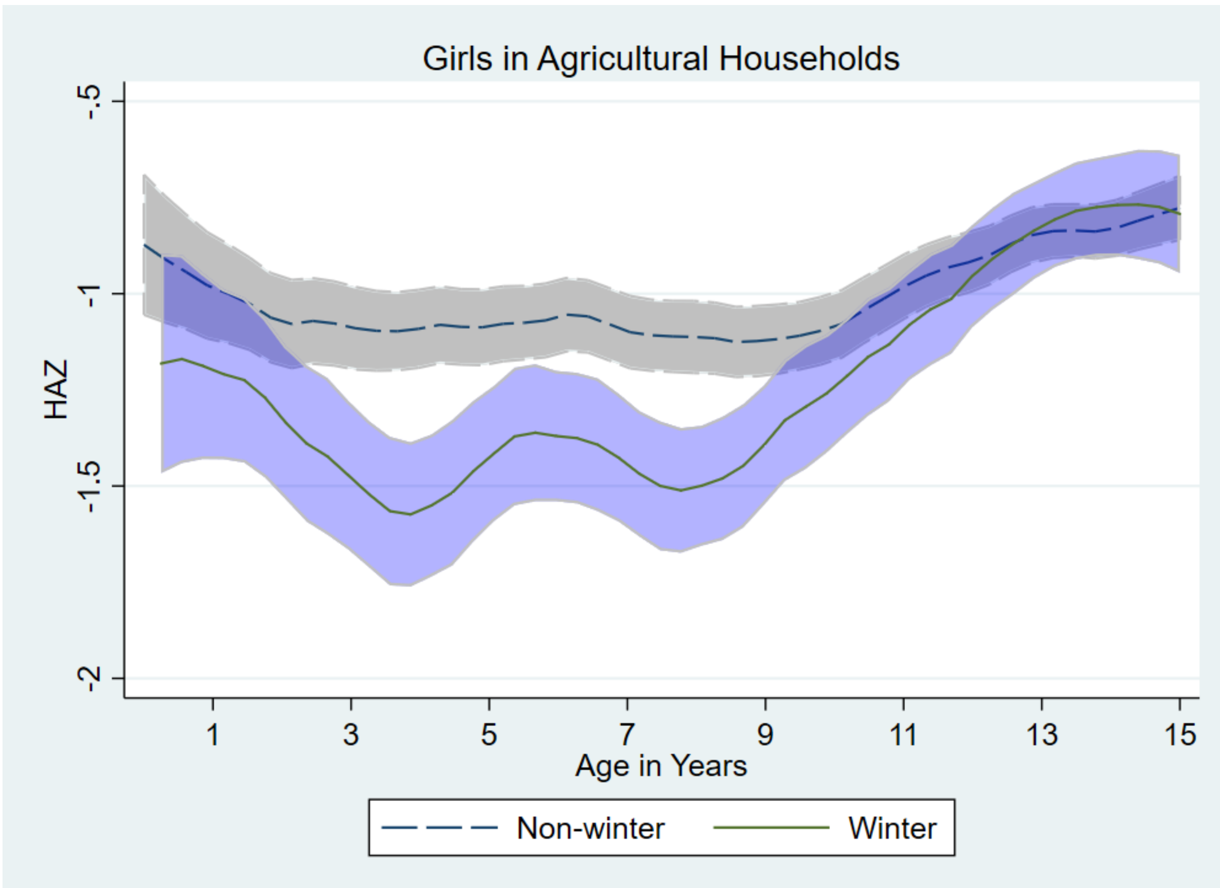
Notes: These seasons are defined as in Figure 1. Using data on average monthly rainfall over the period 1982–2012, the monsoon season in each province is defined as the three consecutive months in a year with the highest average rainfall. The three months immediately preceding the monsoon months are categorized as pre-monsoon; the three month immediately succeeding the monsoon months are categorized as post-monsoon. The remaining three months are the winter months.

Figure 3: Age and Height-for-Age z-scores of Children Aged 0–5 in Agricultural Households



Notes: Smoothed values from a kernel-weighted polynomial regression of unweighted HAZ on age (in months) and the 90% confidence interval (shaded area) presented. Sample restricted to girls aged 0–5 years, residing in agricultural households. Data from CFPS waves 2010, 2012, 2014 and 2016 are used.

Figure 4: Age and Height-for-Age z-scores Children Aged 0–15 in Agricultural Households



Notes: Smoothed values from a kernel-weighted polynomial regression of unweighted HAZ on age (in months) with the corresponding 90% confidence interval (shaded area) are presented. Sample is children aged 0–15 years residing in agricultural households. Data from CFPS waves 2010, 2012, 2014 and 2016 are used.

Table 1: Descriptive Statistics by Household Type and Gender of the Child. Child Outcomes

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Children aged 0–5 years								
Child-specific								
Height for Age z-score (HAZ)	-0.343	-0.355	0.012	-0.974	-0.974	0.000	0.631***	0.619***
	(0.051)	(0.051)	(0.072)	(0.046)	(0.047)	(0.066)	(0.069)	(0.069)
Birth weight	3.364	3.246	0.118***	3.333	3.193	0.140***	0.031**	0.053***
	(0.012)	(0.012)	(0.017)	(0.011)	(0.011)	(0.016)	(0.017)	(0.016)
Stunted	0.204	0.185	0.019	0.315	0.281	0.034***	-0.111***	-0.096***
	(0.010)	(0.010)	(0.014)	(0.009)	(0.009)	(0.013)	(0.013)	(0.013)
Sample size	1717	1620		2467	2242			
Panel B: Children aged 10–15 years								
Child-specific								
Height for Age z-score (HAZ)	0.13	-0.181	0.311***	-0.817	-0.841	0.024	0.947***	0.660***
	(0.032)	(0.030)	(0.044)	(0.027)	(0.028)	(0.039)	(0.041)	(0.041)
Cognitive score: Percentage of correct answers								
Mathematical Test	0.489	0.503	-0.014	0.430	0.438	-0.008	0.059***	0.065***
	(0.005)	(0.006)	(0.008)	(0.004)	(0.004)	(0.006)	(0.007)	(0.007)
Vocabulary Test	0.670	0.699	-0.029***	0.596	0.635	-0.039***	0.074***	0.064***
	(0.006)	(0.006)	(0.009)	(0.005)	(0.005)	(0.007)	(0.008)	(0.008)
Immediate Word Recall	0.644	0.654	-0.01	0.589	0.623	-0.034	0.055***	0.031***
	(0.006)	(0.005)	(0.008)	(0.004)	(0.004)	(0.006)	(0.007)	(0.008)
Delayed Word Recall	0.572	0.57	0.002	0.522	0.541	-0.019***	0.050***	0.029***
	((0.007)	(0.007)	(0.010)	(0.005)	(0.005)	(0.007)	(0.008)	(0.009)
Numerical Series Test	0.687	0.641	0.046***	0.623	0.586	0.037***	0.064***	0.055***
	(0.008)	(0.010)	(0.012)	(0.006)	(0.007)	(0.009)	(0.011)	(0.011)
Non-cognitive scores								
Confidence	3.057	3.207	-0.150***	3.024	3.197	-0.173***	0.033	0.010
	(0.016)	(0.016)	(0.023)	(0.012)	(0.013)	(0.018)	(0.020)	(0.021)
Diligence and self-discipline	3.628	3.771	-0.143***	3.611	3.803	-0.192***	0.017	-0.032**
	(0.012)	(0.011)	(0.017)	(0.009)	(0.009)	(0.012)	(0.015)	(0.014)

Continued . . .

Descriptive Statistics by Household Type and Gender of the Child. Child Outcomes (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Attitude towards school and teacher	4.104	4.187	-0.083***	3.996	4.12	-0.124***	0.108***	0.067***
	(0.017)	(0.016)	(0.024)	(0.013)	(0.013)	(0.018)	(0.021)	(0.021)
Sample size	1,974	1,856		3,655	3438			

Notes: Authors' calculations using the CFPS data. Panel A: Sample includes children aged 0–5 years in CFPS waves 2010, 2012, 2014 and 2016. Panel B: Sample includes children aged 10–15 years in CFPS waves 2010, 2012, 2014 and 2016. Weighted descriptive statistics presented.

Table 2: **Descriptive Statistics on Outcome Variables by Season of Birth in Agricultural Households**

	Boys			Girls			Boys–Girls	
	Non-winter	Winter	Difference	Non-winter	Winter	Difference	Non-winter	Winter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Height for Age z-scores†								
0-5 years old	-1.01	-0.89	-0.12	-0.90	-1.21	0.31***	-0.11	0.32**
	(0.05)	(0.09)	(0.10)	(0.05)	(0.10)	(0.11)	(0.08)	(0.13)
10-15 years old	-0.82	-0.81	0.01	-0.84	-0.82	-0.02	0.02	0.01
	(0.03)	(0.05)	(0.06)	(0.03)	(0.05)	(0.06)	(0.05)	(0.07)
Panel B: Cognitive score (Percentage of correct answer)‡								
Vocabulary Test	0.59	0.61	-0.2	0.63	0.65	-0.2	-0.04***	-0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mathematical Test	0.43	0.43	0.00	0.43	0.45	0.02	0.00	0.02
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Numerical Series Test	0.62	0.63	0.01	0.58	0.61	0.02	0.04***	0.02
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
Immediate Word Recall	0.59	0.58	0.01	0.62	0.62	0.00	-0.03***	-0.04***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Delayed Word Recall	0.53	0.50	0.03**	0.54	0.54	0.00	-0.01	-0.04**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Panel C: Non-cognitive scores‡								
Confidence	3.02	3.04	-0.02	3.20	3.19	0.01	-0.18***	-0.15***
	(0.01)	(0.02)	(0.03)	(0.01)	(0.03)	(0.03)	(0.02)	(0.03)
Diligence and self-discipline	3.61	3.61	0.00	3.81	3.78	0.03	-0.20	-0.17
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
Attitude towards school and teacher	4.01	3.96	0.05	4.13	4.08	0.05	-0.12***	-0.12***
	(0.02)	(0.02)	(0.03)	(0.02)	(0.03)	(0.03)	(0.02)	(0.04)
Panel D: Parental expectation regarding average score‡								
Child's score	89.18	89.21	-0.03	90.65	91.37	0.72**	-1.47***	2.16
	(0.19)	(0.33)	(0.39)	(0.19)	(0.32)	(0.38)	(0.27)	(0.47)
Panel E: Parental expectation regarding the highest level of education the child will attain‡								
Primary	0.02	0.00	0.02***	0.02	0.01	0.01	0.00	-0.01*
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
Junior high school	0.03	0.02	0.01	0.04	0.04	0.00	-0.01	-0.02*
	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Senior high school	0.16	0.15	0.01	0.16	0.14	0.02	0.00	0.01
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)
College/University	0.67	0.69	-0.02	0.66	0.66	0.00	0.01	0.03
	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.03)
Higher education	0.12	0.14	-0.02	0.11	0.16	-0.05***	0.01	-0.02
	(0.01)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)

Notes: Seasons are defined as in Figure 2. Standard errors in parenthesis. †: Sample includes children residing in agricultural households. Sample restricted to children aged 0–5 years with non-missing height and age. Data from CFPS waves 2010, 2012, 2014 and 2016 used. ‡: Sample restricted to children aged 10–15 years at the time of the survey. Data from CFPS waves 2010, 2012, 2014 and 2016 used. Weighted descriptive statistics presented.

Table 3: Season of Birth and Height-for-Age z-score

	Non-agricultural Households		Agricultural Households		Non-agricultural Households		Agricultural Households	
	Boys (1)	**Girls** (2)	**Boys** (3)	**Girls** (4)	**Boys** (5)	**Girls** (6)	**Boys** (7)	**Girls** (8)
Panel A: Height-for-Age z-score (HAZ)								
Pre-monsoon	-0.119	-0.070	-0.163	0.107				
	(0.222)	(0.211)	(0.196)	(0.197)				
Monsoon	-0.083	-0.035	-0.117	0.358*				
	(0.224)	(0.219)	(0.189)	(0.197)				
Post-monsoon	0.147	0.058	-0.150	0.686***				
	(0.193)	(0.202)	(0.181)	(0.172)				
Non-winter					-0.012	-0.013	-0.143	0.419***
					(0.163)	(0.171)	(0.151)	(0.155)
Panel B: HAZ (Including Province Fixed-Effects)								
Pre-monsoon	-0.189	-0.003	-0.140	0.151				
	(0.141)	(0.185)	(0.216)	(0.169)				
Monsoon	-0.046	0.010	-0.215	0.408*				
	(0.225)	(0.239)	(0.146)	(0.222)				
Post-monsoon	0.267	0.012	-0.178	0.523***				
	(0.171)	(0.178)	(0.145)	(0.145)				
Non-winter					0.013	0.006	-0.178	0.384***
					(0.133)	(0.157)	(0.141)	(0.134)
Panel C: HAZ (Including Province Fixed-Effects and Year of Birth Fixed-Effects)								
Pre-monsoon	-0.184	-0.011	-0.117	0.153				
	(0.208)	(0.197)	(0.188)	(0.193)				
Monsoon	-0.020	0.022	-0.212	0.427**				
	(0.209)	(0.207)	(0.194)	(0.196)				
Post-monsoon	0.228	-0.003	-0.151	0.526***				
	(0.189)	(0.194)	(0.187)	(0.174)				
Non-winter					0.006	0.002	-0.160	0.388**
					(0.156)	(0.163)	(0.152)	(0.155)
Panel D: HAZ (Including Province Fixed-Effects and Year of Birth Fixed-Effects and Their Interactions)								
Pre-monsoon	-0.193	-0.042	-0.079	0.131				
	(0.261)	(0.247)	(0.212)	(0.226)				
Monsoon	0.117	0.082	-0.187	0.390*				
	(0.225)	(0.276)	(0.206)	(0.203)				
Post-monsoon	0.221	-0.145	-0.261	0.448**				
	(0.256)	(0.244)	(0.238)	(0.210)				
Non-winter					0.039	-0.033	-0.185	0.334*
					(0.181)	(0.211)	(0.182)	(0.170)

Continued ...

Season of Birth and Height-for-Age z-score (Continued)

	Non-agricultural Households		Agricultural Households		Non-agricultural Households		Agricultural Households	
	Boys (1)	**Girls** (2)	**Boys** (3)	**Girls** (4)	**Boys** (5)	**Girls** (6)	**Boys** (7)	**Girls** (8)
Average for winter-born	-0.431	-0.297	-0.892	-1.212	-0.431	-0.297	-0.892	-1.212
Sample Size	1,498	1,403	2,280	2,083	1,498	1,403	2,280	2,083

Notes: Sample includes data from CFPS waves 2010, 2012, 2014 and 2016. Weighted OLS regression results presented; weights provided by CFPS. Sample restricted to children aged 0–5 years, with non-missing values for height and age. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father, mother's height), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

†: Seasons defined using average monthly rainfall over the period 1982–2012. See Figure 2 for categorization of seasons.

‡: Seasons defined using moving average of monthly rainfall for 20 years prior to birth of the child. Rainfall data were collected in 435 weather stations across the country. Every province is represented.

Table 4: Season of Birth and Stunting

	Non-agricultural Households		Agricultural Households		Non-agricultural Households		Agricultural Households	
	Boys	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Stunting								
Pre-monsoon	0.001	-0.015	-0.006	-0.043				
	(0.037)	(0.040)	(0.041)	(0.039)				
Monsoon	0.009	0.016	0.032	-0.087**				
	(0.042)	(0.037)	(0.040)	(0.039)				
Post-monsoon	-0.016	-0.003	0.007	-0.133***				
	(0.036)	(0.035)	(0.039)	(0.034)				
Non-winter					-0.002	-0.001	0.011	-0.093***
					(0.030)	(0.029)	(0.032)	(0.031)
Panel B: Stunting (Including Province Fixed-Effects)								
Pre-monsoon	0.008	-0.019	-0.007	-0.043				
	(0.040)	(0.027)	(0.061)	(0.036)				
Monsoon	0.003	0.019	0.063*	-0.097*				
	(0.038)	(0.041)	(0.034)	(0.054)				
Post-monsoon	-0.048	0.011	0.015	-0.124***				
	(0.031)	(0.039)	(0.042)	(0.037)				
Non-winter					-0.013	0.004	0.023	-0.093**
					(0.029)	(0.028)	(0.040)	(0.037)
Panel C: Stunting (Including Province Fixed-Effects and Year of Birth Fixed-Effects)								
Pre-monsoon	0.007	-0.016	-0.010	-0.039				
	(0.038)	(0.040)	(0.040)	(0.038)				
Monsoon	0.000	0.015	0.066*	-0.095**				
	(0.042)	(0.036)	(0.040)	(0.039)				
Post-monsoon	-0.040	0.011	0.016	-0.122***				
	(0.034)	(0.036)	(0.039)	(0.035)				
Non-winter					-0.011	0.003	0.024	-0.090***
					(0.030)	(0.030)	(0.032)	(0.031)
Panel D: Stunting (Including Province Fixed-Effects and Year of Birth Fixed-Effects and Their Interactions)								
Pre-monsoon	-0.038	0.009	-0.022	-0.037				
	(0.049)	(0.051)	(0.048)	(0.042)				
Monsoon	-0.053	0.014	0.041	-0.096*				
	(0.048)	(0.057)	(0.044)	(0.052)				
Post-monsoon	-0.053	0.034	0.033	-0.096**				
	(0.050)	(0.052)	(0.050)	(0.043)				
Non-winter					-0.047	0.019	0.020	-0.078**
					(0.038)	(0.046)	(0.039)	(0.038)

Continued . . .

Season of Birth and Stunting (Continued)

	Non-agricultural Households		Agricultural Households		Non-agricultural Households		Agricultural Households	
	Boys (1)	**Girls** (2)	**Boys** (3)	**Girls** (4)	**Boys** (5)	**Girls** (6)	**Boys** (7)	**Girls** (8)
Average for winter-born	0.228	0.179	0.311	0.342	0.228	0.179	0.311	0.342
Sample Size	1,498	1,403	2,280	2,083	1,498	1,403	2,280	2,083

Notes: Dependent variable: child is stunted, defined as height-for-age z-score < -2. Sample includes data from CFPS waves 2010, 2012, 2014 and 2016. Weighted OLS regression results presented; weights provided by CFPS. Sample restricted to children aged 0–5 years, with non-missing values for height and age. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father, mother's height), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01;^{**} p < 0.05;^{*} p < 0.1$.
†: Seasons defined using average monthly rainfall over the period 1982–2012. See Figure 2 for categorization of seasons.
‡: Seasons defined using moving average of monthly rainfall for 20 years prior to birth of the child. Rainfall data were collected in 435 weather stations across the country. Every province is represented.

Table 5: Selection on Unobservables in Agricultural Households

	Pre-Monsoon (1)	**Monsoon** (2)	**Post-Monsoon** (3)
HAZ	-0.028	-0.284	-3.182
Mathtest	-0.081	0.000	0.282
Wordtest	-0.926	-0.695	0.138
Numerical series test	-0.163	-0.014	0.080
Immediate Word Recall	-0.059	-0.103	0.141
Delayed Word Recall	0.081	-0.057	0.132
Confidence	0.057	0.054	-0.069
Hard working	0.174	0.017	-0.051
Attitude	-0.004	-0.436	0.020

Notes: Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Weights provided by CFPS. Sample includes girls in agricultural households. Estimated values of δ are presented in the table. See Oster (2017) for more details.

Table 6: Representativeness of Winter Birth in Agricultural Households

	Girls Aged 0–5 Years (1)	Girls Aged 10–15 Years (2)
Father Education: Primary	-0.022	0.002
	(0.048)	(0.027)
Father Education: Junior	-0.058	0.018
	(0.049)	(0.028)
Father Education: Senior	-0.064	-0.049
	(0.054)	(0.043)
Father Education: College	0.034	-0.100**
	(0.078)	(0.050)
Mother Education: Primary	0.005	-0.017
	(0.038)	(0.023)
Mother Education: Junior	0.045	-0.014
	(0.039)	(0.029)
Mother Education: Senior	0.018	0.057
	(0.049)	(0.056)
Mother Education: College	-0.065	0.071
	(0.057)	(0.057)
Wealth Quintile 2	0.006	0.004
	(0.034)	(0.024)
Wealth Quintile 3	0.001	-0.003
	(0.034)	(0.026)
Wealth Quintile 4	0.006	-0.007
	(0.035)	(0.029)
Wealth Quintile 5 (= Highest)	0.027	0.007
	(0.041)	(0.037)
Sample Size	2,149	3,438
Joint Significance of Explanatory Variables		
Education of mother ($\chi^2(4)$)	5.540	4.020
	[0.237]	[0.404]
Education of father ($\chi^2(4)$)	5.000	5.520
	[0.288]	[0.238]
Wealth quintiles ($\chi^2(4)$)	0.620	0.300
	[0.961]	[0.990]
All ($\chi^2(42)$)	11.830	13.530
	[0.620]	[0.485]

The dependent variable takes the value of 1 if the child is born in winter, 0 otherwise. Marginal effects from unweighted logit regressions (equation (4)) are presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample in columns 1 restricted to girls in agricultural households aged 0–5 years with non-missing values for height and age. Sample in column 2 restricted to girls in agricultural households aged 10–15 years with non-missing values for test scores. Seasons are defined in Figure 2. Regressions control for age of father, age of father squared, mother's height, residential status of mother and father, household size and composition, household facilities, age and birth order of child, and survey year. Significance: $^{***}p < 0.01;^{**} p < 0.05;^{*} p < 0.1$. Standard errors clustered by household in parenthesis. The square brackets denote the p-values of the χ^2 tests of the joint significance of the explanatory variables.

Table 7: Season of Birth and Height-for-Age z-score and Stunting, Excluding Controls

	HAZ (1)	**Stunting** (2)	**HAZ** (3)	**Stunting** (4)
Pre-monsoon	0.053	-0.035		
	(0.138)	(0.027)		
Monsoon	0.362***	-0.083***		
	(0.135)	(0.027)		
Post-monsoon	0.486***	-0.113***		
	(0.128)	(0.025)		
Non-winter			0.321***	-0.081***
			(0.110)	(0.022)
Constant	-1.562***	0.406***	-1.554***	0.404***
	(0.134)	(0.026)	(0.134)	(0.026)
Sample size	2330	2330	2330	2330

Notes: Weighted OLS regression results presented. Dependent variable is height-for-age z-score (HAZ), and whether the child is stunted (height-for-age z-score< -2). Sample includes girls aged 0–5 years in agricultural households with non-missing values for height and age. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Regressions only control for the survey years. Standard errors clustered at the household level in parenthesis. Seasons are defined as in Figure 2. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

Table 8: Season of Birth Effect on Birthweight and Heterogeneity in Height-for-Age z-scores by Household Wealth for Girls in Agricultural Households

	Birthweight†	Height-for-Age z-score‡	
		Below Median Wealth	Above Median Wealth
Non-winter Birth	0.001	0.478**	0.243
	(0.042)	(0.221)	(0.203)
Constant	2.680***	-6.674***	-5.672*
	(0.466)	(2.581)	(2.951)
Sample size	1,963	1,116	967
Average for Winter-born	3.206		

Notes: Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample includes girls aged 0–5 years in agricultural households with non-missing values for birth weight. Weighted OLS regression results presented; weights provided by CFPS. Seasons are defined as in Figure 2. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father, mother's height), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}\ p < 0.05$;$^{*}\ p < 0.1$.

†: Dependent variable is birth weight (in 1000 grams).

‡: Separate regressions for households with below median wealth (column 2) and households with above median wealth (column 3).

Table 9: Season of Birth and Cognitive and Non-Cognitive Test Scores for Girls in Agricultural Households

	Cognitive Test Scores					Non-Cognitive Test Scores		
	Numerical test (1)	Vocabulary test (2)	Numerical series test (3)	Intermediate word recall test (4)	Delayed word recall test (5)	Confidence (6)	Diligence and self-discipline (7)	Attitude (8)
Non-winter Birth	-0.053	-0.090	-0.054	-0.076	-0.043	-0.005	0.019	-0.001
	(0.075)	(0.077)	(0.132)	(0.122)	(0.129)	(0.043)	(0.029)	(0.044)
Constant	-9.626***	-6.136***	-2.216	0.870	0.810	4.375***	4.348***	4.461***
	(1.858)	(2.216)	(1.824)	(1.863)	(1.721)	(0.917)	(0.570)	(1.451)
Sample size	1,704	1,704	1,141	1,326	1,313	2,778	2,796	2,579

Notes: Weighted OLS regression results presented; weights provided by CFPS. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample includes girls aged 10-15 years in agricultural households with non-missing test scores. In Panel A, the dependent variable is the quintile rank of a child's test score. In Panel B, the dependent variable is the score on non-cognitive tests. Seasons are defined as in Figure 2. Regressions control for a set of individual (age, birth order), parental cognitive ability (Panel A) and education (Panel B), age and residential status of mother and father, and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

Table 10: Season of Birth and Cognitive and Non-Cognitive Test Scores for Girls in Agricultural Households, Excluding Controls

	Numerical test (1)	Vocabulary test (2)	Numerical series test (3)	Intermediate word recall test (4)	Delayed word recall test (5)	Confidence (6)	Diligence and self-discipline (7)	Attitude towards teachers and school (8)
Non-winter	-0.117	-0.164*	-0.168	-0.027	-0.076	0.008	0.027	0.048
	(0.093)	(0.093)	(0.139)	(0.136)	(0.137)	(0.043)	(0.028)	(0.046)
Constant	2.820***	3.009***	2.791***	2.384***	2.678***	3.206***	3.697***	3.995***
	(0.085)	(0.089)	(0.135)	(0.123)	(0.125)	(0.044)	(0.028)	(0.047)
Sample Size	1,808	1,808	1,252	1,449	1,434	3,239	3,262	2,995

Weighted OLS regression results presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample includes girls aged 10-15 years in agricultural households with non-missing test scores. In columns 1–5, the dependent variable is the quintile rank of a child's test score. In columns 6–8, the dependent variable is the score on non-cognitive tests. Regressions only control for survey waves. Standard errors clustered at the household level in parenthesis. Seasons are defined as in Figure 2. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

Table 11: Parents' Expectation Regarding Children's Educational Attainment in Agricultural Households

	Boys in Agricultural Households (1)	Girls in Agricultural Households (2)
Panel A: Children's Average Score		
Non-winter Birth	-0.051	-1.093**
	(0.566)	(0.560)
Constant	98.057***	80.869***
	(8.220)	(7.656)
Sample size	3,558	3,200
Panel B: Children's Highest Level of Education		
Non-winter Birth	-0.098**	-0.139***
	(0.040)	(0.046)
Constant	2.991***	4.128***
	(0.885)	(0.717)
Sample size	2,642	2,427

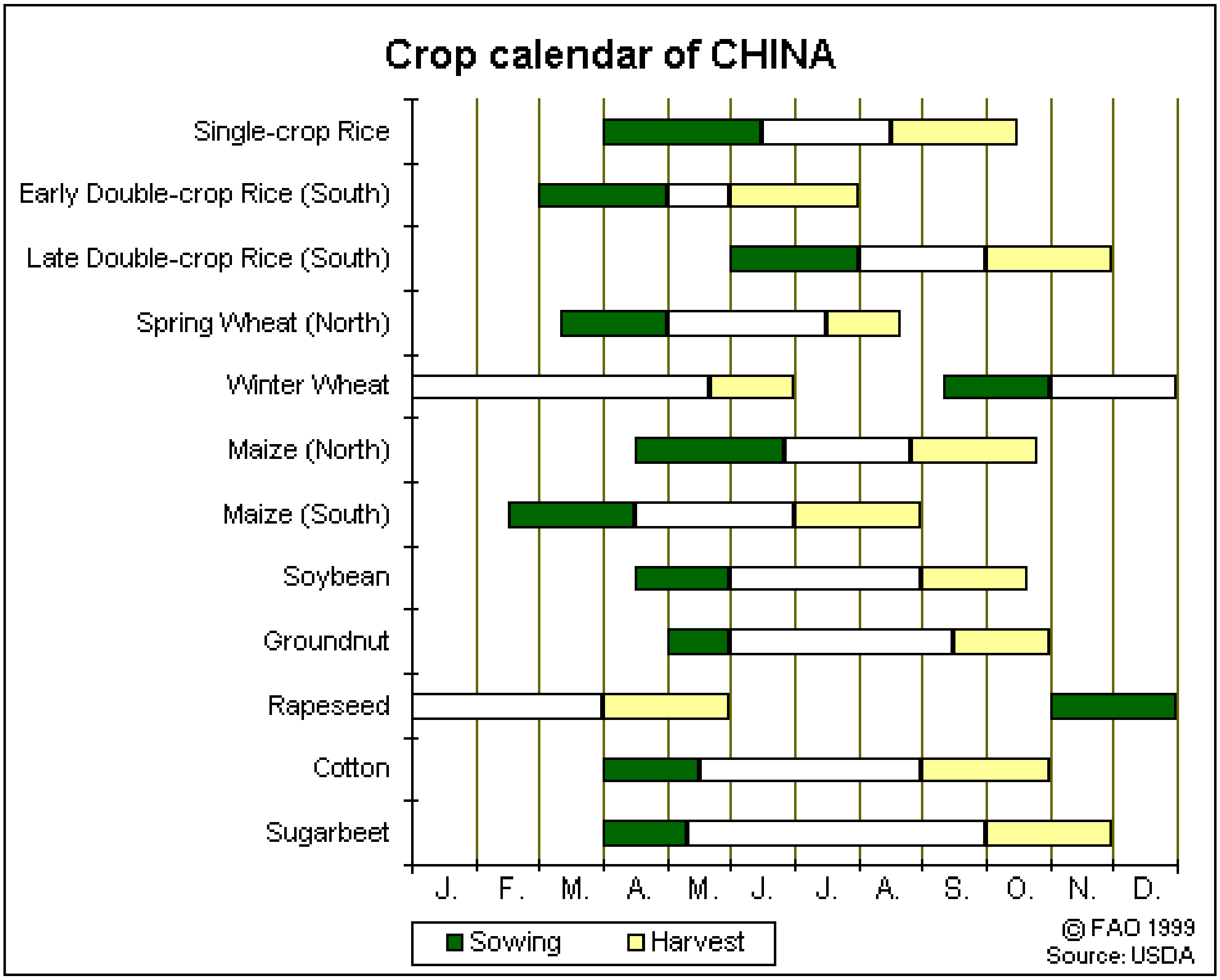
Notes: Dependent variable is parents' expectation of children's average score (Panel A) and highest level of education (Panel B). Weighted OLS regression results presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample restricted to children aged 10–15 years. Seasons are defined as in Figure 2. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

Table 12: Season of Birth, Parental Expectations and Investments in Girls in Agricultural Households

	Education Expense (1)	Hours of Housework (2)	Education Expense (3)	Hours of Housework (4)
Non-winter Birth	0.408	0.019	-0.021	0.040
	(0.389)	(0.097)	(0.055)	(0.114)
Parental expectation regarding:				
Average score this/next semester	0.011***	-0.004		
	(0.004)	(0.005)		
Highest level of education			0.110***	-0.109
			(0.029)	(0.068)
Constant	-2.259***	1.536	-1.534*	1.897
	(0.803)	(2.378)	(0.897)	(2.580)
Sample size	3,091	2,281	2,298	1,866

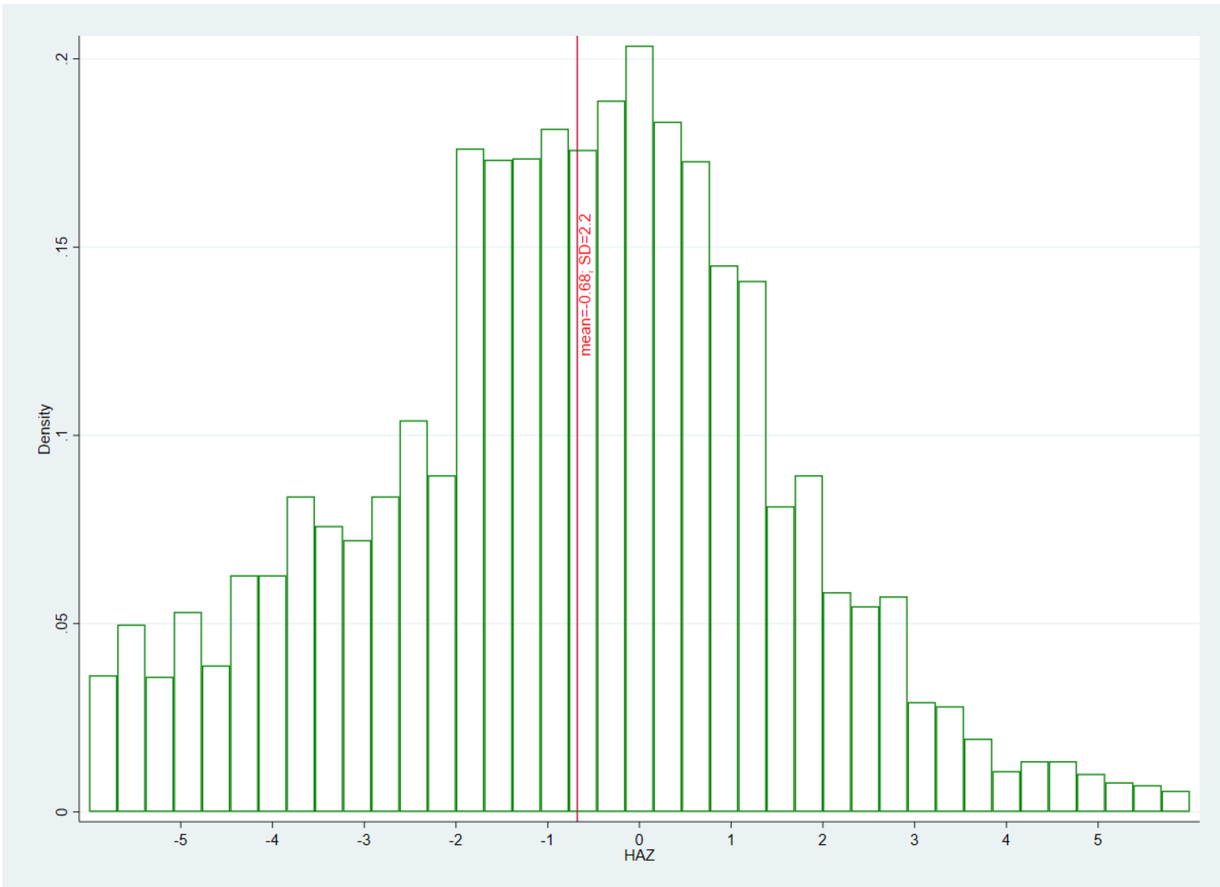
Notes: Weighted OLS regression results presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Seasons are defined as in Figure 2. Sample includes girls aged 10–15 years in agricultural households. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born in winter. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.

Figure A1: Crop Calendar



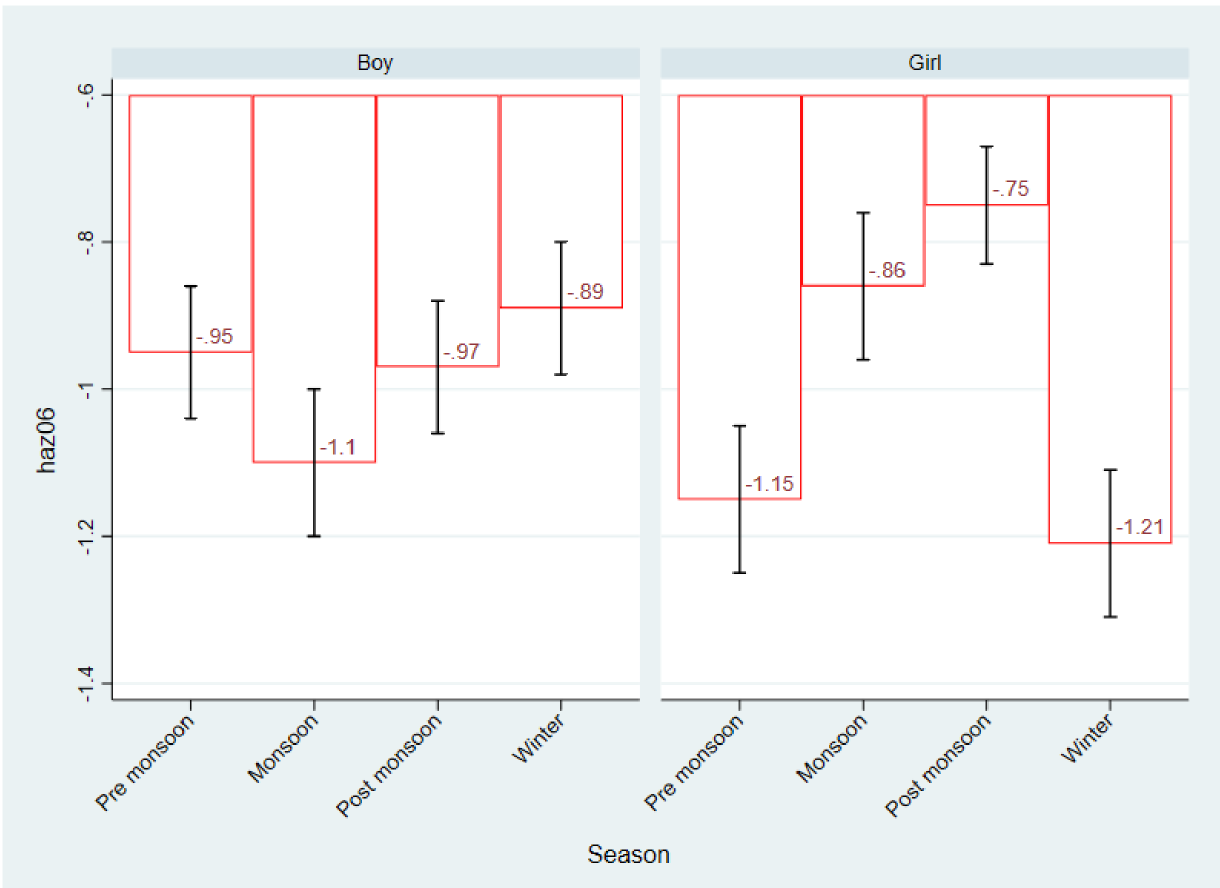
Notes: See https://www.usda.gov/oce/weather/CropCalendars/.

Figure A2: Density of Height for Age z-scores



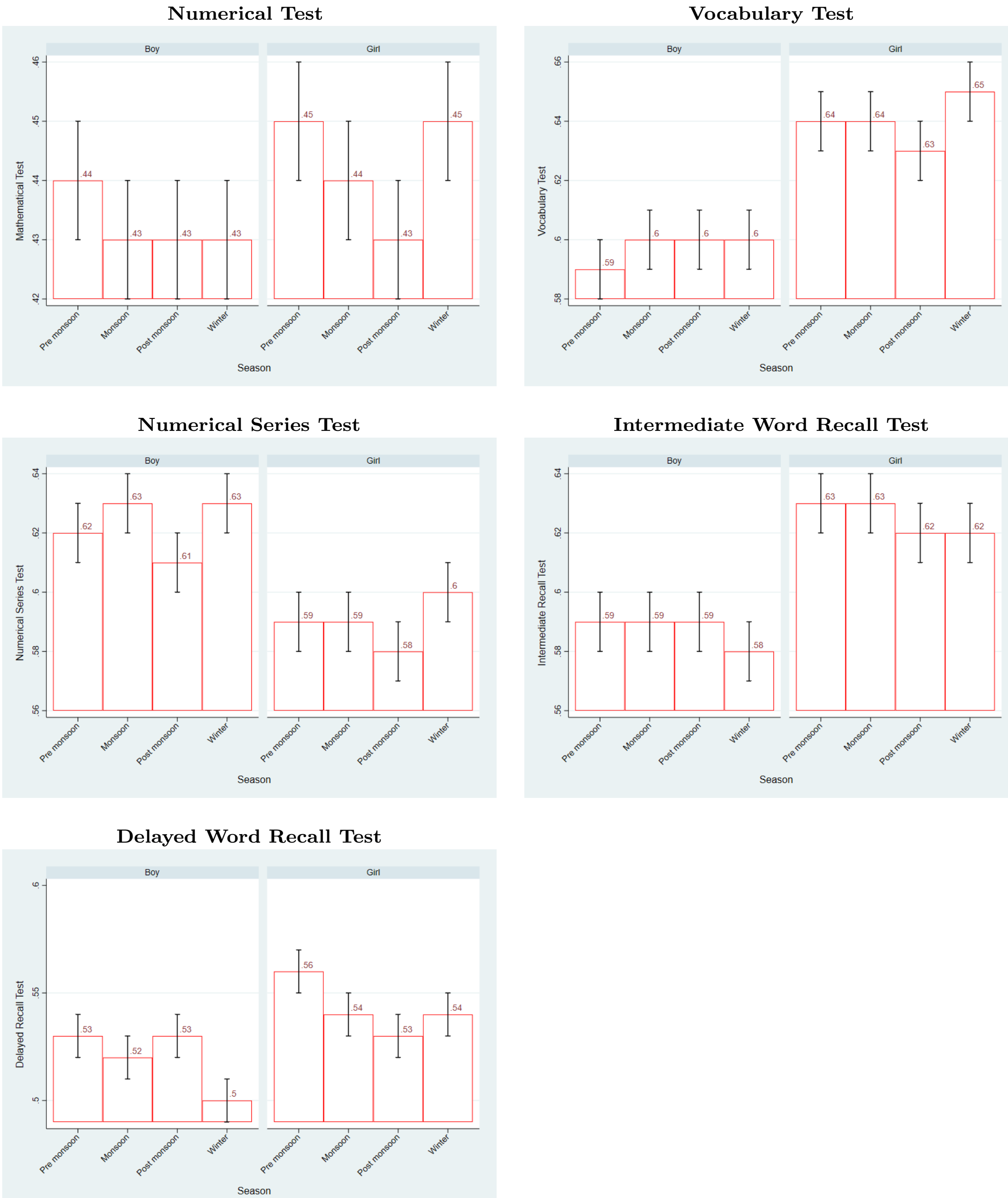
Notes: Sample restricted to children aged 0–5 years at the time of the survey. Data from CFPS waves 2010, 2012, 2014 and 2016 used.

Figure A3: Height for Age z-score Averages by Season of Birth in Agricultural Households



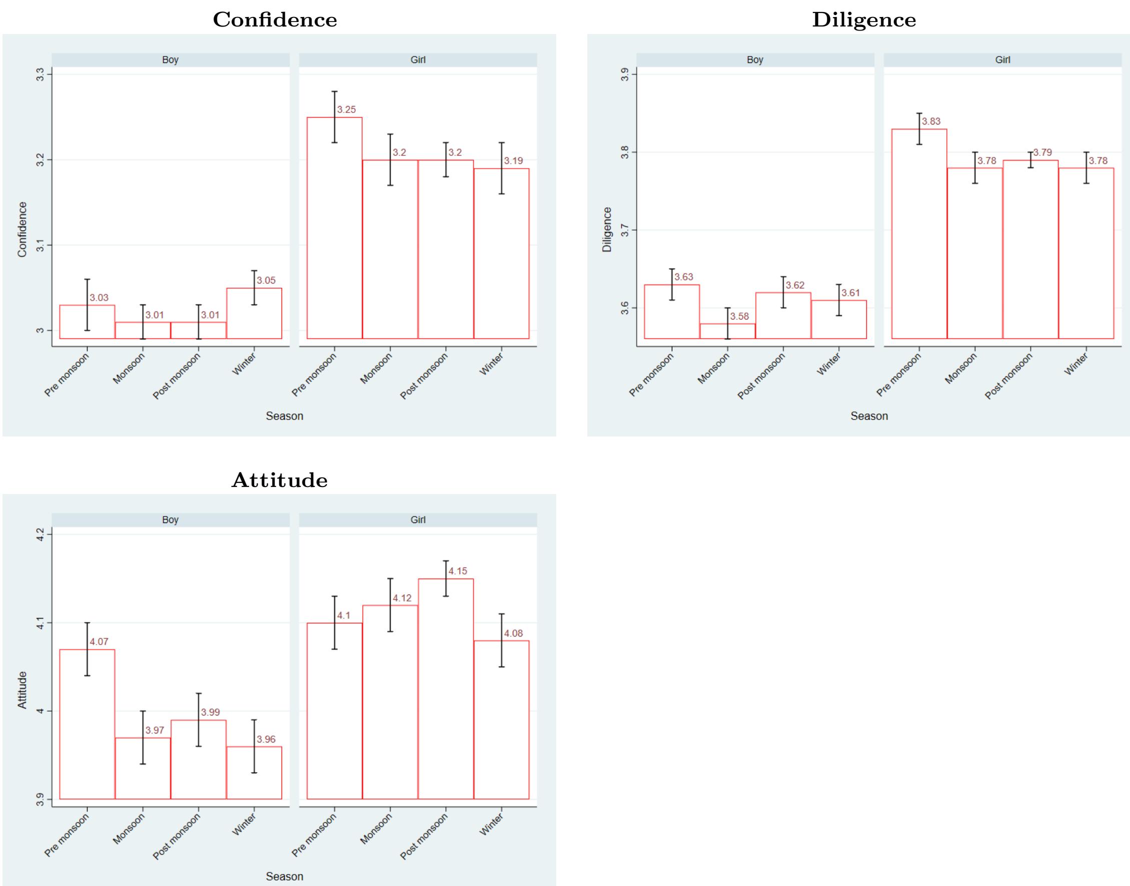
Notes: Sample restricted to children aged 0–5 years at the time of the survey. Data from CFPS waves 2010, 2012, 2014 and 2016 used. Sample Restricted to Agricultural Households. Seasons are defined as in Figure 2.

Figure A4: Cognitive Test Score Averages by Season of Birth in Agricultural Households



Notes: Sample restricted to children aged 10–15 years at the time of the survey. Data from CFPS waves 2010, 2012, 2014 and 2016 used. Sample Restricted to Agricultural Households. Seasons are defined as in Figure 2.

Figure A5: Non-Cognitive Test Score Averages by Season of Birth in Agricultural Households



Notes: Sample restricted to children aged 10–15 years at the time of the survey. Data from CFPS waves 2010, 2012, 2014 and 2016 used. Sample Restricted to Agricultural Households. Seasons are defined as in Figure 2.

Figure A6: Categorization of Monsoon by Province and Year of Birth for Selected Provinces

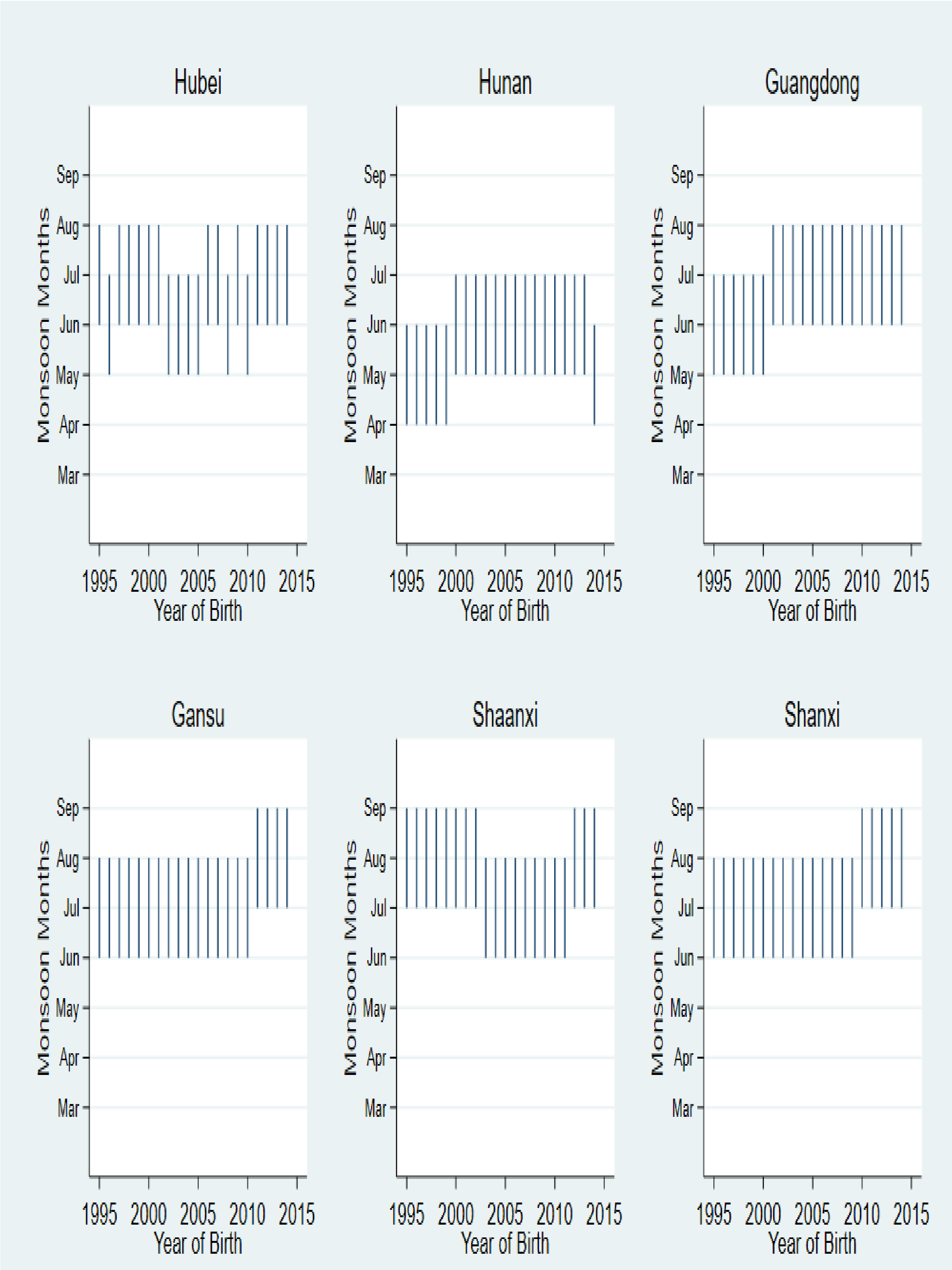


Table A1: Descriptive Statistics by Household Type and Gender of the Child. Independent Variables

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Children aged 0–5 years								
Child-specific								
Child's current age (in months)	29.353	31.478	-2.125***	31.112	32.541	-1.429***	-1.759***	-1.063***
	(0.405)	(0.421)	(0.585)	(0.334)	(0.351)	(0.481)	(0.522)	(0.546)
Child with sibling	0.341	0.352	-0.011	0.518	0.549	-0.031**	-0.177***	-0.197***
	(0.011)	(0.012)	(0.016)	(0.010)	(0.010)	(0.014)	(0.015)	(0.016)
Birth Order: First born	0.714	0.747	-0.033**	0.556	0.591	-0.035***	0.158***	0.156***
	(0.011)	(0.011)	(0.015)	(0.010)	(0.010)	(0.014)	(0.015)	(0.015)
Birth Order: Second born	0.255	0.238	0.017	0.376	0.353	0.023*	-0.121***	-0.115***
	(0.010)	(0.011)	(0.017)	(0.010)	(0.010)	(0.013)	(0.014)	(0.014)
Birth Order: Third born and later	0.031	0.015	0.016***	0.068	0.056	0.012	-0.037***	-0.041***
	(0.004)	(0.003)	(0.006)	(0.005)	(0.005)	(0.007)	(0.007)	(0.006)
Mother's current age	29.463	29.879	-0.416**	28.747	28.620	0.127	0.716***	1.259***
	(0.115)	(0.116)	(0.157)	(0.106)	(0.117)	(0.152)	(0.157)	(0.162)
Father's current age	31.408	31.868	-0.46***	30.556	30.707	-0.151	0.852***	1.161***
	(0.121)	(0.129)	(0.178)	(0.110)	(0.112)	(0.155)	(0.165)	(0.172)
Mother's Education								
No education	0.032	0.033	-0.001	0.098	0.099	-0.001	-0.066***	-0.066***
	(0.004)	(0.004)	(0.007)	(0.006)	(0.006)	(0.009)	(0.009)	(0.009)
Attended Primary	0.113	0.092	0.021**	0.217	0.233	-0.016	-0.104***	-0.141***
	(0.008)	(0.007)	(0.011)	(0.008)	(0.009)	(0.012)	(0.012)	(0.012)
Attended Junior high school	0.350	0.330	0.02	0.500	0.502	-0.002	-0.150***	-0.172***
	(0.012)	(0.012)	(0.016)	(0.010)	(0.011)	(0.014)	(0.015)	(0.016)
Attended Senior high school	0.205	0.242	-0.037***	0.128	0.109	0.019**	0.077***	0.133***
	(0.010)	(0.011)	(0.014)	(0.007)	(0.007)	(0.009)	(0.011)	(0.012)
Attended College	0.300	0.303	-0.003	0.057	0.058	-0.001	0.243***	0.245***
	(0.011)	(0.012)	(0.015)	(0.005)	(0.005)	(0.007)	(0.010)	(0.011)
Father's Education								
No education	0.030	0.026	0.004	0.052	0.072	-0.020***	-0.022***	-0.046***
	(0.004)	(0.004)	(0.006)	(0.004)	(0.005)	(0.007)	(0.007)	(0.007)
Attended Primary	0.120	0.093	0.027**	0.242	0.229	0.013	-0.122***	-0.136***
	(0.008)	(0.007)	(0.011)	(0.009)	(0.009)	(0.012)	(0.012)	(0.012)

Continued . . .

Descriptive Statistics by Household Type and Gender of the Child. Independent Variables (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	Girls	Difference	Boys	Girls	Difference	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Attended Junior high school	0.320	0.353	-0.033*	0.495	0.483	0.012	-0.175***	-0.130***
	(0.011)	(0.012)	(0.017)	(0.010)	(0.011)	(0.014)	(0.015)	(0.016)
Attended Senior high school	0.226	0.244	-0.018	0.144	0.157	-0.013	0.082***	0.087***
	(0.010)	(0.011)	(0.014)	(0.007)	(0.008)	(0.010)	(0.012)	(0.012)
Attended College	0.304	0.284	0.020	0.067	0.059	0.008	0.237***	0.225***
	(0.011)	(0.012)	(0.016)	(0.005)	(0.005)	(0.007)	(0.011)	(0.011)
Mother's height (Average)	160.307	159.933	0.374	159.325	159.467	-0.142	0.982***	0.466**
	(0.134)	(0.152)	(0.200)	(0.122)	(0.117)	(0.168)	(0.180)	(0.190)
Mother's height <155 cm	0.087	0.096	-0.009	0.137	0.112	0.025**	-0.050***	-0.016
	((0.008)	(0.008)	(0.010)	(0.007)	(0.007)	(0.010)	(0.010)	(0.011)
Mother's height 155—164 cm	0.688	0.702	-0.014	0.693	0.706	-0.013	-0.005	-0.004
	(0.013)	(0.013)	(0.018)	(0.010)	(0.011)	(0.015)	(0.016)	(0.017)
Mother's height $\geq$ 165 cm	0.225	0.202	0.023	0.170	0.182	-0.012	0.055***	0.020
	(0.011)	(0.011)	(0.016)	(0.009)	(0.009)	(0.013)	(0.014)	(0.015)
Household specific								
Wealth quintile 1	0.142	0.159	-0.017	0.128	0.112	0.016	0.014	0.047***
	(0.009)	(0.009)	(0.012)	(0.007)	(0.007)	(0.010)	(0.011)	(0.011)
Wealth quintile 2	0.120	0.122	-0.002	0.204	0.237	-0.033***	-0.084***	-0.115***
	(0.008)	(0.008)	(0.011)	(0.008)	(0.009)	(0.012)	(0.012)	(0.013)
Wealth quintile 3	0.149	0.156	-0.007	0.262	0.267	-0.005	-0.113***	-0.111***
	(0.009)	(0.009)	(0.012)	(0.009)	(0.009)	(0.013)	(0.013)	(0.013)
Wealth quintile 4	0.256	0.219	0.037**	0.245	0.244	0.001	0.011	-0.025
	(0.011)	(0.011)	(0.015)	(0.009)	(0.009)	(0.012)	(0.013)	(0.014)
Wealth quintile 5	0.333	0.344	-0.011	0.161	0.14	0.021**	0.172***	0.204***
	(0.012)	(0.012)	(0.016)	(0.007)	(0.007)	(0.010)	(0.013)	(0.013)
Household size	4.629	4.644	-0.015	6.036	5.972	0.064	-1.407***	-1.328***
	(0.043)	(0.046)	(0.063)	(0.040)	(0.039)	(0.055)	(0.059)	(0.060)
Share of children 0—5 years	0.279	0.288	-0.009**	0.236	0.253	-0.017***	0.043***	0.035***
	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Share of children 10–15 years	0.048	0.046	0.002	0.082	0.067	0.015***	-0.034***	-0.021***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Share of adults	0.615	0.598	0.017***	0.606	0.602	0.004	0.009**	-0.004

Continued . . .

Descriptive Statistics by Household Type and Gender of the Child. Independent Variables (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.004)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.005)	(0.004)
Share of elderly	0.00.058	0.069	-0.011***	0.076	0.078	-0.002	-0.018***	-0.009**
	(0.003)	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Main Source of Water for Cooking								
Tap water	0.0.838	0.853	-0.015	0.485	0.536	-0.051***	0.353***	0.317***
	(0.009)	(0.009)	(0.012)	(0.010)	(0.010)	(0.014)	(0.014)	(0.014)
Well/mountain spring water	0.150	0.133	0.017	0.465	0.41	0.055***	-0.315***	-0.277***
	(0.009)	(0.008)	(0.012)	(0.010)	(0.010)	(0.014)	(0.014)	(0.014)
River/lake/pond and other sources	0.012	0.015	-0.003	0.049	0.053	-0.004	-0.037***	-0.038***
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.007)	(0.006)	(0.007)
Survey year								
2010	0.233	0.214	0.019	0.245	0.231	0.014	-0.012	-0.017
	(0.010)	(0.010)	(0.014)	(0.008)	(0.009)	(0.012)	(0.013)	(0.013)
2012	0.188	0.213	-0.025*	0.265	0.258	0.007	-0.077***	-0.045***
	(0.009)	(0.010)	(0.013)	(0.009)	(0.009)	(0.012)	(0.013)	(0.013)
2014	0.259	0.252	0.007	0.249	0.252	-0.003	0.010	0.000
	(0.010)	(0.011)	(0.015)	(0.008)	(0.009)	(0.012)	(0.013)	(0.014)
2016	0.32	0.321	-0.001	0.241	0.26	-0.019	0.079***	0.061***
	(0.011)	(0.011)	(0.016)	(0.008)	(0.009)	(0.012)	(0.014)	(0.014)
Sample size	1717	1620		2467	2242			
Panel B: Children aged 10–15 years								
Child-specific								
Child's current age	12.447	12.536	-0.089	12.497	12.515	-0.018	-0.050	0.021
	(0.037)	(0.039)	(0.053)	(0.027)	(0.029)	(0.039)	(0.045)	(0.048)
Year of schooling	6.133	6.32	-0.187***	5.811	5.923	-0.112***	0.322***	0.397***
	(0.043)	(0.045)	(0.063)	(0.031)	(0.034)	(0.046)	(0.053)	(0.057)

Continued ...

Descriptive Statistics by Household Type and Gender of the Child. Independent Variables (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	Girls	Difference	Boys	Girls	Difference	Boys	Girls
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Child with sibling	0.453	0.472	-0.019	0.728	0.834	-0.106***	-0.275***	-0.362***
	(0.011)	(0.011)	(0.015)	(0.007)	(0.006)	(0.009)	(0.012)	(0.012)
Birth order: First born	0.729	0.815	-0.086***	0.55	0.628	-0.078***	0.179***	0.187***
	(0.010)	(0.009)	(0.013)	(0.008)	(0.008)	(0.011)	(0.013)	(0.013)
Birth order: Second born	0.224	0.159	0.065***	0.341	0.3	0.041***	-0.117***	-0.141***
	(0.009)	(0.008)	(0.012)	(0.007)	(0.008)	(0.011)	(0.012)	(0.012)
Birth order: Third born and later	0.047	0.026	0.021***	0.109	0.072	0.037***	-0.062***	-0.046***
	(0.005)	(0.004)	(0.006)	(0.005)	(0.004)	(0.007)	(0.008)	(0.007)
Mother's current age	39.038	39.163	-0.125	39.272	38.761	0.511***	-0.234***	0.402***
	(0.096)	(0.106)	(0.145)	(0.080)	(0.085)	(0.118)	(0.131)	(0.141)
Father's current age	41.060	41.039	0.021	40.912	40.554	0.358***	0.148	0.485***
	(0.104)	(0.110)	(0.156)	(0.085)	(0.087)	(0.125)	(0.143)	(0.146)
Mother's Education								
No education	0.126	0.114	0.012	0.307	0.305	0.002	-0.181***	-0.191***
	(0.007)	(0.007)	(0.011)	(0.007)	(0.008)	(0.011)	(0.012)	(0.012)
Attended Primary	0.177	0.195	-0.018	0.339	0.322	0.017	-0.162***	-0.127***
	(0.008)	(0.009)	(0.012)	(0.008)	(0.008)	(0.011)	(0.012)	(0.012)
Attended Junior high school	0.360	0.362	-0.002	0.284	0.296	-0.012	0.076***	0.066***
	(0.010)	(0.011)	(0.015)	(0.007)	(0.008)	(0.010)	(0.012)	(0.013)
Attended Senior high school	0.177	0.191	-0.014	0.041	0.056	-0.015***	0.136***	0.135***
	(0.008)	(0.009)	(0.012)	(0.003)	(0.004)	(0.005)	(0.007)	(0.008)
Attended College and above	0.160	0.138	0.022**	0.029	0.02	0.009**	0.131***	0.118***
	(0.008)	(0.008)	(0.010)	(0.003)	(0.002)	(0.004)	(0.006)	(0.007)
Father's Education								
No education	0.070	0.065	0.005	0.152	0.176	-0.024**	-0.082***	-0.111***
	(0.006)	(0.006)	(0.008)	(0.006)	(0.006)	(0.009)	(0.009)	(0.010)
Attended Primary	0.160	0.170	-0.010	0.319	0.324	-0.005	-0.159***	-0.154***
	(0.008)	(0.008)	(0.012)	(0.007)	(0.008)	(0.011)	(0.012)	(0.012)
Attended Junior high school	0.390	0.333	0.057***	0.408	0.411	-0.003	-0.018	-0.078
	(0.011)	(0.011)	(0.015)	(0.008)	(0.008)	(0.011)	(0.013)	(0.013)
Attended Senior high school	0.208	0.253	-0.045***	0.092	0.076	0.016***	0.116***	0.177***

Continued . . .

Descriptive Statistics by Household Type and Gender of the Child. Independent Variables (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(0.009)	(0.010)	(0.013)	(0.005)	(0.004)	(0.006)	(0.009)	(0.009)
Attended College and above	0.171	0.179	-0.008	0.028	0.014	0.014***	0.143***	0.165***
	(0.008)	(0.009)	(0.011)	(0.003)	(0.002)	(0.004)	(0.006)	(0.007)
Household specific								
Wealth quintile 1	0.171	0.163	0.008	0.161	0.166	-0.005	0.010	-0.003
	(0.008)	(0.008)	(0.012)	(0.006)	(0.006)	(0.009)	(0.010)	(0.011)
Wealth quintile 2	0.130	0.140	-0.010	0.241	0.259	-0.018	-0.111***	-0.119***
	(0.007)	(0.008)	(0.011)	(0.007)	(0.007)	(0.010)	(0.011)	(0.012)
Wealth quintile 3	0.133	0.181	-0.048***	0.269	0.259	0.01	-0.136	-0.078
	(0.007)	(0.009)	(0.011)	(0.007)	(0.007)	(0.010)	(0.011)	(0.012)
Wealth quintile 4	0.220	0.232	-0.012	0.222	0.217	0.005	-0.002	0.015
	(0.009)	(0.010)	(0.013)	(0.007)	(0.007)	(0.009)	(0.011)	(0.011)
Wealth quintile 5	0.345	0.284	0.061***	0.106	0.099	0.007	0.239	0.185
	(0.010)	(0.010)	(0.015)	(0.005)	(0.005)	(0.006)	(0.010)	(0.010)
Household size	4.164	4.357	-0.193***	4.94	5.245	-0.305***	-0.776***	-0.888***
	(0.032)	(0.036)	(0.051)	(0.026)	(0.029)	(0.039)	(0.044)	(0.048)
Share of children 0—5 years	0.019	0.028	-0.009***	0.03	0.047	-0.017***	-0.011***	-0.019***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Share of children 10—15 years	0.316	0.327	-0.011***	0.313	0.335	-0.022***	0.003	-0.008*
	(0.002)	(0.003)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)
Share of adults	0.571	0.536	0.035***	0.54	0.497	0.043***	0.031***	0.039***
	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
Share of elderly	0.094	0.11	-0.016***	0.118	0.12	-0.002	-0.024***	-0.010**
	(0.003)	(0.004)	(0.005)	(0.002)	(0.003)	(0.003)	(0.004)	(0.004)
Main Source of Water for Cooking								
Tap water	0.857	0.839	0.018	0.496	0.492	0.004	0.361***	0.347***
	(0.008)	(0.008)	(0.012)	(0.008)	(0.008)	(0.011)	(0.012)	(0.013)
Well/mountain spring water	0.126	0.142	-0.016	0.453	0.452	0.001	-0.327***	-0.310***
	(0.007)	(0.008)	(0.011)	(0.008)	(0.008)	(0.011)	(0.012)	(0.013)
River/lake/pond and other sources	0.016	0.019	-0.003	0.051	0.057	-0.006	-0.035***	-0.038***
	(0.003)	(0.003)	(0.005)	(0.003)	(0.004)	(0.006)	(0.006)	(0.007)

Continued . . .

Descriptive Statistics by Household Type and Gender of the Child. Independent Variables (Continued)

	Non-agricultural			Agricultural			Non-Agricultural – Agricultural	
	Boys	**Girls**	**Difference**	**Boys**	**Girls**	**Difference**	**Boys**	**Girls**
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Survey year								
2010	0.274	0.287	-0.013	0.28	0.306	-0.026**	-0.006	-0.019
	(0.010)	(0.010)	(0.014)	(0.007)	(0.008)	(0.010)	(0.012)	(0.013)
2012	0.234	0.24	-0.006	0.265	0.26	0.005	-0.031***	-0.02
	(0.009)	(0.009)	(0.013)	(0.007)	(0.007)	(0.010)	(0.012)	(0.012)
2014	0.258	0.259	-0.001	0.242	0.232	0.01	0.016	0.027**
	(0.009)	(0.010)	(0.013)	(0.007)	(0.007)	(0.010)	(0.011)	(0.012)
2016	0.234	0.214	0.02	0.213	0.202	0.011	0.021**	0.012
	(0.009)	(0.009)	(0.013)	(0.006)	(0.007)	(0.009)	(0.011)	(0.011)
Sample size	1,974	1,856		3,655	3438			

Notes: Authors' calculations using the CFPS data. Panel A: Sample includes children aged 0–5 years in CFPS waves 2010, 2012, 2014 and 2016. Panel B: Sample includes children aged 10–15 years in CFPS waves 2010, 2012, 2014 and 2016. Weighted descriptive statistics presented.

Table A2: Rotated Component Matrix for Children's Self-Evaluation

	VARIMAX Rotated Loading			Communalities
	Factor 1	Factor 2	Factor 3	
How would you rate your academic performance?	0.733			0.576
How excellent a student do you think you are?	0.779			0.632
How much academic pressure do you put on yourself?†				
To what extent do you think you are suitable to be a student cadre?	0.631			0.422
I study hard		0.562		0.467
I concentrate on studying while in class		0.655		0.490
I check my homework several times before handing it in		0.610		0.410
I abide by the school rules and regulations		0.609		0.387
I like to put my things in order at school		0.635		0.410
I finish my homework before I can play		0.658		0.453
Are you satisfied with your school?			0.675	0.474
Are you satisfied with your class adviser?			0.833	0.701
Are you satisfied with your Chinese language teacher?			0.766	0.593
Are you satisfied with your maths teacher?			0.707	0.512
Are you satisfied with your foreign language teacher?			0.623	0.408
Eigenvalues	3.649	2.000	1.327	
Number of items	3	6	5	
Cronbach's alpha‡	0.606	0.713	0.782	
Inter-item correlation	0.321	0.193	0.419	

Notes: Data from CFPS waves 2010, 2012, 2014 and 2016 are used.
† We excluded the factor that is loaded by only this item.
‡ Cronbach's alpha is a measure of internal consistency of items in a uni-dimensional scale. According to George and Mallery (2003), values for Cronbach's alpha larger than 0.6 are deemed acceptable.

Table A3: Representativeness of Season of Birth in Agricultural Households

	Girls Aged 0–5 Years				Girls Aged 10–15 Years			
	Pre-Monsoon	Monsoon	Post-Monsoon	Winter	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Father Education: Primary	0.021	0.002	-0.001	-0.022	-0.043	0.021	0.020	0.001
	(0.043)	(0.043)	(0.050)	(0.048)	(0.026)	(0.027)	(0.028)	(0.027)
Father Education: Junior	0.026	0.046	-0.015	-0.057	-0.000	-0.028	0.010	0.018
	(0.043)	(0.042)	(0.051)	(0.049)	(0.029)	(0.028)	(0.031)	(0.028)
Father Education: Senior	00.081	0.005	-0.022	-0.064	0.037	-0.003	0.016	-0.050
	(0.053)	(0.048)	(0.058)	(0.054)	(0.045)	(0.044)	(0.047)	(0.043)
Father Education: College	-0.012	0.037	-0.059	0.034	0.123	0.035	-0.055	-0.103**
	(0.060)	(0.063)	(0.070)	(0.078)	(0.076)	(0.070)	(0.064)	(0.049)
Mother Education: Primary	-0.011	-0.021	0.025	0.007	0.017	-0.011	0.009	-0.016
	(0.040)	(0.044)	(0.044)	(0.038)	(0.025)	(0.025)	(0.025)	(0.023)
Mother Education: Junior	0.020	-0.068	0.002	0.046	-0.004	0.000	0.017	-0.014
	(0.040)	(0.043)	(0.043)	(0.039)	(0.028)	(0.029)	(0.030)	(0.029)
Mother Education: Senior	-0.023	-0.057	0.062	0.018	-0.018	-0.055	0.016	0.057
	(0.049)	(0.054)	(0.059)	(0.049)	(0.047)	(0.043)	(0.055)	(0.056)
Mother Education: College	0.018	-0.041	0.087	-0.063	-0.047	-0.048	0.025	0.070
	(0.065)	(0.067)	(0.075)	(0.057)	(0.048)	(0.048)	(0.062)	(0.057)
Wealth Quintile 2	-0.008	0.036	-0.035	0.007	0.015	-0.009	-0.010	0.004
	(0.036)	(0.034)	(0.038)	(0.034)	(0.025)	(0.022)	(0.026)	(0.024)
Wealth Quintile 3	0.001	0.006	-0.008	0.001	0.009	0.021	-0.028	-0.003
	(0.037)	(0.033)	(0.038)	(0.033)	(0.025)	(0.024)	(0.028)	(0.026)
Wealth Quintile 4	-0.014	-0.009	0.017	0.006	0.011	0.010	-0.015	-0.007
	(0.038)	(0.033)	(0.040)	(0.035)	(0.028)	(0.027)	(0.031)	(0.029)
Wealth Quintile 5 (Highest)	-0.070*	0.059	-0.015	0.026	-0.002	0.069*	-0.073*	0.006
	(0.040)	(0.041)	(0.046)	(0.041)	(0.037)	(0.038)	(0.038)	(0.037)
Age of Mother	0.020	0.021	-0.006	-0.035	-0.004	-0.041	0.027	0.018
	(0.022)	(0.026)	(0.025)	(0.022)	(0.023)	(0.026)	(0.032)	(0.028)
Age of Mother Squared	-0.000	-0.000	0.000	0.001	0.000	0.001*	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)

Continued ...

Representativeness of Season of Birth in Agricultural Households

	Girls Aged 0–5 Years				Girls Aged 10–15 Years			
	Pre-Monsoon	Monsoon	Post-Monsoon	Winter	Pre-Monsoon	Monsoon	Post-Monsoon	Winter
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Significance of Explanatory Variables								
Education of Mother ($\chi^2(4)$)		10.79				7.85		
		[0.547]				[0.107]		
Education of Father ($\chi^2(4)$)		11.41				3.58		
		[0.494]				[0.466]		
Wealth Quintiles ($\chi^2(4)$)		11.32				0.27		
		[0.502]				[0.991]		
Joint Test ($\chi^2(42)$)		36.54				15.08		
		[0.709]				[0.372]		

Notes: The dependent variable is season of birth of the child. Marginal effects from Multinomial Logit regressions given by equation (4) are presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample in columns 1–4 restricted to girls in agricultural households aged 0–5 years with non-missing values for height and age. Sample in columns 5–8 restricted to girls in agricultural households aged 10–15 years with non-missing values for test scores. Seasons are defined in Figure 2. Regressions control for age of father, age of father squared, mother's height, residential status of mother and father, household size and composition, household facilities, age and birth order of child, and survey year. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$. Standard errors clustered by household in parenthesis. p-values of $\chi^(2)$ tests in square brackets.

Table A4: Child Height and Month of Birth Relative to the Onset of the Monsoon for Girls in Agricultural Households

	Height-for-Age z-scores (1)	**Stunting** (2)
5 months prior	-0.015	0.059
	(0.276)	(0.063)
–4	0.564	-0.125**
	(0.355)	(0.064)
–3	0.069	0.012
	(0.300)	(0.066)
–2	0.338	-0.014
	(0.324)	(0.066)
–1	0.632*	-0.021
	(0.363)	(0.068)
Monsoon starts	0.772***	-0.124**
	(0.293)	(0.058)
1 month after monsoon starts	0.184	-0.097
	(0.305)	(0.068)
+2	0.158	-0.057
	(0.272)	(0.056)
+3	0.965***	-0.119**
	(0.272)	(0.054)
+4	0.728***	-0.093
	(0.278)	(0.059)
+5	0.600*	-0.106*
	(0.314)	(0.061)
Constant	-5.985***	0.596
	(1.975)	(0.389)
Sample Size	2,083	2,083

Notes: The dependent variables are height-for-age z-scores (column 1) and whether the child is stunted (height-for-age z-scores < -2) (column 2). Weighted OLS regression results presented. Data from CFPS waves 2010, 2012, 2014 and 2016 are used. Sample includes girls in agricultural households aged 0–5 years with non-missing values for height and age. Onset of monsoon is as defined in Figure 1. Regressions control for a set of individual (age, birth order), parental (education, age and residential status of mother and father, mother's height), and household variables (wealth quintile, household size, household composition, source of water for cooking), and dummies for survey wave. Standard errors clustered at the household level in parenthesis. The reference group is children born 6 months after the onset of the monsoon. Significance: $^{***}p < 0.01$;** $p < 0.05$;* $p < 0.1$.

Table A5: Height-for-Age z-score and Cognitive and Non-cognitive Test Results for a Panel of Girls in Agricultural Households

	Height-for-age z-score	Cognitive Test Scores			Non-Cognitive Test Scores		
		Numerical Series Test	Intermediate Word Recall Test	Delayed Word Recall Test	Confidence	Diligence and Self Discipline	Attitude Towards Teachers and School
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Non-winter Birth	0.201	-0.060	-0.437	-0.143	-0.001	0.046	-0.219
	(0.542)	(0.253)	(0.351)	(0.358)	(0.203)	(0.105)	(0.157)
HAZ		0.075	0.030	-0.009	0.013	0.005	0.013
		(0.058)	(0.066)	(0.065)	(0.056)	(0.019)	(0.032)
Constant	-1.766***	2.794***	2.803***	2.430***	3.157***	3.810***	4.504***
	(0.483)	(0.217)	(0.334)	(0.357)	(0.191)	(0.081)	(0.132)
Sample Size	140	141	140	138	135	138	122

Notes: OLS regression results presented. Sample is restricted to 4-5 year old girls in agricultural households whose height-for-age z-score is available in wave 2010, and the same girls when they are 10–11 years old for whom cognitive and non-cognitive test scores are available in wave 2016. Regressions condition on season of birth variables. Significance: $^{***}p < 0.01$;$^{**}p < 0.05$;$^{*}p < 0.1$.