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JEL Classification: I15, I18, J13, O1

Keywords: height, China, economic reform

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Explaining Trends in Adult Height in China: 1950 to 1990 *

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March 25, 2021

Abstract

This paper explores the changing trend of adult height in China for cohorts born in 1950-90. We use information on the household structure and local economic conditions during the individual?s childhood to explain the trend. We find that during the 40-year period, the growth rate of adult height increased, with the most substantial increase occurring in the 1980s. One important contributing factor to the growth of adult height is the continued increase in government per capita spending on health and education. The impressive growth in the 1980s was mainly due to the introduction of market-oriented economic reforms, rather than the advent of the One-Child Policy. We find that the positive effect of economic reforms was larger for urban dwellers than for their rural counterparts and within the rural areas the benefit was far greater for men than for women.

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1 Introduction

Spectacular economic development among the countries of East Asia in recent decades has been associated with dramatic improvements in a variety of health indicators including average stature. A recent study that estimated increases in the height at age 19 of birth cohorts from 1966 to 2000 put China at the top of the league table [NCD, 2020]. China's tumultuous history and its social and economic consequences are well known but the implications for health and height are less clear. How were those turbulent times manifested in the health and heights of the Chinese population? What local indicators were associated with changes over time and between urban and rural areas? And, above all, how were the economic reforms around the early 1980s reflected more rapid improvement and through what mechanisms? In this paper we chart in more detail the heights of individuals born from 1960 to 1990 and we explore the links with a variety of indicators at the household and local level around the time of birth.

The average height of individuals is an important marker of the health conditions that they faced during childhood, especially in the first few years of life. Although genetic variation accounts for around 80 percent of the variation in height between individuals, early childhood conditions have effects that can be identified both within and between population groups [Silventoinen, 2003; Steckel, 2009]. Environmental conditions are transmitted through two main channels: nutrition and disease, both of which strongly influence growth during infancy and early childhood. Inadequate nutrition slows growth and may result in stunting which cannot be fully recovered in adolescence. Exposure to disease diverts the body's energy to fighting repeated infections, rather than building bone and muscle [Beard and Blaser, 2002].

In historical settings health conditions during childhood are typically captured by mortality rates, but height is of separate interest for several reasons. One is that historically mortality rates are often inadequately recorded in many countries. The nature of height, on the other hand, is such that it is stable between adult age 20 and 50, and such a measure can reflect the effects of childhood health conditions on survivors. Thus, notwithstanding potential survivor bias, using contemporary adult height we may retrospectively understand historical health conditions during survivors' childhood. Second, historical child mortalities, when available, are often measured as group averages rather than at the individual level. Thus, it is difficult to understand the causes as related to individual or household level information. Height is often observed and reported at the individual level together with other individual and household demographic and economic information, albeit not often retrospective information. Third, mortality is an extreme outcome, height reflects the more widespread influence of childhood health conditions on survivors. Finally, childhood conditions, reflected in adult height, have persistent effects as they are linked with a range of later life outcomes. Height is found to be positively associated with cognitive function, IQ, and educational attainment and negatively associated with the incidence of chronic disease and physical disability in later life [Currie, 2009; Schellekens and Van Poppel, 2016]. It is also positively associated with economic outcomes such as employment, earnings and occupational attainment, both directly and indirectly through education [Case and Paxson, 2008, 2010].

A variety of historical studies have analysed adult heights to explain historical trends and associations between adult height and conditions in the household and the locality around the time of birth. In Western Europe, the average height of adult male cohorts increased by about 1 cm per decade from the 1870s to the 1970s. Many of the earlier studies on factors affecting height are outlined in surveys by Steckel [1995, 2009]. Using aggregate time-series data for Spain from 1850 to 1958, Maria-Dolores and Martinez-Carrion [2011] finds that height was positively influenced by GDP per capita and the share of health expenditure in total expenditure, and negatively correlated with the mortality rate and the price of consumption goods. Using panel data on the average heights of adult males in 15 European countries from the 1870s to the 1970s, Hatton [2014] finds that both living standards and the disease environment contributed significantly to the long-run increase in height. Other factors such as the decline in family size (the quality-quantity tradeoff), the increase in parental education, and the expansion of welfare services each made a modest contribution. Studies of individual-level adult height support these findings. For example, among prisoners in nineteenth century Bavaria, Baten and Murray [2000] find that women's heights were more sensitive than men's to economic, nutritional and disease conditions. Using a cross-section of British servicemen measured during the First World War, Bailey et al. [2016, 2018] find that the socioeconomic status of the household head, family size, and household composition all influenced adult height, but that the local environment, particularly industrial pollution, mattered even more.

In the past sixty or so years, China has experienced turbulent and significant socioeconomic transformations. The industrialisation process since the early 1950s was accompanied by the following major economic and social upheavals: the Great Famine (1959-1961), the Cultural Revolution (1966-1976), the introduction of loose family planning policies (1973-1978) and the One Child Policy (OCP, 1979 onwards), and the market-oriented economic reforms (1979 onwards). These events generated shocks in economic and demographic factors which are regarded as closely associated with height: nutrition intake, education, fertility, and household income.

A few existing studies have examined the effects of a specific event or policy on adult height of Chinese people. A commonly studied event linked to height in China has been the Great Chinese Famine [Chen and Zhou, 2007; Meng and Qian, 2009; Wang et al., 2010; Gørgens et al., 2012; Li and An, 2015]. Gørgens et al. [2012], for example, find that those exposed to the famine when under five years of age were stunted by 1-2 cm but that this was exactly offset by positive selection among the survivors. Studies of the effect of the Cultural Revolution, which reduced the education level of the parental generation, find that it reduced the height of their children [Chen, 2010]. Many studies also examined the OCP effect, that reduced fertility, and increased children's height-for-age z-scores [Liu, 2014; Kubo and Chaudhuri, 2017].

Studies that examine the change in adult height and its contributing factors over a longer time horizon for China are rare owing to lack of data for the early period. Morgan [2000] found that after a modest advance from the 1920s to the 1950s, heights increased more rapidly in the following decades. Consistently, Bi and Ji [2005] find that between 1956 and 2000, the mean heights of 18-years-old (most closely reflecting adult height)[1] for male and female students increased from 164.9 cm to 172.6 cm and from 155.9 cm to 160.6 cm, respectively. These correspond to increases of 1.75 cm and 1.07 cm per decade for males and females, respectively. Other studies using survey data also find heights advanced over a similar period [Schwekendiek and Baten, 2019, see, for example,]. None of these studies, however, has examined the extent to which the economic and health environmental conditions at the crucial developmental stages of these cohorts might have influenced the change in their height over this period.

This paper fills in this gap. We link individuals' adult height with macro-economic and health conditions in their birth county during their crucial developmental ages, together with individual and family characteristics. The purpose of this paper is to answer the following three questions. (1) What are the general trend of height between the 1950s and 1990s and how did it vary between urban and rural regions and by gender? (2) How have changes in economic and social conditions and policies during an individual's crucial height developmental age affected their heights (and health)? (3) How has the family-planning policy, together with son-preference, affected different urban and rural regions and gender differentially?

To do so, we built a unique set of county-level data on economic conditions (industrial and agri-

[1] Based on WHO height-for-age chart (see https://www.who.int/growthref/cht_hfa_boys_z_5_19years.pdf?ua=1) the mean height for boys would continue to grow at a lesser rate after 18 years of age.

culture outputs or total outputs), a general health indicator (mortality rate), and local government expenditure on social services between 1950 and 1990. We manually collected these data mainly from hundreds of local gazetteers written by historians of each county. It allows us to align individual's adult height with their birth county local conditions at the time of the crucial individual height developmental stage (ages 0-3) for each individual. The information on individuals' adult height was obtained from the China Family Panel Study (CFPS). This survey has two important advantages. One is that it is a nationally representative household survey. The other more important advantage of the CFPS is that it records individuals' childhood information: birth county, household registration (*hukou*) status at age 3, and some basic parental information at the time the person was aged 14. It allows us to link an individual's adult height to the local socioeconomic conditions that he or she faced during early childhood.

We find that the average height growth between 1950 and 1990 for rural and urban males was 1.3 cm and 1.5 cm per decade, respectively. For rural and urban females, the growth was lower than their male counterparts, at 0.7 cm and 1.1 cm per decade, respectively. The height growth was not linear, and the 1980s saw the most significant height growth for all four population groups. The general picture is that height growth was greater in urban areas than in rural areas, and for males than for females. We find that the strong positive time trend on height growth is related to the positive association between height and the improvement in local economic circumstances. The positive effects coming from the agricultural and industrial output are stronger for the rural than for the urban sample and more important for males than for females. However, among all local economic and social condition variables which affect height growth, government social spending per capita (spending on health and education) plays the most important role for all groups. The strong influences of economic and social condition occurred mainly during the period of economic reforms. Further, the family planning policy, together with son-preference, have had a negative impact on height of rural population, in particular on rural females.

The rest of this paper is organised as follows. Section 2 outlines the background of socioeconomic changes in China between 1950 and 1990, and the details of economic reforms and family planning policies made since 1979. Section 3 presents model specifications and estimation issues, and Section 4 introduces the data and the main sample for our analysis. Section 5 presents the main results and discusses potential channels of influence. Section 6 provides robustness checks. Section 7 concludes.

2 Background

In this section we describe socioeconomic and policy changes that are likely to have affected the height of those people born in the 40 years from 1950 to 1990. The modern history of China in this period consists of two major parts: first, a centrally-planned economy from the establishment of the People's Republic of China (PRC) in 1949; and, second, market-oriented economic reforms since 1978.

2.1 A centrally-planned economy 1949-1977

2.1.1 The establishment of urban healthcare system: 1949-1955

On 21 September 1949, the Communist Party Chairman, Mao Zedong, proclaimed the establishment of the PRC as the Chinese Communist Party (CCP) came to power. At that time, China was suffering from severe poverty and health problems associated with malnutrition. The infant mortality rate in 1949 ranged from 12% to 20% among live births in rural regions and almost a third died before the age of five [Liang et al., 1973; Salaff, 1973].[2] Although the CCP introduced a planned economy upon establishment of the PRC, the free market economy coexisted with the centrally-planned economy until 1955 [Bettelheim, 1988]. In rural areas, land reform ensured that all farmers possessed a small piece of land. During the early years, the GDP growth rate was relatively high, albeit rising from a very low level [NBS, 1999].[3]

On the establishment of the PRC, the Chinese government introduced a health care system, which emphasised equity on the demand side and the central role of the government on the supply side [Yip and Hsiao, 2015].[4] Central and local governments owned, funded, and operated all health facilities and clinics in urban areas, and physicians became employees of the state [Yip and Hsiao, 2015]. The urban healthcare system consists of two main schemes: the Government Insurance Scheme, which mainly covered public servants and university staff, and the Labor Insurance Scheme, which covered employees in state-owned enterprises [Xin et al., 2014]. The benefits included comprehensive welfare, such as old-age pensions and maternity benefits, in addition to free medical care [Meng, 2000]. As the prices of all goods and services were determined by the central government, the cost of providing public services was kept at a very low level in line with the low wages received by urban workers.

[2] According to Salaff [1973], there was very little difference in infant mortality between rural and urban China at that time.

[3] The annual growth rate of gross domestic product (GDP) per capita was 8.72 percent in China between 1952 and 1955 [NBS, 1999].

[4] See Liang et al. [1973] for more detailed policy information.

It is important to note, though, that this system only covered urban people. For the rural residents (accounting for 80% of the population), their health care and all other types of welfare, were covered by a cooperative system at the village or commune level (tens of villages) that were established after the collectivisation of agriculture in the late 1950s.[Meng, 2000; Xingzhu and Huaijie, 1992].

2.1.2 The planned economy and the rural healthcare system: 1956-1958

From 1956, the Chinese government accelerated the nationalisation of all non-agriculture parts of the economy and the national economic plans concentrated on boosting industrialisation at the expense of agriculture [Chow, 1993]. Enterprises were owned by the state, they produced goods in line with the national plan, and all profits belonged to the state [Wang, 2018]. In rural areas, the collectivisation movement encouraged individual farmers to pool their land together to form production teams. Soon after, the production teams were compelled to form a larger collective unit (the brigade), while several brigades formed the communes [Lin, 1988]. Under the commune system, all resources were collectively owned. Part of the output was procured by the central government at lower than market price, and the remainder was distributed to the team households according to their basic needs and the household members' annual labour inputs. Revenues from government procurement were reinvested into agricultural production and used to provide communal services [Lin, 1988; Meng, 2000].

During this period, communes and brigades began to establish their own clinics to provide primary health services, which gradually evolved into the cornerstone of the rural healthcare system known as the Cooperative Medical System (CMS) [Zhu et al., 1989; Yip and Hsiao, 2015]. Some local farmers received basic medical training and became the main medical service providers in rural China [Zhu et al., 1989; Yip and Hsiao, 2015]. The CMS spread rapidly and about 20% of the production brigades in China had established the system by the end of 1958 [Xingzhu and Huaijie, 1992]. As medical services were provided within the communes and brigades, medical professionals were treated like farmers and subject to the same distributional rules. This allowed medical service prices to be kept low [Yip and Hsiao, 2015].

2.1.3 The Great Leap Forward and the Great Famine 1958-1961

Together with the establishment of the communes in rural areas, Chairman Mao proposed a national goal to overtake Great Britain in industrial production within 15 years and launched the Great Leap Forward movement in the spring of 1958. The unrealistic industrialisation target pushed many farmers to abandon agricultural production to focus on primitive steel production which largely resulted in useless output. In addition, the aggressive push for rural collectivisation dramatically reduced farmers' incentives for agriculture production. These, together with the inflexible grain procurement system and many other shocks, resulted in the Great Famine [Lin, 1990; Li and Yang, 2005; Gørgens et al., 2012; Meng et al., 2015]. Between 1959 and 1961, malnutrition was widespread, and an estimated 16.5 to 45 million people, mostly living in rural areas, perished from hunger or disease [Ashton et al., 1984; Chen and Zhou, 2007; Li and Yang, 2005; Meng et al., 2015].

2.1.4 Recovery from the Famine 1962-1965

After the crisis, the government brought back its pre-Great Leap Forward system for agricultural production, which restored the output level [Meng et al., 2015]. Further attempts were made to improve production efficiency [Lin, 1990]. Total grain output began to increase from 147.5 million tons in 1961 to 160.0 million tons in 1962, an 8.5 percent increase. Mortality rates fell back to the pre-famine trend from 1962.

The government also considerably increased expenditure on disaster relief, in 1964, it doubled the amount spent in 1961 [NBS, 1999]. The annual growth of total social welfare funds was 7.1% between 1962 and 1965 [NBS, 1999]. In addition, this period also saw a substantial increase in the quantity and quality of medical services. During the Famine, the government started to expand medical services and facilities. This was continued during the recovery period, mainly focusing on disease prevention. There were only 50 laboratories for medicine and chemical reagent tests in 1958, but by 1965 a total of 151 laboratories had been established [NBS, 1999]. The number of specialised prevention stations increased by 16% between 1963 and 1964, while the annual growth was only 0.9% between 1960 and 1963 [NBS, 1999].

Although these health services diffused rapidly after the Great Famine, most of the government-provided services were located in urban centres. Rural health services for more than 80% of the population was left to the collectives to administer [Zhang and Unschuld, 2008].

2.1.5 Cultural Revolution 1966-1976 and family planning policies 1973-1978

The recovery did not last long. To preserve the momentum of the communist ideology and restore his power in the CCP, Mao launched the Cultural Revolution in 1966 [MacFarquhar and Schoenhals, 2006; Booth et al., 2018]. The main objective was to purge 'capitalists' inside the Party and traditional 'anti-revolutionary' elements. All schools in urban areas were closed for many years.

Urban production and some rural agricultural production was stopped [Booth et al., 2018]. Political turmoil lasted for 11 years and seriously further disrupted economic growth [Borensztein and Ostry, 1996]. The annual growth rate of per capita GDP turned negative in the early, chaotic years of the Cultural Revolution, but later production recovered to the pre-Famine level.

During this period, government investment in health services was limited and the training of medical personnel in urban areas collapsed as medical schools were closed until 1972 [Dong and Phillips, 2008]. However, as the Party was concerned about inequality between cities and the countryside, rural areas received more attention. During this period, the village and commune-level healthcare services were formally evolved into the CMS. By the mid-1970s, almost 90% of the rural population participated in the system [Xingzhu and Huaijie, 1992; Liu, 2004] which provided equal access to inexpensive medical care [Tu, 2016]. To provide sufficient healthcare workers, a nationwide training programme was implemented. Many farmers, who were either middle-school graduates from rural schools or urban youth who were sent down to the countryside during the Cultural Revolution, were given some basic training to become health workers: the so-called 'barefoot doctors' [Hesketh and Wei, 1997; Zhang and Unschuld, 2008; Dong and Phillips, 2008; Hipgrave, 2011]. As a result, the number of rural health workers increased from 1.0 million in 1970 to an estimated peak of 1.8 million in 1977 [Hesketh and Wei, 1997; Hipgrave, 2011].[5] The barefoot doctors promoted basic hygiene, preventive healthcare and family planning, and treated common illnesses in the countryside [Gong and Chao, 1982]. The CMS system is widely regarded as a success, and between 1949 and 1975, infant mortality dropped from 20% to 4.7% [Liu et al., 1995].

This period also saw the initiation of family planning policies. In the early 1970s, post-famine population growth and the memory of the hunger during the famine had ignited a philosophical debate over the Malthusian Population Trap. Soon after, the policy of "Later, Longer, and Fewer" was introduced at the end of 1973 [Center for Population Studies and of the China's Population Yearbook, 1986; Peng, 1991; Feeney and Wang, 1993; Cai, 2010], which encouraged couples to get married later, have longer birth intervals, and to have fewer children. The policy had a significant impact on the birth rate, especially for the urban population. Over the 1970s, the total fertility rate fell from nearly six to just above two [Wang, 2011; Gietel-Basten et al., 2019].

[5] See [Hu, 2013] for details on sent-down youth during the Cultural Revolution period.

2.2 Market-oriented economic reforms and the One Child Policy

2.2.1 Economic reform and health care system evolution

Although efforts were made to improve basic living standards and to reduce inequality during the first 30 years of the People's Republic of China, the ideology driven system which ignore economic incentives had hampered economic development. After 30 years of socialist revolution, the system had failed to improve people's living standards substantially. At the end of the 1970s, 40-80% the rural population in China was still living in poverty [Ravallion and Chen, 2007].[6] In response to the poverty in rural areas, covert privatisation began in villages, whereby farming families cultivated their own contracted land and earned income from what they produced and this resulted in bumper harvests [Lin, 1992; Meng, 2012]. Seeing the positive effect of privatisation, the central government officially introduced this new system - the Household Responsibility System (HRS) - to the whole agriculture sector in China in the late 1970s and early 1980s.

The HRS changed the agricultural production system from collective farming to household-based farming, which increased agricultural productivity and gradually raised farm incomes. Accordingly, the persistent problem of food shortages was resolved [Du et al., 2014; Wang, 2018]. From 1977 to 1984, the total grain output increased from 283 million to 407 million tonnes. The gross value of agricultural output increased by 26% between 1980 and 1983 (at constant prices of 1980) [Lin, 1988]. Figure 1 shows the amount of grain consumption per person in rural areas rapidly increased after the introduction of HRS at the end of the 1970s and quickly surpassed that of urban population consumption from 1980.

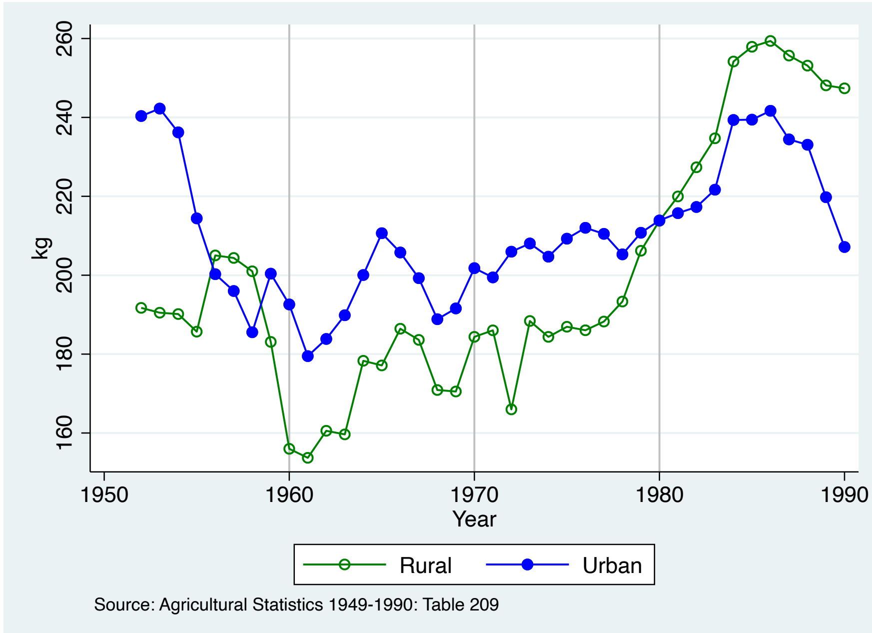
Although privatisation in agriculture successfully incentivised farmers and significantly increased agriculture productivity and rural income, it destroyed the old collective system - the communes. As the communes dissolved, so too did the system of social services in the rural society. Teachers and healthcare workers in rural areas, who were paid by the production teams, brigades, and the communes, now lost their income source and were unable to provide the basic education and health care. In 1978, 82% of all brigades were under the CMS, but by 1983 only 11% brigades remained in the scheme [Huang, 2011; Bloom and Xingyuan, 1997]. With the exception of vaccination and family planning, rural healthcare between the 1980s and the early 2000s relied mostly on private health services [Liu et al., 1995; Blumenthal and Hsiao, 2005].[7]

In the early economic reform period, steps was taken to reform the public finance system. The

[6] Depending on the poverty line used to measure poverty.

[7] It was not until the early 2000s that a New Cooperate Medical Scheme started to take shape.

Figure 1: Grain consumption per person: 1950-1990



Notes: Grain consumption is calculated on a trade weight (processed or milled) basis. The data used are from Table 209 of Colby et al. [1992]. Their data were gathered from the following yearbooks: 1) China Commerce Yearbook (ZllOngguo Shangye Nianjian) 1988, 2) China State Statistical Bureau, Trade Goods and Materials Statistics Division (Zhongguo Shangye Waijing Tongji Ziliao), 1952-88, and 3) China Commerce Yearbook (Zhongguo Shangye Nianjian), 1991.

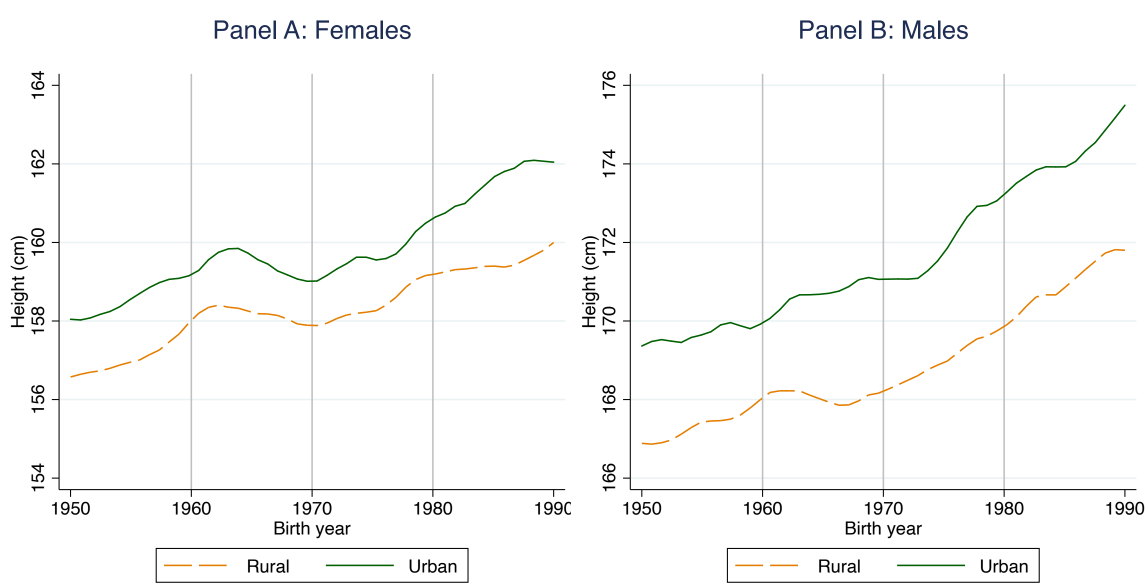
1994 public finance reform allowed the central government to gain more revenue, but delegated fiscal expenditure responsibilities to sub-national governments [Huang, 2011; Shen et al., 2012]. Consequently, health expenditure began to rely on local government fiscal capacity (Park 1996). Overall, the share of health services financed by the central government fell from 40% in the early 1980s to less than 20% in 1993, and a majority of this funding was spent in urban areas [Huang, 2011].

The urban economy also experienced significant changes. The privatisation and marketisation process initiated in from the early 1980s gained momentum in the mid 1990s. While the reform significantly increased urban income, it shifted a large proportion of workers from state-owned to privately-owned work units. The cradle-to-grave social welfare system long enjoyed by urban residents in the pre-reform era gradually changed. Public hospitals were no longer completely funded by the state, but increasingly relied on selling services and medicines to pay salaries and bonuses to their staff. However, these changes to the urban sector occurred after the mid-1990s, which is beyond the period of study for this paper.

2.2.2 One Child Policy and son-preference

After the early success in implementing family planning policies (the 'Later, Longer, and Fewer' policies) to bring down fertility, the much stricter 'One Child Policy' (OCP) was put in place in June 1979 [Center for Population Studies and of the China's Population Yearbook, 1986]. OCP was rigidly implemented in the urban areas, whereas in rural areas, where cultural traditions have always had stronger influence, a second birth was allowed if the first child was a girl to accommodate China's 'son-preference' tradition [Peng, 1991]. Out-of-quota births were subject to fines, but to different degrees depending on local officials' policy enforcement means and political lineage [Edlund et al., 2013]. In any case, the fertility restrictions were real and even with a much looser policy, issues such as abnormal sex ratio at birth became a very serious problem in rural areas.

Figure 2: Height by rural-urban and gender: 1950-1990



Source: China Family Panel Survey; China Health and Nutritional Survey; Rural-Urban Migration in China
Notes: The graph is generated with local polynomial smoothing line with bandwidth of 1.2.

In general, when fertility drops, ceteris paribus, family size reduces and per child nutrition intake increases, health and hence height would improve. However, under a strong culture of son-preference and a potential financial penalty for additional births, the change in height may differ between boys and girls. Indeed, this may well be what happened in rural China. Figure 2 shows the average height by rural/urban status and by gender.[8] The figure indicates that rural men and women are

[8]Due to small sample size, especially for the urban sample, we merge three data sets to plot Figure 2: the China

on average shorter than their urban counterparts who were born in the same year, and more so for men (around 4 cm difference between urban and rural men) than for women (around 2 cm difference between urban and rural women). However, if we consider the long-term trend, rural men track urban men quite closely over the entire period, but rural women's growth in height stalled after the introduction of the OCP (cohorts born after the late 1970s).[9]

3 Model specifications and estimation issues

Although Figure 2 presents the unconditional time trend of how Chinese adult stature evolved between 1950 and 1990, the unconditional means may be influenced by compositional changes in population over time. Thus, to answer our first question, and to quantify the height changes, we estimate a simple regression, controlling for birth-county fixed effects. Specifically, we estimate two different specifications of the following equation:

$$H_{ic} = \alpha_0 + \alpha_1 T_i + \delta_c + \varepsilon_{ic} \tag{1}$$

where H_{ic} is the adult height of individual i born in county c and measured at the survey year. T_i represents the trend in height across birth cohorts, either as a linear trend, or measured as three decade dummy variables, indicating the decade the individual was born (the 1960s, 1970s, and 1980s) with the 1950s used as the omitted category. δ_c is the birth-county fixed effects and ε_{ic} is the random error.

To understand how local economic and social environments affect individuals' stature, we estimate the following equation:

$$H_{ic} = \beta_0 + \beta_1 \sum_{n=1}^{3} \omega_n E_{cn} + \beta_2 X_{i14}^{P} + \beta_3 W_{ic} + \beta_4 Sib_{ic} + \lambda_c + \epsilon_{ic} \tag{2}$$

where E_{cn} is a vector of socioeconomic conditions in county c at time t_n; n represents the individual's age between 0 and 3 (the first three years of a child's life), while ω_n is a damping coefficient, which varies with age. In this study ω_n is calculated based on the WHO height-for-age median value growth chart, which will be discuss in details below. Thus, in this regression we replace a birth year trend,

Family Panel Survey, the China Health and Nutritional Survey, and the Rural-Urban Migration in China. Later in the paper we test the sensitivity of estimation using one or three data sets.

[9] The fast catching up of rural female height to that of the urban female during the famine years may be related to the survival bias discussed in Gørgens et al. [2012].

T, with a vector of local socioeconomic conditions which also vary across birth years to see how the over-time variations in these conditions affected the average height of the population. E consists of four different measures for socioeconomic conditions at the county level: log of industrial and agricultural outputs per capita, separately, (we also use the variable 'total output per capita' to test the sensitivity), the log of government social expenditure per capita, and the population mortality rate.[10] X_{i14}^{P} is a vector of parental characteristics at the time the individual was aged 14,[11] including parental education, whether the father was a party member, and the rank of the father's occupation. This parental information during individuals' childhood can capture family income information over and above local socioeconomic condition effect at individuals' childhood. W_{ic} is a vector of variables including individual i's ethnicity, gender, and birth order index at the survey year.[12] Sib_{ic} is the number of siblings individual i has. λ_c captures the birth-county fixed effects and ϵ_{ic} is the random residual.

In equation (2) we try to mitigate the potential endogeneity problem by using the lagged economic and social conditions together with county fixed effects. We argue that, controlling for time-invariant county factors, it is unlikely that individuals' adult height could affect the socioeconomic conditions in their childhood (the reverse causality issue). There may still be omitted variable problems. For example, parental height is an important determinant of child's height but we did not control for it as only a very small proportion of the observations have this information. There is a possibility that parental height could also be related to socioeconomic conditions of the county at the time of the individual's childhood. To the extent that this slight possibility exists, $\widehat{\beta}_1$ in equation (2) may be estimated inconsistently. However, as the socioeconomic conditions are recorded at the time the individual was a child and at that time their parents' heights had long stopped growing, it is less likely that parental heights and the local socioeconomic conditions measured at that time are

[10]Here we are generating weighted average local socioeconomic conditions during the person's critical growing period. Ideally, we would want to take into account the entire height growth period (age 0-16) when estimating equation (2). However, two issues stop us from doing so. First, to take a 16 year weighted average of these variables we need to have data extending to 2006 for those who were born in 1990, but our data end at 1990. If we do take a 16 year weighted average, we would lose a large proportion of observations from our sample. Second, taking a 16 year weighted average will significantly reduce the variation of these variables across different cohorts and hence reduce the precision of our estimates. In addition, based on the WHO height growth chart, the first three years of child life account for 40% of height growth, we therefore decide to take the weighted averages of the first three years' of socioeconomic conditions of the individual's birth county.

[11]It would be ideal if we had parental information at a much earlier stage of the child development as the stature development mainly occurs in the first three years of individual's life according to WHO height-for-age median value chart. However, the earliest information we can obtain from the survey is at age 14.

[12]The birth order index is a normalised birth order, which is calculated based on Hatton and Martin [2010]. The reason for using the index instead of the actual birth order is because the variables 'number of siblings' and 'birth order' are highly correlated. In our samples, the correlation coefficient between the number of siblings and the actual birth order is 0.6748, while after normalisation the coefficient of correlation reduced to 0.1091.

strongly correlated.

In this situation, parental heights can only be correlated with the 'socioeconomic condition' variables if there were strong persistence in these variables. We have two reasons to suggest that this is unlikely to affect our estimation. First, considering China's economic growth path, as discussed in Section 2, it is clear that local socioeconomic conditions have changed dramatically. Second, to the extent that there is a certain degree of persistence, this should be absorbed by the county-level fixed. Nevertheless, we test the effect of this omission in the sensitivity test section (Section 6).

Equation (2) assumes that the impact of socioeconomic conditions is linear: the effects are constant over the forty-year period. To test if this is the case, and more importantly, to identify the economic reform effect, we introduce an exposure measure, which indicates what proportion of individuals' most important stature growth period (age 0-3) occurred during the economic reform period (1979 and after). To do so, we augment equation (2) above as follows:

$$H_{ic} = \gamma_0 + \gamma_1 \sum_{n=1}^{3} \omega_n E_{cn} + \gamma_2 X_{i14}^{P} + \gamma_3 W_{ic} + \gamma_4 Sib_{ic} + \gamma_5 Expo_{ic} + \gamma_6 Expo_{ic} * Sib_{ic} + \mu_c + \upsilon_{ic} \quad (3)$$

where $Expo_{ic}$ measures the share of the individual's first three years of life, weighted by the damping coefficient, exposed to the '1979-and-post' period. Specifically, the variable takes a value of zero for those born before 1977, one for those born in 1979 and after, and a fraction between 0 and 1 for those born in 1977 or 1978.[13] Including the exposure variable in equation (2) allows us to capture the net '1979-and-post' effect. It is important to note that the exposure term and its interaction with the number of siblings captures the effects of reform over and above those reflected in the per capita output terms and the main sibship size effect.

However, there is a complication. The economic reform was introduced in 1979, and so was the OCP.[14] Thus, the exposure variable can only measure the net effect of the combination of the two policies. Our purpose is to identify the economic reform effect and to answer our third question of how the OCP and accompanying economic sanctions for violations of the policy may have affected the two gender groups differentially due to the son-preference culture. To do so we need to separately

[13] We discuss the details of this exposure measure in the next section.

[14] Note that both economic reform and OCP have different channels through which they can affect height of individuals. Economic reform increased household income, but in its early years it reduced rural household access to health care. The situation did not improve much until the late 1990s. The net effect of the reform should be a combination of these two potentially opposite effects. Similarly, the introduction of the OCP should reduce sibling numbers, hence increase resources to be shared among siblings within the family. But for households that prefer sons over daughters, the out-of-quota birth in order to get a male birth would increase sibling number. What is more, if an out-of-quota birth occurs it would incur a financial fine for the family and further reduces the resources to be shared among siblings.

identify them. Our strategy is to interact the exposure variable with the number-of-siblings variable. We argue that the effect of OCP on height mainly goes through fertility. Conditional on household income during childhood (which is captured mainly by variables on parental characteristics at the time the individual was 14 years of age), 'fertility' interacted with the post-OCP dummy has implications on resources available to our sample individuals, not only through the Quantity-Quality trade-off of reduced number of siblings due to the OCP, but also through potential fines incurred for violation of the OCP birth quotas (the additional negative income effect). Because we control for both the level effects of 'exposure' (post-reform positive income effect) and 'number-of-siblings' (pre-OCP fertility effect) variables, the interaction term captures the sibling effect for individuals who were born in the period of post-OCP policy. The un-interacted exposure variable captures the economic reform effect. We estimate this specification separately for male and female samples to gauge the differential effect of OCP on the two gender groups.

4 Data and descriptive statistics

4.1 Data

We use two main data sources: the China Family Panel Studies (CFPS) initial 2010 wave complemented with its 2012 and 2014 waves, and the county-level gazetteer data we hand collected from hundreds of books. The CFPS is an ongoing panel survey conducted by Peking University.

The CFPS 2010 wave surveyed 33,600 respondents. The survey covers a rich array of individual and household level information, including individual self-assessed anthropometric measurements. We focus on the height of individuals born between 1950 and 1990 and this restriction reduces our sample to a total of 25,243 individuals. Further, excluding individuals with missing values relevant to our estimation, we have a final sample of 18,508 individuals. While our sampling frame is based on the 2010 wave, to reduce reporting errors on height, we take the mean height reported in the three survey years (2010, 2012 and 2014). But, to maintain the sample size we include individuals who reported height at least once in the three waves. We also exclude obvious outliers from our final sample.[15]

The height variable in the CFPS survey is self-reported. Comparing self-reported height by birth cohort from the CFPS with the measured heights for the same cohorts from the China Health and

[15]Table A1 in Appendix A reports details as to how many observations were excluded based on each of the sample restrictions.

Nutrition Survey (CHNS) we find that the differences between self-assessed and measured heights are not large (see Section 6.1). However, the height-by-age measure could be subject to other biases. One is that there could be positive selection among those that survive to older ages, which could create upward bias among older cohorts. In the case of China, there is also a concern about those born just before and during the famine years.[16] For cohorts born after the early 1960s it should not be a problem. Another measurement-related issue is that height decreases in older age, largely due to compression of the spinal column, which would lead to an downward bias in earlier cohorts.[17] Both of these potential measurement issues point to our 1950s cohorts as being problematic, but the direction of the bias from the two issues are opposite and could to some extent cancel out each other. Further, Fernihough and McGovern [2015] found that the potential shrinkage in age 50 to 60 is quite small and stable. To allow our analysis for a longer period we opt to keep the 1950s cohorts in the sample, but test the sensitivity of this inclusion for our main conclusions.[18] While the full age range is useful to illustrate the long run trends, for most of what follows we restrict our analysis to those that were aged 20 to 60 at the time of the survey.

An important feature of the CFPS is that it records each respondent's birthplace and household registration status in childhood at the county level, which the CHNS does not. This means that we can fairly accurately capture their birth location and link individuals to local socioeconomic conditions. We divide our final sample into two subsamples: those whose household registration at age 3 was rural (16,051) and those who were registered as urban (2,457). Given the vastly different economic institutions for the rural and urban regions as discussed in the background section, our analyses are always conducted separately for rural and urban samples.

To link individuals to local socioeconomic conditions in early childhood, we merge the CFPS data with data collected from local gazetteers using birth year and birth county. Our sample individuals were born into 159 counties of 25 provinces. The data from county gazetteers include annual agricultural and industrial output values (and total output values), government social expenditure (mainly including expenditure on health and education), mortality rate, and total population over the years from 1950 to 1990. According to Almond et al. [2019], data from the gazetteers are similar to those from the yearbooks but are more accurate when they disagree. However, not all the counties have all the variables for every year between 1950 and 1990. We use yearbook data to fill in some of

[16] Gorgens et al. (2012) estimate that selection during the Great Chinese Famine increased height by about 1-2cm. On the other hand, the so-called the scarring effect decreased height by about the same amount [Gørgens et al., 2012].

[17] Huang et al. [2013] estimate the height shrinkage for Chinese men and women from the age of 60 onwards at about 2 cm per decade.

[18] See Table A8 in Appendix A.

the missing values, but that still leaves a rather large proportion of missing values. To ensure that the sample size is not reduced too much, we use available years of county-level data together with the prefecture or provincial time trend to obtain predictions for the years in which the county-level data are missing. More details of data sources, collection, and prediction are presented in Appendix C.

There is another issue related to merging county-level gazetteers data with individual-level data. In China each region has two types of household registration (*hukou*): 'rural' or 'urban'. A majority of the population in rural areas have 'rural' household registrations, but a small proportion also has 'urban' household registrations, such as local mayors or a small number of public servants. In urban regions, a majority of the population has 'urban' household registrations, but there are also 'rural' *hukou* people living in the periphery of the city. However, the aggregated data on county level socioeconomic conditions do not distinguish between 'rural' and 'urban'. Thus, we merge county-level variables with individuals' birth-county identification, regardless of their *hukou* status. That is to say that in the same county or city everybody is merged to the same local socioeconomic condition variables relevant to their birth year regardless of their *hukou* status.[19] In the regression, however, we include a variable which captures each county's rural or urban *hukou* population share. The information on rural or urban *hukou* populations at the county level are also collected from the county gazetteers.

4.2 Descriptive Statistics

Table 1 reports the summary statistics for the rural and urban samples, separately. As height development mainly occurs in childhood, we define 'rural' and 'urban' samples based on individuals' *hukou* registration status at age 3.[20] Panel A of Table 1 reports individual and parental characteristics, and Panel B presents the socioeconomic conditions of the individuals' birth counties at their birth year.

The average height of our rural male sample is 169 cm, and that of the urban sample is 172 cm, a 3 cm difference. For females, the difference is around 2 cm (=161-159). However, as indicated in Figure 2, the difference varies by birth cohorts, it is larger for the younger birth cohorts than for the older birth cohorts. The average ages of the rural and urban samples are about the same, with the rural sample being around 0.7 years older than that of the urban sample. The average number

[19] For example, individuals A and B were born in a county C. A's household registration status was urban, and B's was rural at birth. In our data, county-level characteristics for A are the same as for B.

[20] Around 15% of our sample switched *hukou* status from rural to urban between age 3 and the date of survey.

of siblings is 3 among rural individuals and 2 for urban individuals.

One key element of family background is parental education. The average years of schooling of the parents (the average of mother and father) is 2.9 years for rural individuals and 6.2 years for urban individuals. To better capture family income level when our sample individuals were young, we generate a variable of father's occupation rank when the child was 14 years of age. The occupation classification in the CFPS is very detailed. There are 364 occupations in total and 28 for agriculture workers alone in the sample. We rank these occupations based on the mean earnings in 2010 for each occupation.[21] The higher the rank of occupation, the higher the average earning. The average rank of father's occupation is 66 in the rural sample and 191 in the urban sample, which is about three times higher than the rural sample. About 11.4% and 21.1% of individuals' fathers were the communist party members in the rural and urban samples, respectively. The individual's own education differs sharply between rural and urban individuals by about 4.5 years of schooling. Finally, the proportion of Han Chinese is over 90% in both samples.

Panel B of Table 1 shows that people in rural areas faced poorer socioeconomic conditions compared to those in urban areas.[22] For example, the total value of output per capita in the rural sample is 650 yuan in 1990 prices, which is far lower than that of the urban sample (3,690 yuan).[23] The local government social expenditure per capita is 10 yuan for rural people, and 20 yuan for urban people. The average mortality rate is higher among rural residents compared to those in urban areas.

5 Results

5.1 Long-term trends in the Chinese heights

This section explores the long term trend in adult heights of individuals born between 1950 and 1990. As shown in Figure 2, over the four decades, male height increased by around 6-7 cm, and female height increased by around 4 cm. A common pattern across the four groups is that slopes are steeper among post-1970 birth cohorts relative to pre-1970.

[21] It would be more accurate to use the average income level of each occupation at child's age 14, rather than as of 2010 but we do not have that information.

[22] Earlier, we mention that county-level variables are aggregated regardless of *hukou* status. Here we see significant differences in county-level characteristics because rural *hukou* individuals are more likely to live in rural areas where the socioeconomic environments are poorer than in urban areas.

[23] The reason why the urban sample also recorded agriculture output is that there are rural areas within each prefecture, such as the peripheries of cities. When Statistical Bureaus of these cities reporting their total output, it includes both non-agriculture and agriculture outputs.

Table 1: Descriptive statistics

	Rural *hukou*			Urban *hukou*		
Mean (Std. Dev)	Total	Male	Female	Total	Male	Female
Panel A: Individual characteristics						
Height (cm)	163.85	168.79	158.83	166.69	172.20	160.79
	(7.37)	(5.73)	(5.13)	(7.82)	(5.63)	(5.05)
Birth year	1969	1969	1969	1970	1970	1969
	(11.05)	(11.04)	(11.05)	(11.81)	(11.74)	(11.89)
Age in 2010	41.16	41.31	41.00	40.48	40.27	40.70
	(11.05)	(11.04)	(11.06)	(11.80)	(11.73)	(11.89)
Male	0.50			0.52		
	(0.50)			(0.50)		
Number of siblings	3.00	2.92	3.07	2.01	1.96	2.06
	(1.85)	(1.86)	(1.84)	(1.86)	(1.83)	(1.89)
Birth order	2.56	2.56	2.57	2.15	2.16	2.14
	(1.59)	(1.59)	(1.60)	(1.48)	(1.47)	(1.49)
Birth order index	0.06	0.09	0.03	0.15	0.18	0.11
	(1.21)	(1.20)	(1.22)	(0.95)	(0.95)	(0.95)
Parental average schooling years	2.94	2.95	2.92	6.20	6.24	6.17
	(3.23)	(3.23)	(3.23)	(4.29)	(4.32)	(4.25)
Father's occupation rank at child's age 14	66.14	65.40	66.89	191.23	190.06	192.49
	(80.27)	(79.49)	(81.04)	(79.52)	(79.40)	(79.66)
Father's party membership at child's age 14	0.11	0.11	0.11	0.21	0.21	0.22
	(0.32)	(0.32)	(0.32)	(0.41)	(0.40)	(0.41)
Individual schooling years	6.83	7.70	5.95	11.40	11.45	11.33
	(4.37)	(3.98)	(4.58)	(3.36)	(3.25)	(3.48)
Han Chinese	0.90	0.90	0.91	0.96	0.96	0.96
	(0.29)	(0.29)	(0.29)	(0.19)	(0.19)	(0.20)
Panel B: County characteristics[1)]						
Total output per capita[2)]	0.07			0.37		
	(0.10)			(0.39)		
Agricultural output per capita[2)]	0.03			0.03		
	(0.02)			(0.07)		
Industrial output per capita[2)]	0.03			0.33		
	(0.09)			(0.38)		
Gov. expenditure on social services per capita[2)]	0.001			0.002		
	(0.002)			(0.003)		
Death rate (‰)	9.52			7.27		
	(5.63)			(4.45)		
N	16051	8098	7953	2457	1270	1187

Note:
1) County-level variables are weighted by the rural *hukou* population share for the rural sample and urban hukou population share for the urban sample;
2) Unit: 10000 yuan; measured in 1990 price level;

However, the unconditional trend of the mean height presented in Figure 2 may be influenced by compositional changes in population over time. Thus, we estimate time trends in a simple regression, controlling for birth-county fixed effects as indicated in equation (1), and see the average growth within a county across cohorts. As discussed in Section 3 we estimate two different specifications of equation (1), where time is measured as: (1) a linear trend and (2) three decade dummy variables.

Table 2 presents the results from the first two specifications. Panels A and B present results for the rural and urban samples respectively. Columns 1 and 3 present results for the linear trend in height for males and females separately. The results in Panel A indicate that the annual height increase is 0.127 cm for rural males, and 0.070 cm for rural females. Panel B shows that the annual height growth is 0.153 cm for urban males and 0.104 for urban females, which is approximately 0.03 cm higher than for the rural sample. Since birth-county fixed effects are included, this growth reflects within-county growth patterns. Thus, over 40 years, and controlling for regional variations, rural and urban male height increased by 5.08 and 6.12 cm, respectively, while rural and urban females increased by 2.80 and 4.16 cm, respectively. However, here we assumed a linear growth path of height and based on the discussion in the background section, the economic and social environment over the 40-year period has changed dramatically. The height increases should also vary accordingly.

Columns 2 and 4 present the results using three decade dummy variables to capture the effect of change in the economic and social environment over different decades on height. The omitted category in each case is those who were born in the fifties. Thus, as each decade of the 1960s to 1980s is compared to the same base, their relative magnitudes should not be affected by the shrinkage issue caused by the 1950s cohort being in their 50s. Panel A shows that rural males born in the 1960s are 0.944 cm taller than the reference category of the 1950s, while the difference for rural females is 1.122 cm. For the urban sample (Panel B) we find that the 1960s males and females are 0.589 and 0.721 cm taller than their 1950s counterparts, respectively, but the difference is statistically significant only for the female sample. The fact that female 1960s cohorts are doing better than their male counterparts when compared to those born in the 1950s could be related to the shrinkage issue, which is greater for men than for women (see, for example, Huang et al. [2013]; Fernihough and McGovern [2015]).

The 1970s cohorts are taller than the 1960s cohorts for both rural and urban samples. The difference for rural males is 0.993 cm (=1.937-0.944), for rural females it is 0.247 cm (1.369-1.122), for urban males it is 1.267 cm (1.856-0.589), and for urban females it is 0.727 cm (1.448-0.721). The differences between the 1970s and 1980s cohorts are 2.010 cm for rural males, 0.935 cm for rural

Table 2: Time trend in height growth

	Rural Total		Rural Male		Rural Female	
	(1)	(2)	(3)	(4)	(5)	(6)
Time trend	0.091***		0.127***		0.070***	
	(0.006)		(0.006)		(0.006)	
Born in 1960s		0.785***		0.944***		1.122***
		(0.138)		(0.153)		(0.157)
Born in 1970s		1.416***		1.937***		1.369***
		(0.177)		(0.199)		(0.167)
Born in 1980s		2.859***		3.947***		2.304***
		(0.202)		(0.203)		(0.188)
Constant	162.140***	162.672***	166.401***	167.218***	157.498***	157.657***
	(0.120)	(0.112)	(0.118)	(0.118)	(0.111)	(0.109)
Observations	16051	16051	8098	8098	7953	7953
Adjusted R^2	0.097	0.096	0.225	0.222	0.164	0.163

	Urban Total		Urban Male		Urban Female	
	(1)	(2)	(3)	(4)	(5)	(6)
Time trend	0.149***		0.154***		0.107***	
	(0.011)		(0.012)		(0.009)	
Born in 1960s		0.634		0.589		0.721**
		(0.382)		(0.422)		(0.359)
Born in 1970s		2.326***		1.856***		1.448***
		(0.497)		(0.526)		(0.540)
Born in 1980s		4.293***		4.378***		3.346***
		(0.350)		(0.408)		(0.361)
Constant	163.775***	164.892***	169.151***	170.463***	158.710***	159.422***
	(0.212)	(0.243)	(0.233)	(0.296)	(0.176)	(0.249)
Observations	2457	2457	1270	1270	1187	1187
Adjusted R^2	0.090	0.087	0.223	0.214	0.118	0.117

Note:
1) Robust Standard Errors (SEs) are presented in parentheses;
2) SEs are clustered at the county and prefecture levels for the rural and urban samples, respectively;
3) County and prefecture fixed effects are included for the rural and urban samples, respectively;
4) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

females, 2.522 cm for urban males, and 1.898 cm for urban females. All of these differences are statistically significant with the exception of urban females between the 1960s and 1970s.[24]

The results obtained from Table 2 confirm the strong and sustained increase in average Chinese heights, which exceeded 1 cm per decade for three out of four subgroups. Despite the economic and social turmoil that blighted much of the period, this is comparable with the experience of western Europe in the century to 1980 although maybe slower than that of South Korea and Taiwan since the 1950s [Hatton, 2014; Schwekendiek and Baten, 2019]. Most of the height growth for the Chinese population occurred after the 1970s and particularly so in the 1980s, which corresponds with the economic reforms started in late 1970s.

Also evident from Table 2 is that the urban population, on average, is taller than the rural population (the constant terms in Table 2 indicate that urban males and females who were born in the 1950s are about 3 cm and 2 cm taller than their counterparts born in rural areas, respectively[25]) and also had more height growth than their rural counterparts. China's rural-urban divide policy can probably explain a large part of the difference in the level and increment of the average height between rural and urban populations. This is not only because urban average per capita income is almost three times of that of rural average per capita income and urban people consume more calories (see Figure 1), but also because healthcare provision has always been more widespread and better quality in urban than in rural areas as discussed in Section 2.

The final observation from Table 2 is that the average height of males increased more than their female counterparts over time. More importantly, the gender gap in height is larger in rural than urban areas and it is increasingly so. This finding is consistent with Schwekendiek and Baten [2019] who also show that a pro-male bias in height is larger among the 1980s birth cohort than the 1970s. The increasing difference in height between men and women over time, especially for the rural population, is likely to be related to the introduction of the OCP under the culture of son-preference. The late 1970s and the 1980s saw the introduction of OCP which reduced the fertility rate. In the same period, the introduction of the Household Responsibility System in rural areas significantly increased household incomes. Both of these events should be positively related to average height as they increased available resources to each child in the household. However, the benefits seem

[24] The significance test results are available upon request from the authors.

[25] When comparing the constant terms across regressions one needs to be aware of the omitted categories of multiple category dummy variables are consistent across the regressions. Luckily, the only group of dummy variables we include in these regression (apart from dummies for decades) is the county-fixed effects. We have estimated these regressions without county-fixed effects and the results show that they do not affect the constant terms much. These results are available upon request from the authors.

to have been reaped more by males than by females. This is likely to be related to the traditional son-preference under the OCP. Under the son-preference culture, traditional families (more likely to be rural households) are likely to provide more to boys than to girls. Thus, within a family with mixed-gender siblings girls are likely to be discriminated against in resource allocation. In addition, in rural areas, the OCP allowed families with firstborn girls to have a second child. As a result, rural females are likely to be in households with more children. If Becker's Quantity-Quality trade-off effects are at work, ceteris paribus, we would also expect females be further discriminated against in resource allocation [Becker and Lewis, 1973]. The combined effect would see female height move slowly relative to male height despite the reduction in the fertility rate and the increase in per capita income during the same period.

5.2 Height and its contributing factors

5.2.1 Socioeconomic factors

Although columns 2 and 4 of socioeconomic Table 2 have shown that the period where average height growth is the most is in the late 1970s and the 1980s, what exactly contributed to such a growth is unknown. In this subsection we turn to our second question to examine how changes in local living conditions are associated with the height-growth pattern. In doing so, we estimate equation (2). As previously discussed, equation (2) examines the effect of socioeconomic conditions in the individual's birth county in the first three years of life on height. To better capture the birth-period effect, we examined WHO height-for-age median values for boys and girls separately, which show that height increases most in the first three years of life, accounting for almost 40% of the total.[26] We thus use the share of the first three years' height growth as the weight to adjust the social economic conditions at the time of individual's first three years to generate a weighted average of local conditions.[27]

Table 3 presents the results for the rural total, male and female samples (columns 1 to 3) and the urban total, male and female samples (columns 4 to 6). Controlling for parental education, occupation, and party membership status when the person was a child (aged 14 years), individual and family characteristics, together with birth-county fixed effects, we find that local conditions during the first three years of life play important roles in rural individuals' adult height. For rural areas, every 10% increase in agricultural and industrial outputs increase average height by 0.043 cm and 0.021 cm, respectively, and the coefficients are statistically significant at the 5% and 1% levels,

[26] See Section 3 for more discussions regarding why we focus on the first three years.
[27] The details of how the weight is calculated are presented in Appendix B.

respectively. These are rather large impacts. During this period, China's average agricultural and industrial output increased by 3.1% and 8.0% per annum, respectively [NBS, 1999]. In particular, during the economic reform period of the 1980s, the annual growth rates were 6.0% and 7.6%. These large effects, however, mainly affected rural male average height, but not that of females. A 10% increase in agricultural and industrial outputs increased average male height by 0.075 cm and 0.026 cm and both are statistically significant, but the effects on average rural female height are almost zero and none is statistically significant.[28] Government social expenditure per capita (mainly on education and health) at the time of individuals' first three years of life also appear to have been an important contributor to both rural male and female average heights. However, the effect is almost twice the size for males as for females. A 10% increase in social spending increases male average height by 0.065cm and female average height by 0.033cm. General health conditions at the time of individuals' first three years of life measured by the county-level mortality rate, has the expected negative effect overall but is significant only for females. A 10% reduction in mortality rate is associated with a 0.0053 cm increase in rural female average height.

These results suggest that the local socioeconomic environment contributed more to rural male average height change than to rural female average height increase. Indeed, including the four county-level variables in rural male and female regressions explains, respectively, 23% and 16% of the average height of rural males and females (the adjusted R^2s are 0.23 and 0.16). If we exclude the four social/economic environment variables, the adjusted R^2 for the rural male sample is reduced by 2.5 percentage points to 0.20 (11% of the total explained variation in individuals height can be attributed to these social/economic factors), whereas for the rural female sample, it only drops by 1 percentage point to 0.155 (6.1% of the total explained variation).

The results for those who grew up in urban areas stand in sharp contrast. For the urban sample, output variables have limited effects on average height, except for a small positive effect of the industrial output on average heights of urban females. The effect of government social spending per capita, however, seems to be very important influence on heights of urban people. A 10% increase in government social spending increases average urban height by 0.089 cm. The effect is particularly strong for males; a 10% increase in social spending increases average urban male height by 0.113 cm, whereas for females, it increases the average height by only half as much: 0.054 cm. The level of government social spending per capita for our sample prefectures increased by 8.4%

[28] The joint significance of the two variables is also not statistically significant with a p-value of 0.26. Table A2 in Appendix A includes total output per capita instead of the two separate output variables and shows a consistent pattern.

Table 3: Effects of regional social and economic factors on height

	Rural sample			Urban sample		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Log Agricultural output p.c.- age 0 to 3	0.427**	0.746***	0.074	0.039	0.212*	-0.155
	(0.168)	(0.233)	(0.217)	(0.106)	(0.125)	(0.137)
Log Industrial output p.c.- age 0 to 3	0.206***	0.259**	0.158	0.066	-0.057	0.177*
	(0.077)	(0.101)	(0.103)	(0.089)	(0.167)	(0.106)
Log Gov. Social expenditure p.c.- age 0 to 3	0.477***	0.646***	0.332***	0.893***	1.134***	0.542***
	(0.099)	(0.136)	(0.115)	(0.092)	(0.123)	(0.147)
Death rate (‰) - age 0 to 3	-0.032**	-0.015	-0.053***	0.019	0.018	0.014
	(0.012)	(0.015)	(0.016)	(0.037)	(0.047)	(0.052)
Parental schooling years	0.077***	0.102***	0.049**	0.127***	0.169***	0.123***
	(0.016)	(0.023)	(0.022)	(0.033)	(0.039)	(0.042)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002**	0.000	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Father's party membership at child's age 14	0.360***	0.299	0.382**	-0.093	-0.329	0.148
	(0.129)	(0.195)	(0.190)	(0.294)	(0.409)	(0.353)
Male	10.022***			11.340***		
	(0.096)			(0.245)		
Han Chinese	0.108	0.259	-0.005	-0.459	0.145	-1.149
	(0.250)	(0.365)	(0.329)	(0.848)	(0.842)	(1.020)
Number of siblings	-0.054*	-0.054	-0.028	-0.226***	-0.137	-0.315***
	(0.028)	(0.036)	(0.039)	(0.069)	(0.098)	(0.097)
Birth order index	0.061	0.034	0.053	-0.058	-0.064	-0.042
	(0.037)	(0.050)	(0.050)	(0.121)	(0.219)	(0.177)
Observations	16051	8098	7953	2457	1270	1187
Adjusted R^2	0.560	0.225	0.164	0.610	0.218	0.119

Note:

1) Robust Standard Errors (SEs) are presented in parentheses;

2) SEs are clustered at the county and prefecture levels for the rural and urban samples;

3) Unit: log of 10000 yuan; measured in 1990 price level

4) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

5) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

per annum between 1950 and 1990. For the last decade, the annual increase was much higher at 13.9% per year. On the other hand, the reduction in mortality rates plays no role in average urban population height, either for males or females. Once again, the four regional socioeconomic condition variables, in particular government social spending, contributed a rather large portion of explained height variation for the male sample (11.8%=0.0257/0.218) but was small for the female sample (5.3%=0.006/0.119).

Parental characteristics at the time the person was aged 14 are used to capture family socioeconomic background when the individual was young. We have three variables: the average years of schooling of mother and father (labelled as parental years of schooling); father's occupation rank when the child was 14 years of age, based on the mean earnings of the occupation in 2010; and whether the father was a communist party member when the child was 14 years of age. All three variables are statistically significant and positively related to individuals' height for the rural sample. For the urban sample, the only statistically significant parental variable is parental years of schooling. Other family and individual characteristics are not associated with average height apart from the number of siblings. For both rural and urban full samples, sibship size is associated with individual's height negatively, which is consistent with the Quantity-Quality trade-off theory, as well as the empirical literature on other countries [Hatton and Martin, 2010; Liu, 2014; Hatton, 2014, 2017; Bailey et al., 2016; Kubo and Chaudhuri, 2017]. However, when we separately estimate for the male and female samples, none of the coefficients is statistically significant. As discussed previously, while the fertility policy in China has changed significantly, in Table 3 we do not take the policy change into account.

5.2.2 Economic reform, the One Child Policy and height

In light of the dramatic shifts in public policy detailed in the background section, it seems likely that the effects of some of the variables that appear in Table 3 would have changed over time. Here we focus on the reforms outlined above, which took place from the late 1970s, specifically economic liberalisation, notably the HRS in rural areas, and the OCP. As these took place at the same time they are difficult to separate. However, we can make inferences by first deriving a measure of exposure to the reforms and then interacting this variable with family size to distinguish the effects of the OCP from those of economic reforms. This is represented by equation 3.

To recap, the exposure variable captures the shift from the planned economy to the market system. As discussed in the background section the introduction of the Household Responsibility System in rural areas and the subsequent switching from a planned to a market-oriented economic system for the urban economy led China to experience unprecedented and sustained economic growth; the abolition of the commune system reduced social services provided in rural areas for a long time; and the introduction of the OCP substantially reduced fertility. All of these important socioeconomic changes would have had important implications for average height. An increase in income provides families with more resources for everyone, while at the same time the reduction in social services at the village level and the privatisation of healthcare in cities could have the opposite effect. Similarly, the introduction of the OCP reduced fertility and enabled each child to get more resources, *ceteris paribus*. However, under the culture of son-preference and with the financial punishment of a violation of the policy being very high,[29] the net impact of the OCP is complicated depending on whether the individual is male or female, and whether the family has son-preference.

The lack of social-welfare provision generated by the abolition of the old commune system during the initial economic reform period mostly affected rural people. The potential negative impact of OCP was also mainly borne by rural people, in particular, rural girls. In general, rural Chinese are more traditional and have stronger son-preference than urban dwellers. In the presence of a strong son preference, and when the firstborn is a girl, it is more likely that parents would have a second birth and if the second is still a girl, they may continue to have a third and more births until they have a boy, whereas if the first or the second birth is a boy, parents are likely to stop. Thus, girls are more likely to have more siblings than boys under OCP. In addition, girls are more likely to be born in families that violate the birth quota and hence trigger a substantial fine, which in turn generates more financial difficulties for the family. Therefore, the introduction of the economic reform and the OCP might have contributed to the less height growth for the rural people, girls in particular, than their urban counterparts.

To understand the economic reform and the OCP effects, equation (3) is estimated for the rural and urban samples separately and the results for the two samples are reported in Tables 4 and 5, respectively. The first three columns of each table report the results for the total sample, while columns 4 to 6, and 7 to 9 present results for male and female samples separately. For all three samples we present three specifications: the reproduction of the estimated results from equation (2) (column 1) for comparison purposes; a specification adding only $Expo_{ic}$, the post-1979 exposure variable, to equation (2) to capture the net effect of both economic reform and the introduction of

[29] According to Scharping [2003]; Ebenstein [2010], the fine for violation of OCP in the 1980s was between 20-360% of urban household annual income, which is normally 2 to 3 times of rural household annual income.

the OCP; and the estimated results from equation (3).

In this subsection we discuss the results from the second specification. Both the rural and urban samples results show that people who spent some of their first 3 years of life after the introduction of economic reform and OCP are on average taller than those who did not (compare columns 2, 5 and 8 with 1, 4 and 7). For the rural male sample, this difference is around 1.07cm. That is to say, those who spent 100% of their first 3 years of life during the reform and OCP era are 1.07cm taller than those whose first three years in life was during the pre-reform and pre-OCP era. Those who spent a lesser share of their first 3 years during this period had less gain in their height. This difference for the rural female sample is smaller, but is still statistically significant, at around 0.41cm. The difference for the urban male sample is the largest, at 1.83cm. It is more than twice as large (1.79cm) for the urban female sample as for the rural female sample. As a proportion of mean heights the gains are 0.6% for rural males 0.3% for rural females, 1.1% for urban males, and 1.1% for urban females. Thus, the proportional gains are greater for men than for women, at least in rural areas, and greater for the urban-born than for the rural-born.

Table 4: Reform and OCP effects — Rural sample

	Rural Total			Rural Male			Rural Female		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Agricultural output p.c.- age 0 to 3	0.427**	0.194	0.193	0.746***	0.401	0.399	0.074	-0.050	-0.050
	(0.168)	(0.172)	(0.170)	(0.233)	(0.247)	(0.244)	(0.217)	(0.235)	(0.235)
Log Industrial output p.c.- age 0 to 3	0.206***	0.180**	0.182**	0.259**	0.230**	0.226**	0.158	0.141	0.144
	(0.077)	(0.079)	(0.078)	(0.101)	(0.099)	(0.098)	(0.103)	(0.105)	(0.105)
Log Gov. Social expenditure p.c.- age 0 to 3	0.477***	0.358***	0.349***	0.646***	0.472***	0.466***	0.332***	0.267**	0.261**
	(0.099)	(0.099)	(0.099)	(0.136)	(0.137)	(0.137)	(0.115)	(0.122)	(0.123)
Death rate (‰) - age 0 to 3	-0.032**	-0.032**	-0.036***	-0.015	-0.014	-0.019	-0.053***	-0.053***	-0.055***
	(0.012)	(0.013)	(0.013)	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.017)
Parental schooling years	0.077***	0.071***	0.067***	0.102***	0.095***	0.090***	0.049**	0.046**	0.043**
	(0.016)	(0.016)	(0.016)	(0.023)	(0.023)	(0.024)	(0.022)	(0.022)	(0.022)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002***	0.002***	0.002***	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Father's party membership at child's age 14	0.360***	0.386***	0.400***	0.299	0.334*	0.357*	0.382**	0.397**	0.401**
	(0.129)	(0.130)	(0.131)	(0.195)	(0.196)	(0.197)	(0.190)	(0.191)	(0.190)
Male	10.022***	10.024***	10.006***						
	(0.096)	(0.096)	(0.095)						
Han Chinese	0.108	0.110	0.097	0.259	0.246	0.244	-0.005	0.002	-0.012
	(0.250)	(0.252)	(0.255)	(0.365)	(0.366)	(0.363)	(0.329)	(0.332)	(0.335)
Number of siblings	-0.054*	-0.040	0.002	-0.054	-0.031	0.012	-0.028	-0.021	0.002
	(0.028)	(0.028)	(0.029)	(0.036)	(0.037)	(0.037)	(0.039)	(0.040)	(0.041)
Birth order index	0.061	0.072*	0.072*	0.034	0.049	0.054	0.053	0.059	0.058
	(0.037)	(0.037)	(0.037)	(0.050)	(0.050)	(0.049)	(0.050)	(0.051)	(0.050)
Exposure age 0-3		0.738***	1.455***		1.066***	1.812***		0.405*	0.814**
		(0.164)	(0.218)		(0.248)	(0.322)		(0.244)	(0.319)
Exposure age 0 to 3 × Number of siblings			-0.393***			-0.440***			-0.210**
			(0.068)			(0.108)			(0.095)
Observations	16051	16051	16051	8098	8098	8098	7953	7953	7953
Adjusted R^2	0.560	0.560	0.561	0.225	0.227	0.228	0.164	0.164	0.164

Note:
1) County fixed effects, a share of rural population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;
2) Robust Std. Err. are clustered at the county level;
3) * (**,***) denotes statistical significance at the 10% (5%, 1%) level;

Table 5: Reform and OCP effects — Urban sample

	Urban Total			Urban Male			Urban Female		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Log Agricultural output p.c.- age 0 to 3	0.039	-0.130*	-0.130*	0.212*	0.040	0.043	-0.155	-0.341***	-0.345***
	(0.106)	(0.073)	(0.072)	(0.125)	(0.093)	(0.093)	(0.137)	(0.108)	(0.108)
Log Industrial output p.c.- age 0 to 3	0.066	0.029	0.031	-0.057	-0.094	-0.093	0.177*	0.142	0.144
	(0.089)	(0.099)	(0.096)	(0.167)	(0.179)	(0.174)	(0.106)	(0.096)	(0.096)
Log Gov. Social expenditure p.c.- age 0 to 3	0.893***	0.463***	0.455***	1.134***	0.687***	0.684***	0.542***	0.091	0.079
	(0.092)	(0.121)	(0.122)	(0.123)	(0.199)	(0.195)	(0.147)	(0.184)	(0.187)
Death rate (‰) - age 0 to 3	0.019	0.021	0.014	0.018	0.020	0.014	0.014	0.014	0.009
	(0.037)	(0.033)	(0.033)	(0.047)	(0.048)	(0.048)	(0.052)	(0.047)	(0.046)
Parental schooling years	0.127***	0.114***	0.112***	0.169***	0.156***	0.152***	0.123***	0.107***	0.106***
	(0.033)	(0.031)	(0.031)	(0.039)	(0.039)	(0.039)	(0.042)	(0.039)	(0.039)
Father's occupation rank at child's age 14	0.000	0.001	0.001	-0.001	-0.000	-0.000	0.001	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Father's party membership at child's age 14	-0.093	0.002	0.003	-0.329	-0.280	-0.280	0.148	0.314	0.312
	(0.294)	(0.307)	(0.307)	(0.409)	(0.408)	(0.408)	(0.353)	(0.378)	(0.379)
Male	11.340***	11.324***	11.322***						
	(0.245)	(0.238)	(0.238)						
Han Chinese	-0.459	-0.384	-0.405	0.145	0.087	0.049	-1.149	-0.949	-0.947
	(0.848)	(0.827)	(0.822)	(0.842)	(0.834)	(0.823)	(1.020)	(1.003)	(1.005)
Number of siblings	-0.226***	-0.167**	-0.143**	-0.137	-0.072	-0.051	-0.315***	-0.260***	-0.240**
	(0.069)	(0.067)	(0.068)	(0.098)	(0.099)	(0.103)	(0.097)	(0.096)	(0.092)
Birth order index	-0.058	-0.030	-0.031	-0.064	-0.029	-0.021	-0.042	-0.014	-0.022
	(0.121)	(0.118)	(0.117)	(0.219)	(0.211)	(0.211)	(0.177)	(0.171)	(0.171)
Exposure age 0 to 3		1.731***	1.934***		1.834***	2.016***		1.787***	1.963***
		(0.308)	(0.329)		(0.579)	(0.589)		(0.584)	(0.628)
Exposure age 0-3 × Number of siblings			-0.391*			-0.390			-0.316
			(0.230)			(0.278)			(0.399)
Observations	2457	2457	2457	1270	1270	1270	1187	1187	1187
Adjusted R^2	0.610	0.613	0.613	0.218	0.224	0.224	0.119	0.125	0.125

Note:
1) Prefecture fixed effects, a share of rural population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;
2) Robust Std. Err. are clustered at the county level;
3) * (**,***) denotes statistical significance at the 10% (5%, 1%) level;

It is interesting to note that when the exposure variable is included, the coefficients on all of the previous statistically significant production output variables become smaller in size and some even become statistically insignificant. The magnitude of the coefficients on 'per capita government social spending' are also reduced by around one third of the size relative to the estimation without controlling for the exposure variable. These results suggest that perhaps the gains in population height due to local socioeconomic conditions are more important during the period after the economic reform and the introduction of OCP. Indeed, when we interact the exposure variable with the local socio-economic condition variables, we observe, for the rural sample, that the slope for industrial output is steeper for the group whose first 3 years of life was under the reform era than for those who were born earlier (See Table A3 in Appendix A). For the earlier cohort, this coefficient is positive and statistically significant. The effect of agricultural output is also positive for both groups and it is larger for the younger group, but none of them are precisely estimated. The effect of per capita government spending on health and education is strong and positive for the older group but slightly smaller for the younger group. Both are statistically significant. The largest difference is in the negative effect of mortality on height. While for both groups it is significant, the magnitude is much larger for the post reform group. For the urban sample, however, the only statistically significant difference between the post- and pre-reform groups is the effect of government per capita health and education spending. For pre- and post-reform groups, the coefficient on government health and education spending is positive, but it is statistically significantly larger for the post-reform group. It is also very interesting that when we interact these socioeconomic variables with the exposure variable, the size of the exposure variable is enlarged significantly. Perhaps, there are economic reform effects over and above its effects through an increase in output and reduction in mortality on height. Such additional effects could include the effect of general increase in household income (more nutrition and other income enabled health enhancing measures) and the fact that the reforms increased the ability of households to allocate resources in their own interest.

5.3 The fertility effect

Another question we raised in this paper is the contribution of fertility change to the significant increase in average height of individuals. The discussion above does not separately identify the economic reform effect from that of the introduction of the OCP. Studies have shown that fertility decline improves child health through the Quantity-Quality trade-off mechanism [Becker and Lewis, 1973; Liu, 2014; Kubo and Chaudhuri, 2017]. As family size decreases, the amount of food or other resources available for each child increases. This may lead to an increase in height. At the same time, the introduction of the OCP, especially in the 1980s, is accompanied by a significant financial fine to the households which violate their birth quotas.

In columns 3, 6 and 9 of Tables 4 and 5 we separately identify the economic reform and the introduction of the OCP effects by including an interaction term between the exposure variable and the number-of-siblings variable. Recall that we assume the effect of the OCP on height mainly goes through fertility. The interaction term between the exposure and sibling variables measures the net effect on 1979-and-post cohort of the reduced fertility due to the OCP and the negative effect due to potential fines incurred for violation of the OCP birth quotas.[30]

The results in Table 4 for both rural male and female samples show that the coefficients on the number of siblings are small and not statistically significant. The interaction terms, however, are large and precisely estimated. These results suggest that height of rural male and female individuals who were born before the introduction of the OCP were not affected by the number of siblings they had, but if they were born after the OCP an additional sibling reduces male and female heights by 0.44cm and 0.21cm, respectively. The difference in the coefficients for the male and female samples suggest that the reduction in sibling size due to the OCP would benefit males more than their female counterparts.[31]

What is more, controlling for the potential OCP effect, the coefficients on the main exposure variable, which captures the economic reform effect, now becomes larger. Rural males exposed to the economic reform since birth are 1.81cm taller than those who were not exposed during the first 3 years of life (pre-reform birth cohorts). This is an increase of 70% from the effect estimated without controlling for the OCP effect. For rural females the economic reform effect is 0.81cm, double that before including the OCP interaction. The fact that controlling for the OCP effect increases the effect of the economic reform may imply that the net OCP effect on rural height is negative. Recall that the introduction of OCP embodies two potential effect on height: the reduction of siblings increases the resources invested in each child, and an above quota birth incurs a substantial fine which would reduce the resources invested in each child.

For urban samples, although the size of the interactions between exposure and sibling numbers for both urban male and female samples are not small, none of them is precisely estimated and joint

[30] Although the exposure variable includes the early birth cohort of 1977 and 1978, the level of share of these early births is small. We also estimated another specification using dummy variable for birth year at and after 1979 to interact with the number of sibling variable and the results are largely consistent with the results presented here. These results are available upon request from the authors.

[31] Males also benefited more because, as noted above, their number of siblings fell by more after the reform.

significance tests between the 'sibling' level effect and the interaction term for both samples are not statistically significant either. Controlling for the OCP effect, the coefficient on exposure increased slightly from 1.86cm to 2.02cm for males, a 9% increase, and from 1.79cm to 1.96cm for females, a 9.5% increase.

Our results from columns 3, 6 and 9 of Tables 4 and 5 suggest that the net economic reform effect on height is large in both rural areas and in the urban areas. But compared to the mean height, urban dwellers benefited much more than their rural counterparts and rural females gained the least (the size of the coefficient on 'exposure' variable obtained in estimation of equation (3) as a share of the mean height is 1.2% for urban males, 1.2% for urban females, 1.1% for rural males, and 0.5% for rural females). The OCP effect is larger in rural areas than in urban areas and is more adversely felt by rural females than for rural males.

6 Robustness checks

6.1 Self-reported height

Our dependent variable, adult height, is a self-reported variable. To mitigate random reporting errors, we have averaged the heights reported by the same individual across three years, 2010, 2012 and 2014. However, existing evidence suggests that self-reported height could be systematically biased across different age groups [Pirie et al., 1981; Rowland, 1990; Lu et al., 2016]. If an over-reporting problem is more prevalent among younger generations and high income areas, our estimates of economic growth effects on height could be driven by that.

In this subsection we test the potential problem generated due to reporting errors on height by using two surveys which directly measure height of individuals by interviewers – the China Health and Nutrition Survey (CHNS) and the Rural-Urban Migration in China (RUMiC). As with CFPS, CHNS and RUMiC are both panel surveys. However, some differences between these data sets need to be discussed. First, in the CFPS survey we use individuals' household registration (*hukou*) at birth to define rural vs. urban samples. Neither CHNS nor RUMiC provide this information. So, we can only use current *hukou* status to define our sample. Second, RUMiC data only includes households whose current *hukou* status is rural but who migrated to cities to work. Third, the CFPS survey covers 25 provinces and the CHNS covers 9 provinces. For the RUMiC survey as our sample is rural-urban migrants, we use their sending province information, which covers 23 of the 25 CFPS provinces. Finally, while RUMiC is a panel survey, the measured height information only available for three years. Due to the issue of high attrition, only the first year (2009) information is used. Appendix D describes how the CHNS and RUMiC samples are compiled.

Table 6 compares the estimated results for equation (1) using the CFPS and the combined CHNS and RUMiC data for rural male and female samples, respectively.[32]

Table 6: Time trends in the CHNS and CFPS — Rural samples

	CFPS		CHNS/RUMiC		CFPS		CHNS/RUMiC	
	Male	Female	Male	Female	Male	Female	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Time trend	0.126***	0.073***	0.136***	0.095***				
	(0.008)	(0.007)	(0.007)	(0.009)				
Born in 1960s					0.896***	1.142***	1.010***	1.414***
					(0.160)	(0.145)	(0.286)	(0.259)
Born in 1970s					1.950***	1.394***	2.346***	1.532***
					(0.212)	(0.139)	(0.232)	(0.261)
Born in 1980s					3.921***	2.381***	3.870***	2.856***
					(0.266)	(0.226)	(0.249)	(0.301)
Constant	166.415***	157.405***	165.822***	156.061***	167.208***	157.593***	166.460***	156.112***
	(0.153)	(0.123)	(0.141)	(0.169)	(0.134)	(0.100)	(0.148)	(0.168)
Observations	8438	8330	6173	5051	8438	8330	6173	5051
Adjusted R^2	0.198	0.140	0.184	0.155	0.195	0.138	0.184	0.160

Note:
1) Robust Standard Errors (SEs) are presented in parentheses;
2) SEs are clustered at the provincial level;
3) Birth provincial fixed effects are included;
4) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;

6.2 Endogeneity of fertility

Until now we have assumed the 'number of siblings' is exogenous. However, it is likely that some unobservable parental characteristics determined both the individual's height and the number of siblings he/she has. For example, parental son-preference may affect how many children parents choose to have as well as how much resources their male/female children are allocated. If so, our coefficients on the number-of-siblings variable using the OLS method would be biased. To test whether the issue of endogeneity on the number-of-siblings may alter our conclusion, we estimate equation (2) using an instrumental variable approach. The following first-stage equation is estimated:

$$Sib_{ict} = \gamma_0 + \gamma_1 \sum_{n=0}^{2} \omega_n E_{c(t_n)} + \gamma_2 X^P_{i(t_{14})} + \gamma_3 W_{ict} + \gamma_4 Z_{ct_m} + \rho_c + \upsilon_{ict} \tag{4}$$

[32] Neither CFPS nor RUMiC provide individual and household information at birth or at individuals' childhood. We therefore only estimate equation (1) here.

where t_m indicates individual's birth year, and Z is the instrument. The IV used in this study is a birth-control rate at the county level for each year since the 1950, constructed by Chae [2020], where birth-control methods include male and female sterilisation, intrauterine devices, pills, use of condoms, and any other method of birth controls. Given that the birth-control rate increased sharply after the introduction of the OCP, if we take the Local Average Treatment Effect (LATE) interpretation of the IV results, the IV estimate of β_4 in equation (2) measures the average sibling effect generated from the increase in the birth-control rate, or generated by the introduction of the OCP. Appendix E provides details of how the birth-control rate is constructed.[33]

Our IV is highly correlated with the endogenous variable (the sibling numbers) as indicated at the bottom of Table 7 (as well as Table A4 in Appendix A and Figure E2 in Appendix E). We argue that fertile women's share of contraceptive use at the county level should not have direct impact on individuals' adult height over and above its impact through the number-of-siblings variable.

Table 7 reports the selected IV results. The coefficient on the number of siblings for different samples is still negative and statistically significant, suggesting that our conclusion using OLS should not be altered significantly. The magnitude of the coefficients, however, increased significantly. This may be related to the LATE interpretation: those whose parents' fertility decision was altered by the change in the birth control rate at the county of residence had larger effect on their height than the average effect for individuals whose parents' fertility decision were not affected by the birth control policies.

Due to the fact that both our IV and exposure variable have a strong time trend we are unable to estimate the specification with the exposure effect included.

6.3 Missing values in local gazetteer data

As discussed in the data section and detailed in Appendix C, our county-level data have many missing values. We used available years of county-level data on a particular variable together with prefecture/provincial level trend for this variable to predict values for the missing years.

To check whether our main results are driven by these predicted values we estimate equation (2) excluding all the predicted observations for each county-level variable in turn for the rural sample. Table A5 in Appendix A presents the estimated results for equation (2).[34] These results show that

[33] Also see Chapter 2 in Chae [2020] for further details

[34] We also estimate results with additional 'exposure' variable and its interaction term with the number-of-siblings and the results are largely consistent. These results are available upon request from the authors. Results for urban samples are also available.

Table 7: Instrumental variable results for fertility effect

	Rural sample			Urban sample		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Log agricultural output p.c.- age 0 to 3	-0.008	0.085	-0.121	-0.338**	-0.149	-0.522**
	(0.177)	(0.274)	(0.244)	(0.135)	(0.160)	(0.229)
Log industrial output p.c.- age 0 to 3	0.116	0.098	0.124	0.009	-0.132	0.151
	(0.084)	(0.105)	(0.108)	(0.124)	(0.235)	(0.099)
Log gov. social expenditure p.c.- age 0 to 3	0.388***	0.499***	0.293**	0.362**	0.596***	0.047
	(0.102)	(0.135)	(0.119)	(0.163)	(0.184)	(0.340)
Death rate (‰) - age 0 to 3	-0.017	0.009	-0.046***	0.063	0.070	0.048
	(0.013)	(0.016)	(0.017)	(0.047)	(0.046)	(0.064)
Parental schooling years	0.038**	0.040	0.032	0.040	0.067	0.057
	(0.018)	(0.028)	(0.025)	(0.039)	(0.045)	(0.045)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002**	0.001	-0.000	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Father's party membership at child's age 14	0.502***	0.513**	0.447**	-0.158	-0.399	0.059
	(0.136)	(0.200)	(0.194)	(0.299)	(0.379)	(0.342)
Male	9.928***			11.211***		
	(0.095)			(0.223)		
Han Chinese	0.146	0.301	0.013	-0.464	-0.129	-0.941
	(0.249)	(0.352)	(0.327)	(0.943)	(1.024)	(1.043)
Birth order index	0.162***	0.212***	0.094*	0.379**	0.368	0.364
	(0.042)	(0.059)	(0.057)	(0.182)	(0.252)	(0.279)
Number of siblings	-0.587***	-0.871***	-0.269*	-1.202***	-1.141***	-1.197**
	(0.117)	(0.180)	(0.158)	(0.249)	(0.288)	(0.471)
Observations	16051	8098	7953	2457	1270	1187
Adjusted R^2	0.547	0.175	0.158	0.582	0.164	0.058
Kleibergen-Paap Wald F stat	357.104	260.281	236.240	188.931	217.200	84.618

Note:

1) Robust Standard Errors (SEs) are presented in parentheses;

2) SEs are clustered at the county and prefecture levels for the rural and urban samples;

3) Unit: log of 10000 yuan; measured in 1990 price level

4) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

5) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

dropping in turn the predicted observations for agricultural and industrial output has little effect on the estimated coefficients for these variables, although their statistical significance declines slightly. The coefficients on the other variables are also little affected. When predicted values of death rates and government social expenditure variables are excluded, the magnitudes of the coefficients increase for both males and females.

Table A6 in Appendix A reproduces the Table 4 results excluding all the predicted values, i.e. individuals with at least one predicted value of county-level variables are excluded. This involves a dramatic 37% reduction in the number of observations. Nevertheless, the results remain broadly similar to those in Table 4. In particular, the coefficients on government social expenditure retain their size and significance. The coefficients on the exposure variable and its interaction with sibship size are similar in magnitude and significance to those in Table 4.

6.4 Other sensitivity tests

As discussed earlier, parental height is an important determinant of a child's height, and our main equation (2) omits this variable due to the limited information available. We observe parental height information only when the individual's parents also participate in the CFPS survey. Out of 16,051 observations in the rural sample, only 3,141 individuals (19.6%) have mother's height and 2,664 (16.6%) have father's height information. We lose more than 90% of female and about 70% of male observations, and the huge gender difference is possibly due to the fact that males are more likely than females to live with their parents in the same households after marriage.

In Table A7 Appendix A we compare the results with and without mother's height variable for the same subsample with parental height information.[35] For the total and the male samples, controlling for parental height does not greatly affect the results. The coefficients on government social expenditure becomes smaller once mother's height is controlled for (columns 1, 2, 4, 5) but are still statistically significant at the 5% level and still sizeable. Regardless of the inclusion of mother's height variable, the coefficients on the number of siblings are statistically significant and the magnitudes do not change much.

Another concern is the potential shrinkage in age 50 to 60 in our sample as discussed in the Data Section. Table A8 in Appendix A shows that excluding those over 50 reduces the coefficient size of agricultural output to a large extent (columns 1 and 4), although it is still economically meaning-

[35] We choose mother's height as it has about 500 more observations. The estimation results with father's height variable are available upon request from the authors.

ful among males (column 5). Among males, the coefficient on the government social expenditure increases by 69% (columns 2 and 5), and the sibling effects on height almost doubles when people over 50 are excluded.

7 Conclusion

This study explores the relationship between height of individuals born between 1950 and 1990 and economic development and fertility policy changes over the period. We find that China experienced rapid growth in the average height of individuals. If we take a linear trend, rural and urban male heights increase by more than 1 cm per decade (1.3 cm for rural males and 1.5 cm for urban males), which is faster than what was found for the Western European males between 1870 and 1970 (1 cm per decade). The height growth, however, was not linear over the 40-year period, with the fastest growth happening in the 1980s. In the 1980s decade, the height of rural and urban males grew by 2 cm and 2.5 cm, respectively. For rural and urban females the 1980s decade saw 0.9 cm and 1.7 cm growth, respectively.

The average of the 1980s height growth is a combination of two offsetting forces: the introduction of the market-oriented economic reform and the introduction of the OCP. We find that the height growth during this period is mainly driven by the economic reforms which led to fast and sustained improvements in local socioeconomic conditions, whereas the introduction of the OCP reduced height growth for families with a strong son-preference. Controlling for the introduction of the OCP, we observe an even larger height growth due to the reforms (1.8 cm for rural males, 2.0 cm for urban males, 0.8 cm for rural females and 2.0 cm for urban females). For the pre-reform era, the single most important factor for height growth is per capita government spending on health and education.

This study provides suggestive evidence as to how the market-oriented economic reforms changed people's lives. In particular, it improved living standards of rural families by boosting agricultural and local industrial output growth which should have directly increased food availability and household income. By expanding the choice set faced by households it improved health and well-being over and above that due to the improvement in the available local resources. However, the impact of the OCP in general was negative, especially so for the rural population, and even more so for rural females, predominantly due to the wide-spread son-preference in the rural society.

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Appendix A: Figures and Tables

Table A1: Main sample generation

Description	Observations
All CFPS respondents in 2010	33600
+ Born between 1950 and 1990	25243
++ Height info. available	25095
+++ *hukou* at age 3 info. available	24793
++++ Birth county info. available	19430
+++++ Birth county gazetteer data available	18715
++++++ Individual gender and ethnicity info. available	18677
+++++++ Sibling info. available	18511
++++++++ Height>190cm excluded	18508
Final sample - Rural	16051
Final sample - Urban	2457

Table A2: Estimated results with total output

	Rural sample			Urban sample		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Log total output p.c. - age 0 to 3	0.520***	0.812***	0.228	0.185	0.046	0.309*
	(0.145)	(0.197)	(0.188)	(0.131)	(0.156)	(0.183)
Log Gov. social expenditure p.c.- age 0 to 3	0.546***	0.724***	0.386***	0.874***	1.099***	0.532***
	(0.097)	(0.128)	(0.117)	(0.087)	(0.117)	(0.162)
Death rate (‰) - age 0 to 3	-0.035***	-0.018	-0.054***	0.021	0.019	0.019
	(0.013)	(0.016)	(0.016)	(0.037)	(0.046)	(0.051)
Parental schooling years	0.079***	0.106***	0.050**	0.125***	0.172***	0.114***
	(0.016)	(0.024)	(0.022)	(0.033)	(0.038)	(0.043)
Father's occupation rank at child's age 14	0.002***	0.002**	0.002**	0.000	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Father's party membership at child's age 14	0.354***	0.284	0.382**	-0.091	-0.361	0.202
	(0.130)	(0.195)	(0.190)	(0.288)	(0.408)	(0.346)
Male	10.023***			11.339***		
	(0.096)			(0.242)		
Han Chinese	0.115	0.287	-0.009	-0.449	0.083	-1.121
	(0.249)	(0.360)	(0.329)	(0.847)	(0.844)	(1.017)
Number of siblings	-0.056*	-0.057	-0.028	-0.223***	-0.159	-0.283***
	(0.028)	(0.035)	(0.040)	(0.066)	(0.097)	(0.092)
Birth order index	0.064*	0.038	0.056	-0.061	-0.049	-0.051
	(0.037)	(0.050)	(0.050)	(0.122)	(0.222)	(0.177)
Observations	16051	8098	7953	2457	1270	1187
Adjusted R^2	0.560	0.224	0.164	0.610	0.218	0.120

Note:

1) Robust Standard Errors (SEs) are presented in parentheses;

2) SEs are clustered at the county and prefecture levels for the rural and urban samples;

3) Unit: log of 10000 yuan; measured in 1990 price level

4) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

5) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3: Selected results including interaction terms btw 'exposure' and county variables

	Rural sample	Urban sample
	(1)	(2)
(a) Log Agricultural output p.c.- age 0 to 3	0.110	-0.153**
	(0.186)	(0.076)
(b) Log Industrial output p.c.- age 0 to 3	0.181**	0.024
	(0.080)	(0.104)
(c) Log Gov. social expenditure p.c.- age 0 to 3	0.361***	0.279*
	(0.108)	(0.160)
(d) Death rate (‰) - age 0 to 3	-0.035***	-0.004
	(0.013)	(0.032)
Exposure age 0 to 3	2.031*	5.130***
	(1.136)	(1.813)
(e) Exposure age 0 to 3 × Log Agricultural output p.c.- age 0 to 3	0.118	-0.105
	(0.211)	(0.105)
(f) Exposure age 0 to 3 × Log Industrial output p.c.- age 0 to 3	0.047	0.144
	(0.078)	(0.140)
(g) Exposure age 0 to 3 × Log Gov. social expenditure p.c.- age 0 to 3	-0.024	0.571***
	(0.147)	(0.211)
(h) Exposure age 0 to 3 × Death rate (‰) - age 0 to 3	-0.141***	0.012
	(0.038)	(0.124)
Observations	16051	2457
Adjusted R^2	0.561	0.614
Total effect for the exposed group		
Coefficient (a)+(e)	0.228	-0.258
Test h_0 : Coefficient on $(a) + (e) = 0$ [P value]	[0.294]	[0.028]
Coefficient (b)+(f)	0.228	0.168
Test h_0 : Coefficient on $(b) + (f) = 0$ [P value]	[0.036]	[0.137]
Coefficient on (c)+(g)	0.337	0.850
Test h_0 : Coefficient on $(c) + (g) = 0$ [P value]	[0.018]	[0.000]
Coefficient on (d)+(h)	-0.176	0.008
Test h_0 : Coefficient on $(d) + (h) = 0$ [P value]	[0.000]	[0.950]

Note:

1) Robust Standard Errors (SEs) are presented in parentheses;

2) SEs are clustered at the county and prefecture levels for the rural and urban samples;

3) Unit: log of 10000 yuan; measured in 1990 price level;

4) All the covariates included in Table 3 are included;

5) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4: IV first stage results

	Rural sample			Urban sample		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Birth control rate (%)	-0.021***	-0.021***	-0.022***	-0.022***	-0.022***	-0.023***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)
Observations	16051	8098	7953	2457	1270	1187

Note:

1) Robust Standard Errors (SEs) are presented in parentheses;

2) SEs are clustered at the county and prefecture levels for the rural and urban samples;

3) Unit: log of 10000 yuan; measured in 1990 price level

4) All the variables in Table 7 are included;

5) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A5: Main estimation excluding predicted observations (excluding predicted observations of one variable at a time)

	Main sample			Excluding predicted observations of Agricultural output			Industrial output			Death rate			Government social expenditure		
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Log Agricultural output p.c.- age 0 to 3	0.427**	0.746***	0.074	0.393*	0.768**	0.042	0.422*	0.722**	0.118	0.329*	0.763***	-0.152	0.367*	0.737***	-0.012
	(0.168)	(0.233)	(0.217)	(0.224)	(0.316)	(0.307)	(0.242)	(0.315)	(0.310)	(0.188)	(0.272)	(0.225)	(0.192)	(0.275)	(0.250)
Log Industrial output p.c.- age 0 to 3	0.206***	0.259**	0.158	0.209*	0.331**	0.105	0.220**	0.250*	0.204	0.180**	0.198*	0.170	0.062	0.186	-0.045
	(0.077)	(0.101)	(0.103)	(0.110)	(0.154)	(0.147)	(0.099)	(0.134)	(0.132)	(0.086)	(0.115)	(0.117)	(0.097)	(0.138)	(0.121)
Log Gov. social expenditure p.c.- age 0 to 3	0.477***	0.646***	0.332***	0.481***	0.706***	0.249	0.449***	0.724***	0.186	0.593***	0.823***	0.409***	0.673***	0.915***	0.472***
	(0.099)	(0.136)	(0.115)	(0.152)	(0.203)	(0.174)	(0.156)	(0.213)	(0.170)	(0.129)	(0.169)	(0.142)	(0.117)	(0.150)	(0.147)
Death rate (‰) - age 0 to 3	-0.032**	-0.015	-0.053***	-0.008	0.006	-0.028	-0.012	0.004	-0.033*	-0.042***	-0.026	-0.061***	-0.015	0.013	-0.047***
	(0.012)	(0.015)	(0.016)	(0.015)	(0.019)	(0.021)	(0.017)	(0.022)	(0.019)	(0.014)	(0.017)	(0.018)	(0.013)	(0.016)	(0.016)
Parental schooling years	0.077***	0.102***	0.049**	0.081***	0.087***	0.075**	0.085***	0.120***	0.044	0.064***	0.074***	0.051**	0.085***	0.095***	0.069***
	(0.016)	(0.023)	(0.022)	(0.022)	(0.030)	(0.030)	(0.021)	(0.031)	(0.028)	(0.018)	(0.025)	(0.024)	(0.018)	(0.027)	(0.025)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002**	0.003***	0.003***	0.002*	0.001*	0.002*	0.001	0.002***	0.002***	0.002**	0.002***	0.002**	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Father's party membership at child's age 14	0.360***	0.299	0.382**	0.357*	0.280	0.384	0.423**	0.328	0.463*	0.371***	0.371*	0.326*	0.451***	0.411*	0.433*
	(0.129)	(0.195)	(0.190)	(0.189)	(0.303)	(0.284)	(0.165)	(0.280)	(0.246)	(0.135)	(0.221)	(0.196)	(0.154)	(0.241)	(0.228)
Male	10.022***			10.164***			10.044***			9.987***			9.994***		
	(0.096)			(0.126)			(0.126)			(0.098)			(0.110)		
Han Chinese	0.108	0.259	-0.005	0.091	-0.200	0.483	0.070	-0.094	0.298	0.005	0.043	0.019	0.309	0.339	0.366
	(0.250)	(0.365)	(0.329)	(0.289)	(0.500)	(0.457)	(0.354)	(0.488)	(0.420)	(0.280)	(0.396)	(0.365)	(0.275)	(0.359)	(0.383)
Number of siblings	-0.054*	-0.054	-0.028	-0.049	-0.026	-0.052	-0.055	-0.037	-0.052	-0.059*	-0.050	-0.045	-0.046	-0.026	-0.040
	(0.028)	(0.036)	(0.039)	(0.036)	(0.044)	(0.056)	(0.036)	(0.042)	(0.054)	(0.032)	(0.041)	(0.041)	(0.033)	(0.039)	(0.049)
Birth order index	0.061	0.034	0.053	0.025	0.015	0.016	0.072	0.069	0.047	0.056	0.017	0.069	0.060	0.049	0.036
	(0.037)	(0.050)	(0.050)	(0.051)	(0.078)	(0.066)	(0.045)	(0.068)	(0.061)	(0.040)	(0.055)	(0.053)	(0.043)	(0.057)	(0.058)
Observations	16051	8098	7953	8480	4227	4253	9209	4650	4559	13462	6781	6681	12043	6087	5956
Adjusted R^2	0.560	0.225	0.164	0.567	0.213	0.158	0.562	0.238	0.168	0.559	0.218	0.164	0.560	0.237	0.169

Note:

1) Rural sample only

2) Robust Standard Errors (SEs) are presented in parentheses;

3) SEs are clustered at the county and prefecture levels for the rural and urban samples;

4) Unit: log of 10000 yuan; measured in 1990 price level

5) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

6) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A6: Main estimation excluding predicted observations (excluding all predicted values)

	Main sample			All predicted values are excluded								
	Total	Male	Female	Total	Male	Female	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log Agricultural output p.c.- age 0 to 3	0.427**	0.746***	0.074	0.046	0.344	-0.310	-0.222	-0.090	-0.435	-0.230	-0.089	-0.446
	(0.168)	(0.233)	(0.217)	(0.273)	(0.413)	(0.342)	(0.275)	(0.433)	(0.377)	(0.275)	(0.431)	(0.378)
Log Industrial output p.c.- age 0 to 3	0.206***	0.259**	0.158	0.148	0.325*	0.012	0.006	0.097	-0.054	0.021	0.099	-0.037
	(0.077)	(0.101)	(0.103)	(0.113)	(0.173)	(0.149)	(0.119)	(0.184)	(0.152)	(0.118)	(0.178)	(0.154)
Log Gov. social expenditure p.c.- age 0 to 3	0.477***	0.646***	0.332***	0.881***	1.088***	0.674***	0.608***	0.649**	0.546**	0.546***	0.576**	0.507*
	(0.099)	(0.136)	(0.115)	(0.208)	(0.270)	(0.239)	(0.204)	(0.258)	(0.259)	(0.203)	(0.257)	(0.262)
Death rate (‰) - age 0 to 3	-0.032**	-0.015	-0.053***	-0.010	0.014	-0.039	0.010	0.047*	-0.031	-0.001	0.036	-0.039
	(0.012)	(0.015)	(0.016)	(0.022)	(0.026)	(0.032)	(0.023)	(0.027)	(0.032)	(0.022)	(0.025)	(0.033)
Parental schooling years	0.077***	0.102***	0.049**	0.067***	0.066*	0.074**	0.055**	0.053	0.067*	0.052**	0.050	0.063*
	(0.016)	(0.023)	(0.022)	(0.025)	(0.037)	(0.035)	(0.026)	(0.037)	(0.035)	(0.025)	(0.036)	(0.035)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002**	0.003***	0.003**	0.002	0.003***	0.003**	0.002	0.002***	0.003**	0.002
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Father's party membership at child's age 14	0.360***	0.299	0.382**	0.587***	0.451	0.629**	0.615***	0.478	0.649**	0.636***	0.516	0.655**
	(0.129)	(0.195)	(0.190)	(0.205)	(0.378)	(0.308)	(0.205)	(0.375)	(0.304)	(0.207)	(0.375)	(0.304)
Male	10.022***			10.289***			10.261***			10.242***		
	(0.096)			(0.145)			(0.145)			(0.144)		
Han Chinese	0.108	0.259	-0.005	-0.097	-0.383	0.195	-0.078	-0.412	0.222	-0.086	-0.405	0.206
	(0.250)	(0.365)	(0.329)	(0.317)	(0.507)	(0.459)	(0.320)	(0.520)	(0.461)	(0.325)	(0.512)	(0.471)
Number of siblings	-0.054*	-0.054	-0.028	-0.055	-0.050	-0.035	-0.023	0.009	-0.022	0.070	0.106	0.041
	(0.028)	(0.036)	(0.039)	(0.050)	(0.060)	(0.078)	(0.048)	(0.061)	(0.076)	(0.058)	(0.064)	(0.097)
Birth order index	0.061	0.034	0.053	0.079	0.059	0.090	0.066	0.030	0.085	0.090	0.068	0.095
	(0.037)	(0.050)	(0.050)	(0.067)	(0.094)	(0.084)	(0.067)	(0.095)	(0.083)	(0.065)	(0.096)	(0.082)
Exposure							1.447***	2.344***	0.677	2.327***	3.248***	1.287**
							(0.429)	(0.755)	(0.525)	(0.430)	(0.809)	(0.602)
Exposure × Number of siblings										-0.422***	-0.452**	-0.283*
										(0.120)	(0.185)	(0.152)
Observations	16051	8098	7953	5879	2923	2956	5879	2923	2956	5879	2923	2956
Adjusted R^2	0.560	0.225	0.164	0.583	0.231	0.176	0.584	0.235	0.176	0.585	0.236	0.177

Note:

1) Rural sample only

2) Robust Standard Errors (SEs) are presented in parentheses;

3) SEs are clustered at the county and prefecture levels for the rural and urban samples;

4) Unit: log of 10000 yuan; measured in 1990 price level

5) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

6) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Estimated results with parental height variable included — Rural sample

	without parental height			with parental height		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Log Agricultural output p.c.- age 0 to 3	0.950**	0.969*	1.007	0.876**	0.975**	0.473
	(0.414)	(0.494)	(1.136)	(0.383)	(0.465)	(1.069)
Log Industrial output p.c.- age 0 to 3	0.042	0.008	0.433	-0.050	-0.056	0.182
	(0.212)	(0.241)	(0.542)	(0.210)	(0.234)	(0.544)
Log Gov. Social expenditure p.c.- age 0 to 3	0.802***	1.070***	-0.278	0.578**	0.789**	-0.136
	(0.281)	(0.350)	(0.558)	(0.271)	(0.336)	(0.538)
Death rate (‰) - age 0 to 3	-0.010	0.020	0.033	-0.008	0.023	-0.011
	(0.041)	(0.042)	(0.096)	(0.039)	(0.042)	(0.082)
Parental schooling years	0.003	-0.002	0.032	-0.024	-0.024	-0.006
	(0.034)	(0.040)	(0.090)	(0.033)	(0.039)	(0.082)
Father's occupation rank at child's age 14	0.002*	0.002	0.003	0.001	0.001	0.001
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)
Father's party membership at child's age 14	0.619**	0.775**	0.022	0.548*	0.663**	0.060
	(0.296)	(0.322)	(0.707)	(0.290)	(0.326)	(0.672)
Male	11.025***			11.046***		
	(0.266)			(0.263)		
Han Chinese	0.286	0.707	-1.186	0.385	0.801	-0.962
	(0.501)	(0.607)	(1.000)	(0.462)	(0.599)	(0.976)
Number of siblings	-0.209***	-0.180**	-0.056	-0.156*	-0.132	-0.007
	(0.074)	(0.075)	(0.225)	(0.079)	(0.080)	(0.194)
Birth order index	0.079	0.185	-0.359	0.149	0.262**	-0.302
	(0.102)	(0.124)	(0.241)	(0.106)	(0.127)	(0.229)
Mother's height (cm)				0.296***	0.273***	0.372***
				(0.024)	(0.028)	(0.048)
Observations	3141	2360	781	3141	2360	781
Adjusted R^2	0.507	0.254	0.173	0.553	0.313	0.298

Note:

1) Rural sample only

2) Robust Standard Errors (SEs) are presented in parentheses;

3) SEs are clustered at the county and prefecture levels for the rural and urban samples;

4) Unit: log of 10000 yuan; measured in 1990 price level

5) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

6) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A8: Main estimation excluding 1950s cohort — Rural sample

	Including 1950s cohort			Excluding 1950s cohort		
	Total	Male	Female	Total	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)
Log Agricultural output p.c.- age 0 to 3	0.427**	0.746***	0.074	0.217	0.279	0.071
	(0.168)	(0.233)	(0.217)	(0.182)	(0.268)	(0.284)
Log Industrial output p.c.- age 0 to 3	0.206***	0.259**	0.158	0.148	0.260**	0.089
	(0.077)	(0.101)	(0.103)	(0.092)	(0.105)	(0.149)
Log Gov. Social expenditure p.c.- age 0 to 3	0.477***	0.646***	0.332***	0.664***	1.079***	0.296*
	(0.099)	(0.136)	(0.115)	(0.123)	(0.192)	(0.160)
Death rate (‰) - age 0 to 3	-0.032**	-0.015	-0.053***	-0.028	-0.003	-0.050**
	(0.012)	(0.015)	(0.016)	(0.017)	(0.024)	(0.020)
Parental schooling years	0.077***	0.102***	0.049**	0.050***	0.066***	0.032
	(0.016)	(0.023)	(0.022)	(0.017)	(0.025)	(0.024)
Father's occupation rank at child's age 14	0.002***	0.002***	0.002**	0.002***	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Father's party membership at child's age 14	0.360***	0.299	0.382**	0.304**	0.280	0.255
	(0.129)	(0.195)	(0.190)	(0.143)	(0.221)	(0.213)
Male	10.022***			10.118***		
	(0.096)			(0.111)		
Han Chinese	0.108	0.259	-0.005	0.230	0.208	0.365
	(0.250)	(0.365)	(0.329)	(0.294)	(0.399)	(0.338)
Number of siblings	-0.054*	-0.054	-0.028	-0.108***	-0.108**	-0.070
	(0.028)	(0.036)	(0.039)	(0.033)	(0.047)	(0.045)
Birth order index	0.061	0.034	0.053	0.046	0.051	-0.006
	(0.037)	(0.050)	(0.050)	(0.044)	(0.062)	(0.059)
Observations	16051	8098	7953	12334	6165	6169
Adjusted R^2	0.560	0.225	0.164	0.569	0.235	0.159

Note:

1) Rural sample only

2) Robust Standard Errors (SEs) are presented in parentheses;

3) SEs are clustered at the county levels;

4) Unit: log of 10000 yuan; measured in 1990 price level

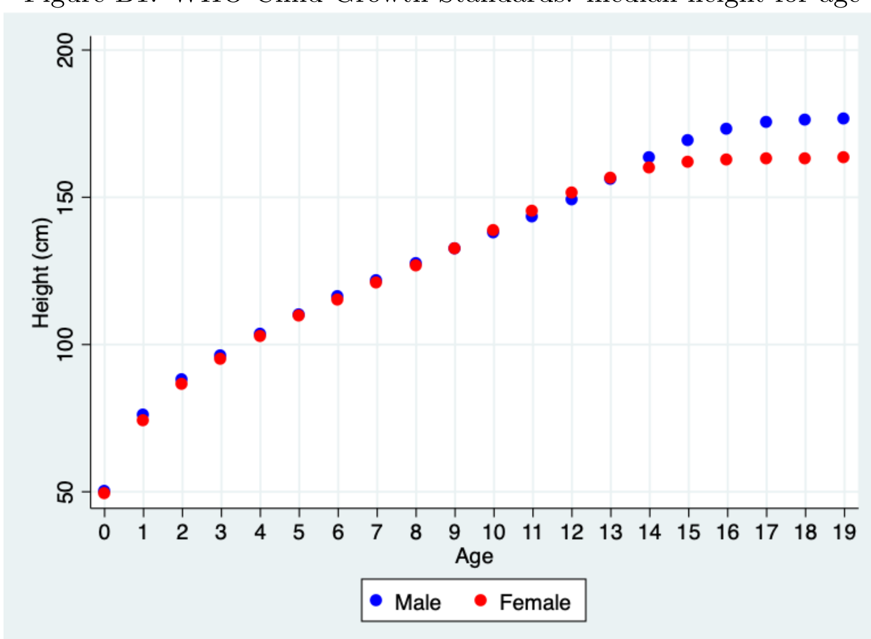
5) County fixed effects, a share of urban population in each county, and a group of dummy variables indicating the missing values for father's party membership and occupation as well as birth order variables are included;

6) * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix B: How the damping coefficients and the exposure variable are generated

The WHO Multicentre Growth Reference Study (MGRS) provides reference growth standards for infants and young children using longitudinal surveys. The sample used consists of about 8,500 children from six countries - Brazil, Ghana, India, Norway, Oman, and the United States [Onis et al., 2004].[36] Figure B1 plots median height-for-age from the WHO Child Growth Standards. At age 0, the median height-for-age is about 50 cm for both females and males, and it jumps to 75 cm (female 74.005 cm; male 75.739 cm) at age 1, then further to about 87 cm (female 86.401 cm; male 87.802 cm) at age 2. As childhood evolves, the increment between two consecutive ages becomes smaller. At age 15, the growth for females stops, whereas for males it stops at around age 16. The height grows the most during the first two years of children's life.

Figure B1: WHO Child Growth Standards: median height-for-age



Using this growth reference data, we compute two variables: 1). the damping coefficient ω_n in equation (2) and 2). the exposure variable, which captures the share of an individual's first three years of life (age 0-3) that was at and after 1979, the year of the start of the economic reform and introduction of the OCP.

The basic idea is to calculate the relative increase in height between age 0 and 3. We calculate

[36] Data source: Boys 0-5 years old - https://www.who.int/childgrowth/standards/h_f_a_tables_z_boys/en/; Girls 0-5 years old - https://www.who.int/childgrowth/standards/h_f_a_tables_z_girls/en/; 5-19 years old - https://www.who.int/growthref/who2007_height_for_age/en/

an increase in height between two consecutive ages then divide it by the total increment between age 0 and 3. For example, female median height at age 0 is 49.148 cm, 74.005 cm at age 1, 86.401 cm at age 2, and 95.034 cm at age 3. The increments are 24.857 cm between age 0 and 1, 12.396 cm between age 1 and 2, and 8.633 cm between age 2 and 3. Since the total increment between age 0 and 3 is 45.886 cm (=95.034-49.148), each increment accounts for 54.17%, 27.01%, and 18.81% of the total increment between age 0 and 1, 1 and 2, and 2 and 3, respectively. The increment for each age is plotted in Figure B2.

This relative increase is the damping coefficient ω_n. Suppose one was born in 1970, and the log of agricultural output per capita is 0.1 in 1970, 0.2 in 1971, and 0.3 in 1972. Then $\omega_n E_{cn} = 0.1 * 0.5417 + 0.2 * 0.2701 + 0.3 * 0.1881$ in her case.

We apply this method to compute the exposure variable, which captures the degree of which one was exposed to the economic reform and introduction of the OCP between age 0 and 3. For example, if one was born in 1978, her exposure value is equal to 27.01%+18.81% as she was exposed to the economic reform and introduction of the OCP at age 1 and 2. If one was born in 1975, her exposure value is equal to zero as she did not experience those events before age 3. For those born in 1979 onwards, the exposure value is 100%. Figure B3 shows the distribution of the exposure variable for males (blue dots) and females (red dots) separately.

Figure B2: Increments between consecutive ages

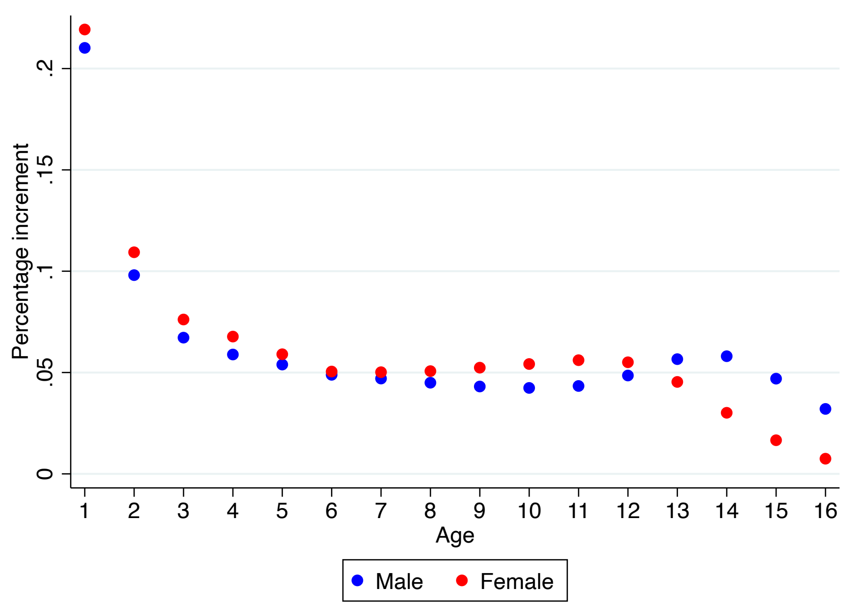
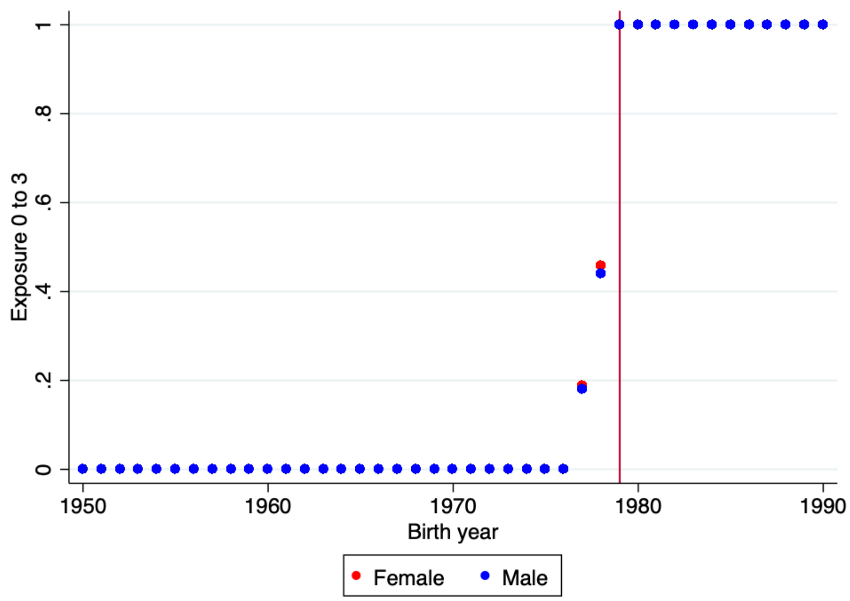


Figure B3: Cohort distribution of the 'exposure' variable



Appendix C: Local gazetteer data collection

C-1. Variable description

We collected annual data on the following variables from county gazetteers for the period between 1950 and 1990.

1) Industrial output value: This variable is the value of annual total industrial output produced in a county. Some counties use the corresponding year price, but others use a constant price across years. We convert all the values into the 1990 prices using a provincial-level retail price index. The unit is ten thousand yuan.

2) Agricultural output value: This variable is the value of total agricultural output produced in a county. It includes farming, forestry, animal husbandry, and fishery. Some counties use the corresponding year price, but others use a constant price across years. We convert all the values into the 1990 prices using a provincial-level retail price index. The unit is ten thousand yuan.

3) Local government expenditure on social services: This variable is the amount of annual local government expenditures on social services, including health care, education, social security benefit, culture, and science. We convert all the values into the 1990 prices using a provincial-level retail price index. The unit is ten thousand yuan.

4) Death rate: The definition of death rate is the number of deaths divided by the total population for each year. The unit is ‰.

5) Rural *hukou* population: It is the number of people whose household registration (*hukou*) is agricultural in a county. We generate the rural and urban *hukou* share variables using this variable and county total population information.

6) Population: We generate per capita output and expenditure variables using total population data. The unit is persons.

C-2. Data source

Table C1 provides data sources. The main sources are local gazetteers and statistical yearbooks. China has changed its administrative divisions significantly over the last decades, so some regions have multiple gazetteers. We do not merge data from different sources unless available observations for the overlapping periods are the same across the books.

C-3. Missing information

Table C2 shows data source and the proportion of missing values for each variable. We collected 6492 agricultural output observations (by county and year) from the local gazetteers and 1988 observations from the statistical yearbooks. 47.2% of the total observations of agricultural output and 42.6% of industrial output observations are predicted owing to missing information. Local government social expenditure information is mostly from the local gazetteers and 25.0% of the total observations in our sample are predicted. About half of the collected mortality rate observations are from the gazetteers and the other half is mainly collected from provincial-level population statistical yearbooks. Its proportion of missing observations is the lowest among the four county-level variables.

C-4. Data prediction

To fill missing values, we impute them using available observations. The following equations (5) and (6) describe the main imputation methodologies.

$$\hat{x}_{c,p,t} = x_{c,t-1} \frac{x_{p,t}}{x_{p,t-1}} \tag{5}$$

where $\hat{x}_{c,p,t}$ is a predicted value for a missing observation of county c in province p in year t. $x_{c,t-1}$ is a non-missing observation of the same county c in year $t-1$. The observations for province p are available for both years t and $t-1$. First, we compute the ratio between $x_{p,t}$ and $x_{p,t-1}$ at provincial level. Second, we multiply $x_{c,t-1}$ by this ratio and compute $\hat{x}_{c,p,t}$. This methodology requires an assumption that the growth rate of x between years t and $t-1$ at provincial level is the same as that of the county c. We use this method for all county-level variables included in equation 2 (agricultural and industrial outputs, local government expenditure on social services, and death rate).

There are cases where the gazetteers or yearbooks provide county-level gross domestic product (GDP) data, which covers the whole 40-year period, while economic output information is not fully available. In this case, we impute missing values of the output variables using county-level GDP

Table C1: Data source

Province	Source
Anhui	1) Local gazetteers
Beijing	1) Local gazetteers 2) Comprehensive Statistical Data and Materials on 50 Years of New China
Chongqing	1) Local gazetteers
Fujian	1) Local gazetteers 2) Fujian Statistical Yearbook "New China 60 Years-Fujian"
Gansu	1) Local gazetteers 2) Gansu Population Statistical Yearbook 1949-1987;
	3) Gansu Statistical Yearbook "New China 60 Years - Gansu"
Guangdong	1) Local gazetteers 2) 2 City Statistical Yearbooks
Guangxi	1) Local gazetteers 2) Guangxi Population Statistical Yearbook 1949-1985
Guizhou	1) Local gazetteers 2) Guizhou Population Statistical Yearbook 1949-1984
	3) Guizhou Statistical Yearbook "Guizhou 60 Years 1949-2009"
	4) Guizhou Statistical Yearbook "Guizhou 30 Year" 5) City Statistical Yearbook
Hebei	1) Local gazetteers 2) Hebei Statistical Yearbook "New Hebei 60 Years"
	3) Hebei Statistical Yearbook "New Hebei 50 Years"
	4) Hebei Province Population Statistical Yearbook 1949-1984
Heilongjiang	1) Local gazetteers 2) Heilongjiang Statistical Yearbook "Longjiang 60 Years"
	3) Heilongjiang Population Statistical Yearbook
Henan	1) Local gazetteers 2) Henan Statistical Yearbook "Henan 30 Years"
Hubei	1) Local gazetteers 2) Hubei Statistical Yearbook 1985 and 1987
	3) Hubei Statistical Yearbook "Hubei 30 Years"
Hunan	1) Local gazetteers 2) Hunan Population Statistical Yearbook 1949-1991
	3) City statistical yearbook
Jiangsu	1) Local gazetteers 2) Jiangsu Population Statistical Yearbook 1949-1985;
	3) Jiangsu Statistical Yearbook - "Jiangsu 60 Years"
Jiangxi	1) Local gazetteers 2) Jiangxi Statistical Yearbook "New China 50 Years - Jiangxi";
	3) Jiangxi Population Statistical Yearbook 1949-1985
Jilin	1) Local gazetteers 2) Jilin Population Statistical Yearbook 1949-1984
Liaoning	1) Local gazetteers 2) Liaoning Statistical Yearbook "Liaoning 60 Years"
	3) Liaoning Statistical Yearbook "Liaoning 40 Years" 4) Liaoning Population yearbook 1949-1984
	5) city statistical yearbook
Shaanxi	1) Local gazetteers
Shandong	1) Local gazetteers 2) Shandong Statistical Yearbook "New China 50 years - Shandong province"
	3) Shandong Population Statistical Yearbook 1949-1984 4) City economic statistical yearbook
Shanghai	1) Local gazetteers 2) Shanghai Population Statistical Yearbook 1949-2000
	3) Shanghai Statistical Yearbook - "Shanghai 60 Years of Statistics compilation"
Shanxi	1) Local gazetteers 2) Shanxi Population Statistical Yearbook
	3) Shanxi Statistical Yearbook "Shanxi 60 Years"
Sichuan	1) Local gazetteers 2) Sichuan Statistical Yearbook "Sichuan Statistics Compilation (1979-1990)"
Tianjin	1) Local gazetteers 2) Tianjin Population Statistical Yearbook 1979-1988
Yunnan	1) Local gazetteers 2) Yunnan Population Statistical Yearbook 1949-1988
Zhejiang	1) Local gazetteers 2) Zhejiang Statistical Yearbook "Zhejiang 60 Years"
	3) Zhejiang Population Statistical Yearbook 1949-1985
All provinces	China City Statistical Yearbook 1985, 1986, 1987, 1988, 1989, and 1990
	Retail price index: Comprehensive Statistical Data and Materials on 50 Years of New China

Table C2: Data source and the proportion of missing values

	Data source		**Missing Obs.**	**Total Obs.**	
	Gazetteer	Yearbook	(a)	(b)	(a/b)
Rural sample					
Agricultural output	6492	1988	7571	16051	0.472
Industrial output	7219	1990	6842	16051	0.426
Government expenditure	11758	258	4008	16051	0.250
Death rate	6889	6573	2589	16051	0.161
Urban sample					
Agricultural output	293	1359	805	2457	0.328
Industrial output	364	1214	879	2457	0.358
Government expenditure	248	1959	250	2457	0.102
Death rate	226	1731	500	2457	0.204

Column 1 shows the number of observations collected from local gazetteers, column 2 shows the number of observations collected from yearbooks, column 3 indicates the number of missing values.

data as shown in equation 6:

$$\hat{x}_{c,p,t} = gdp_{c,t}\frac{x_{p,t}}{gdp_{p,t}} \tag{6}$$

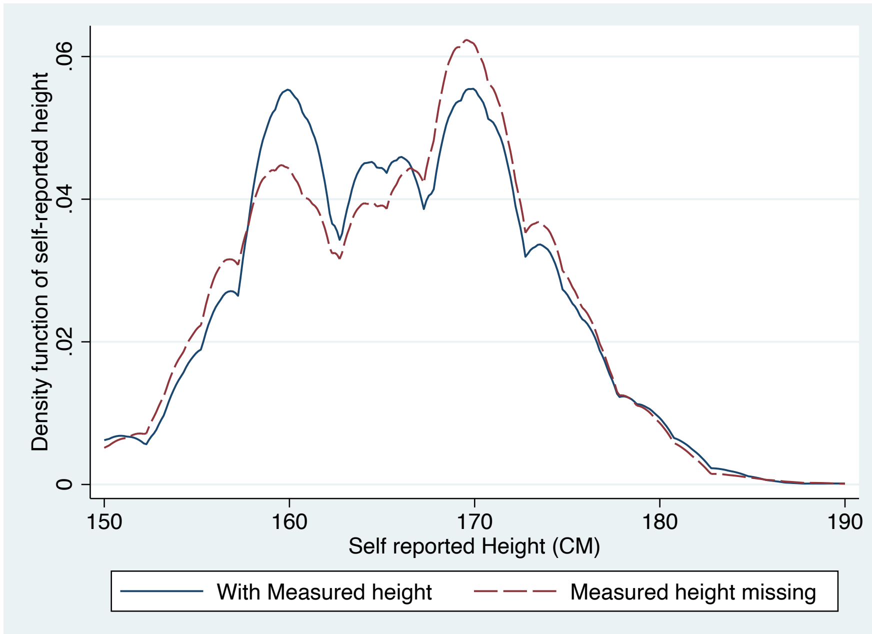
where $\hat{x}_{c,p,t}$ is a predicted value of a missing observation of county c in provincial p at year t. Available observations are, 1) $gdp_{c,t}$: GDP for county c in year t, 2) $x_{p,t}$: economic output for province p in year t, and 3) $gdp_{p,t}$: GDP for province p in year t. First, we compute the ratio between GDP and economic output levels at the provincial level. Then we multiply this ratio by the county-level GDP $gdp_{c,t}$ and calculate $\hat{x}_{c,p,t}$. This methodology requires an assumption that the ratio between GDP and economic output values is the same between provincial-level and county-level data. More details on imputation methodologies are available upon request from the authors.

Appendix D: CHNS/RUMiC sample construction

The China Health and Nutrition Survey (CHNS) is a longitudinal survey of households and individuals conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill and the National Institute for Nutrition and Health at the Chinese Center for Disease Control and Prevention since 1989. We use all rounds between 1989 and 2011 (1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011), and the survey covers 9 provinces in China - Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou. There are 157,286 observations (including repeated individuals) between the 1989 and 2011 waves, and 82,122 of the individuals of them were born between 1950 and 1990 and aged between 20 and 60 at the survey. Birth region information is a crucial part of our analysis, but the CHNS did not collect individual birth county information. Instead, it provides birth province of each household's head and her/his spouse but only 7,827 out of 82,122 observations have that information. We assume that all household members were born in the same province as the household head, and we use the spouse birth province instead when the household head's birth province information is missing. As a result, 73,789 (18,992 individuals) out of 82,122 observations have birth province information. Among them height observations are available for the 14,993 individuals. To minimise the measurement error due to either shrinkage or premature height, we use the maximum height of available observations for each individual. We include 12,348 (82.3%) of 14,993 individuals who were born in the 9 CHNS survey provinces. The CHNS does not collect information on the *hukou* status at birth so we instead use the current *hukou* status to define the rural sample. This assumption is reasonable considering that 85% of individuals in the CFPS rural sample currently hold the rural *hukou* in 2010. The final CHNS rural sample consists of 7,044 individuals.

The Rural-Urban Migration in China (RUMiC) project was established to investigate the impacts of internal migration in China by a group of researchers at the Australian National University. The survey began in 2008 and ended in 2016. The measured height was available between 2009 and 2011. Due to the high attrition rate, we only used the 2009 data. The RUMiC survey sampled rural-to-urban migrants in 15 destination cities. However, as they are migrants with rural *hukou*, their household registration locations are the sending province, which indicates that RUMiC 2009 sample came from 28 out of 30 provinces. In the 2009 survey there are 7418 individuals who were born between 1950 and 1990. Of those, 3738 observations have non-missing values for measured the height variable, whereas all 7418 observations self-reported the height variable. Figure D1 presents the distribution of self-reported height for the samples with and without missing values on measured height. As can be seen from the figure that the two distributions are quite similar. The mean difference between the two sample on self-reported height is 0.24cm with the t-statistic being 1.44.

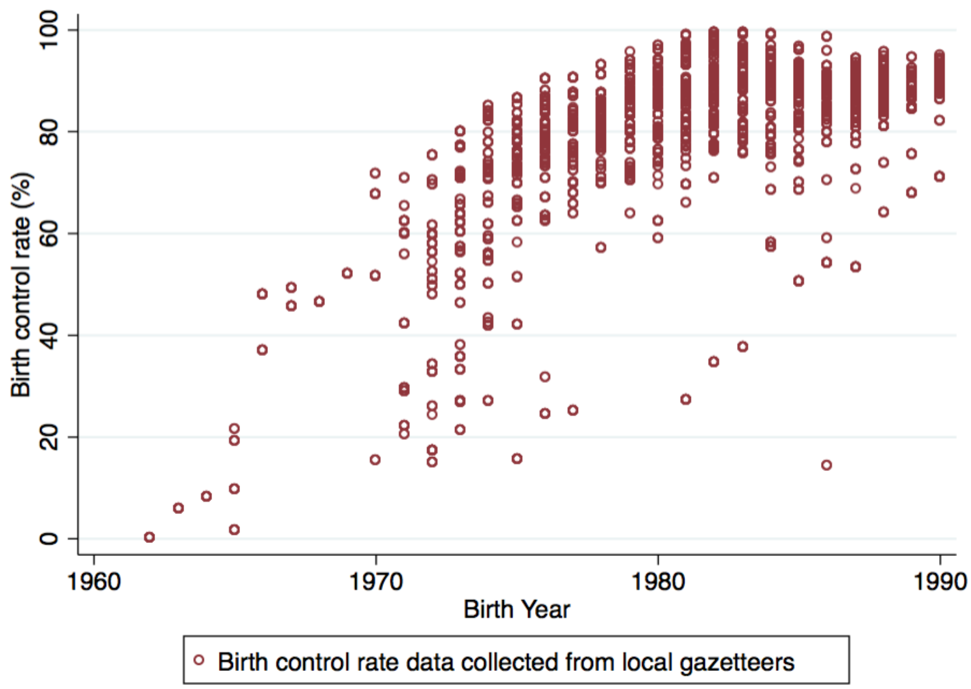
Figure D1: Comparison of reported height between missing and non-missing measured height samples: RUMiC 2009



Appendix E: Instrumental variable construction

We use an instrument for the endogenous variable 'number of siblings' constructed by Chae [2020], which is the proportion of fertile women who use any contraceptive method in their birth county for the period around the individual's birth. This variable is called '*jieyu*' in Chinese, and we translate this as 'Birth Control Rate (BCR)'. It is reported in most regional gazetteers and used to reflect each local government's fertility control intensity.

Figure E1: Birth Control Rate collected from local gazetteers



There is a total of 159 counties in our main sample, and we have the BCR information for 103 counties (64.8%) as plotted in Figure E1, of which 59.22% are from county-level gazetteers and 29.21% from prefecture-level gazetteers. In the remaining counties, we are unable to find gazetteer information. Further details of how to impute missing values are available in Chae [2020].

Consistent with Chae [2020], we use the average rate over the period of three years before and three years after the individual's birth which is $\bar{B}_{ct}$ in equation (6).[37] $\bar{B}_{ct}$ captures the family planning policy intensity a few years around the timing of one's birth, which should highly correlated with the number of siblings one has. More specifically:

[37] Chae [2020] conducts a sensitivity test of varying years of the coverage including 2 years before and after (=within 5 years of one's birth) and 1 years before and after (=within, and 2 year before and after).

$$\bar{B}_{ct} = \frac{1}{7} \sum_{t=-3}^{+3} \frac{CW_{ct}}{W_{ct}} \quad (7)$$

where $\bar{B}_{ct}$ is the average BCR within 7 years of one's birth year t in birth county c. CW_{ct} is the number of fertile women who either are sterile or use contraception and W_{ct} is the total number of fertile women in county c in year t. We average the proportion of CW_{ct} to W_{ct} between 3 years before and after one's birth including one's birth year. In other words, we use 7 year average of $\frac{CW_{ct}}{W_{ct}}$ for $t-3$, $t-2$, $t-1$, t, $t+1$, $t+2$, and $t+3$ as the instrument for the number of siblings of an individual born in t. The contraceptive method includes (1) female sterilisation, (2) male sterilisation, (3) intrauterine contraceptive devices, (4) oral contraceptive pills, (5) abortions, (6) pills in external use, (7) injections, (8) condoms, and (9) other medicine or medical devices. Intuitively, $\bar{B}_{ct}$ captures the likelihood of having siblings within 3 years before or after one was born. Figure E2 plots the distribution of the Birth Control Rate. Further details of how to construct the instrument are available in Chae [2020].

Figure E2: The instrument - Birth Control Rate (BCR) (%)