Intergenerational Correlation of Health in China

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1 Introduction

Child health is one of the key indicators of economic development. It is closely related with other development indicators, such as adult health, educational attainment, productivity, and income. In most countries, large numbers of children die each year due to outbreak of disease, nutrition deficiencies, or simply due to lack of knowledge of health care services. Thus, child health enhancement is one of the major public policy goals in most countries. There are several maternal factors that affect child's health among which mother's health, education, and income are considered as the most important ones.

A large number of studies have shown a negative correlation between mother's education level and child's health. Breierova and Duflo (2004) showed the effect of education on fertility and child mortality in Indonesia between 1973 and 1978. Their result implies that both male and female education plays a significant role in reducing child mortality. For instance, they show that an increase in education of women resulted in lower number of very early births and lower child mortality. Similarly, Chou, Liu, Grossman and Joyce (2007) estimated the impact of parental education on child health in Taiwan. They found that an increase in mother's schooling associated with the reform (government of Taiwan extended compulsory education from six to nine years) saved almost 1 infant life in 1000 live births, as a result infant mortality declined approximately by 11 percent. Since educated mothers have better knowledge of health care and nutrition and may provide a safer environment for their children, it is considered that educated mothers may have healthier children.

Similarly, there is a growing literature that shows that higher parental income is related with better child health (see, for example, Burgess, Propper and Rigg and the ALSPAC Study Team 2004). Parents with higher incomes can afford to take better care of their child's health simply because they are able to provide proper immunization and better nutrition compared to parents with low income.

In this paper I focus on the link between the health of a mother and a child in China. It is important to investigate this relationship because poor health in childhood is an important mechanism for intergenerational transmission of economic status (Case, Fertig, and Paxson, 2005; Grossman, 2000). For instance, it has been shown that poor health in childhood is related with lower educational attainment, poorer labor market outcomes and worse health later in life.[1] In addition, Currie and Madrian (1999) shows that poor childhood health can decrease educational attainment by decreasing returns to education or by increasing the costs of school attendance. Therefore, it is important to determine the factors that affect child health and understand to what extent the health of a mother impacts the health of a child.

In the past, few empirical studies have shown the intergenerational correlation of health. As far as I am aware my research is one of the few to investigate the effect of maternal health on child health, using height as an indicator of both mother's and child's health, and the first to do this using China Health and Nutrition Survey (CHNS) data set. I use height as a measure of health for several reasons: firstly, height is an indicator of long term or permanent health,

[1] Marmot and Wadsworth (1997) shows different ways by which childhood health affects adult health

because once fully attained, it does not change within individual; secondly, research has shown that malnutrition in early life may have persistent effect on the attained height; finally it is available in the dataset and is also easy to measure.

Although I use height as a measure of health, it is not an exogenous variable. There are other unobserved factors that might affect both mother's and child's health, thus I instrument mother's height using an index of environmental conditions in her childhood i.e. the Great Famine that took place in China from 1959-1961. There has been few studies done that shows the long term effect of the great famine on the health and economic status of the survivors. For instance, Chen and Zhou (2002) using a CHNS data set and difference-in-difference estimator show that on average, in the absence of the famine, individuals of 1959 birth cohort would have grown 3.35 cm taller in their adulthood. In this paper, like Chen and Zhou I also use a CHNS data set but for a different year and show the effect of the famine on the height of the women who were in their childhood during the famine and then I use that predicted value to estimate the impact of their height on their child's height. Thus, my paper is the first to investigate the impact of maternal height on child's height using CHNS data set for 1989.

The remainder of this paper is organized as follows. In section 2, I discuss the literature review. Section 3 briefly describes the Great Famine. Section 4 describes the data. Section 5 discusses the methodology for the empirical analysis. Section 6 discusses the identification strategy used to investigate the effect of the maternal height on child height. Section 7 discusses some econometric issues. Section 8 presents results and its interpretations. Finally section 9 discusses the conclusions of this research.

2 Literature Review

Among the very few empirical studies that have shown the intergenerational correlation of health, Currie and Moretti (2007) is one that investigates the intergenerational correlations in birth weight of newborns. In their paper they show a positive intergenerational correlation in birth weight of mothers and children.In addition, they found that a measure of household income at the time of mother's birth is also predictive of low birth weight and there is an interaction between maternal low birth weight and poverty in the production of low birth weight. This provides evidence of intergenerational transfer of health and wealth.

Conly and Bennet (2000), using intergenerational data from the Panel Study of Income Dynamics, for 1968-1992, investigates whether the income and other socioeconomic conditions of a mother during her pregnancy affects her chances of having a low-birth-weight infant. They show that maternal income does not impact the birth weight significantly. On the other hand, Kebede (2005) examines the determinants of child health in rural Ethiopia for the period 1994-1997 using height-for-age z-scores as measures of long-term health. The paper finds that the the height of parents is highly significant and correlations between child and parental health are better explained by genetic inheritance than by behavior in an environment where there are no major differences in the nutritional and disease environments of parents and children.

Similarly, using household survey data from Brazil, Thomas et al (1990) investigate the impact of household characteristics including parental heights on child survival and height. After controlling for per capita household expenditure and education, they find a positive effect of parental height on child height and survival. Furthermore, using data on 381 Guatemalan women from 1977-1979,without controlling for education or income, Martorell et al (1981) find that shorter women have more children than taller women, but fewer of these survive. Dubois et al (2007) examine the relative effect of environment and genetics on height and weight of children, using a sample of 17 twins from the Quebec Newborn Twin Study. They find that to a large extent, weight is determined by genetics. However, their results do not take into account any environmental factors that affect body weight. On the other hand, they find a significant effect of environmental factors on early childhood height.

In addition to the papers mentioned above, the motivation for this paper comes from Bhalotra and Rawlings (working papers March 2008 and July 2008). In March (2008) paper, using survey data on 1.26 million children born to 250000 mothers in 28 African countries during 1970-2000, they investigate the intergenerational transmission of health. Their measure of maternal health is height and the measure of child health is infant mortality risk and child height. They find a positive correlation between maternal health and child health in every country in the sample. Their result show that on average, children born to mothers who are at least one standard deviation below the mean height in their region are 1.1 percentage points more likely to suffer infant death than children born to mothers of mean height. Similarly, in their July 2008 paper using a survey data on 2.24 million children born to 600000 mothers, they investigate the same relationship but for 38 developing countries. The results are similar in both papers.

Although the empirical studies mentioned above examine the intergenerational transmission of health, most of them do not consider the childhood exposure to some environmental condition that affects the height of an individual. For example, the results of Kebede (2005) is based on the assumption that there are no major differences in the nutritional and disease environments of parents and children. However, in my paper, the environmental condition for both parents and children are different because parents in my sample are either directly or indirectly exposed to the famine. In this aspect, my paper fills the gap in the literature. Furthermore,using height as an indicator of both maternal and child health, the purpose of my paper is similar to Bhalotra and Rawlings with two major differences. First, I examine the intergenerational transmission of health for China, which is not present in their sample countries. Secondly, I use an instrumental variable approach and use the Great Famine as an instrument for mother's height.

3 Background:The Great Famine

During 1959-1961, China suffered from the Great Famine where an estimated 16.5 to 30 million individuals died and about 30 million lost or postponed births (Chen and Zhou). The 1959-61 famine was caused by many factors, such as bad weather, excessive procurement by the state, delayed response to the food shortage, the weakened production incentives due to the sweeping collectivization program in 1958, and resource diversion as a result of massive industrialization strategy (Eckstein, 1966; Ashton et al., 1984; Peng, 1987; Lin, 1990; Lin and Yang, 2001; An, Li and Yang 2001). Before the famine, China's grain output was growing steadily and it reached a peak of 200 million tons in 1958. However, in 1959, grain output fell sharply by 15 percent and it continued to decline in the following two years. Thus among all factors mentioned above a sharp decrease in grain production in 1959-1961 was directly responsible for the great famine. According to Li and Yang (2005)the major contributing factor to the collapse of grain production was over-procurement of grain from rural areas and diversification of resources away from agriculture.

Over-procurement in 1959 led to a decrease in rural workers' physical capacity to produce grain. The reduction in work capacity together with the consumption of inputs such as seeds in the winter of 1959 extended the famine. In 1960, the central government decreased procurement and returned rural workers back into the agricultural labor force.Famine ended in 1961 when the central government distributed national grain reserves and also accepted food aid.(Qian and Meng).

Although most regions were affected by the famine, the severity of the famine was not the same in all regions. Exposure to the famine varied greatly across provinces due to several factors: the difference in the proportion of rural population, population density, exposure to natural disaster, and provincial response to food shortage. As famine also affected the fertility rates it is likely that the cohort size in 1959-1961 is smaller compared to the cohort size in non famine years. I use the size of the surviving cohort in the community of birth to proxy for the intensity of the famine. When the survey data were collected, there had been little migration due to strict migration laws. Thus, the birth cohort should be smaller for communities that faced high intensity of the famine. I measure the variation in the severity of famine by the ratio of cohort size of individuals born during the famine years and the cohort size of individuals born before the famine years. This fraction should be decreasing in the famine intensity. In Table 1, I present the number of births in each year from 1943-1970, aggregated for all communities. We see that the births were increasing prior to 1959, but during 1959-1961, births fell sharply and were on average significantly lower than other years before and after the famine. Figure 1 plots the sample of the total population by birth year.

4 Data

The data for this paper is taken from 1989 China Health and Nutrition Survey (CHNS). The CHNS provides individual-level survey data which took place over a 3-day period using a multistage, random cluster process to draw a sample of approximately 3800 households with a total of 15925 individuals. These surveys were conducted by the Carolina Population Center at the University of North Carolina. This data set can be found on the website www.cpc.unc.edu/projects/china.

The CHNS data covers 8 provinces–Liaoning, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou that differ in geography, economic development, public resources, and health indicators. In terms of living standards, Jiangsu, Liaoning and Shandong are among the richest provinces, Henan and Hunan near the median, and Guangxi and Guizhou are among the poorest (Chen and Zhou 2002). In addition, these provinces also differed in famine intensity and thus the data provides a good sample for the purpose of this paper.

The survey data consists of detailed information about individual and households characteristics such as: education of individuals, occupations of household members, incomes from different sources, time allocations for home activities, availability of health and medical services and family planning. The survey also contains information on physical examination of all individuals providing data on health status such as height, weight, arm and head circumference etc. It also contains information regarding the relationship to the Head of the Household, linking children to their parents.

The data are collapsed and matched by community and birth year for each individual. For the empirical analysis, the ratio of the logarithm of cohort size from 1959-1961 to the cohort size from 1943-1958 for each community and birth year will be used as the measure of famine intensity for individuals born in that community and birth year. The benefit of using cohort size as a measure of famine intensity is that it is a measure that can be easily obtained from any famine.

Using large cross section of 1744 children born between 1982-1989 from 1989 survey data, first I match them with their mothers using the information on relationship to the head of household. Based on the information given, it is only possible to match the children with their mothers if the relationship of the head of household with them is as follows: son, daughter, grandson or granddaughter. So using this information I was able to match 1402 children with their mothers. Some mothers have more than one child so in general there are 1082 mothers from birth year 1937-1970 with at least one child. Among these 1082 mothers I only use mothers who were born between 1943-1970 as a sample size for two reasons. First, all women born before 1943 were older than 16 years in 1959 when the famine started. Thus, their height should not have been affected by the famine because they should have already gained their maximum height. Second, some of them who were born before 1943 may have shrunk because of their age. I also exclude people who were born after 1970 because they were less than 20 years old at the time of survey and may be still growing. In general, after excluding mothers born before 1943 and after 1970, the sample consists of 1395 children and 1077 mothers.

5 Methodology

The effect of mother's health on child health is estimated using 2SLS regression.

The baseline model is

$$\log(Y_{imtj}) = C + \beta_1 \log(H_{itj}) + \beta_2 X'_{itj} + \alpha_j + \gamma_t + \epsilon_{itj} \tag{1}$$

The dependent variable Y_{imtj} indicates the attained height of a child i born to mother m in community j in year t, measured in centimeters. X'_{itj} is a vector of control variables that includes education of the mother and father measured by the highest level of education attained, total wage income of parents measured in yuan earned per day, maternal age at birth of a child and gender of the child. Like many previous studies of mother and a child health, I also ignore other characteristics of fathers. α_j denotes the community fixed effect that captures all observed and unobserved time invariant community characteristics that are constant across individuals born in the same community. Similarly, γ_t denotes year fixed effects that captures the time invariant unobserved heterogeneity that are common to both mother and child. Fixed effects also captures all aggregate shocks that induce a spurious correlation between child health and mother's health.

H_{itj} which indicates mother's attained height in centimeters is the regressor of interest and is endogenous. Height of a mother and height of a child may be affected by other unobserved variables in the model, which leads to omitted variable bias. For example, some region specific variables such as lack of health care facilities may affect both mother's height and child's height which is used as an indicator of health. The OLS estimator $\widehat{\beta_1}$ is then inconsistent for β_1 because $\widehat{\beta_1}$ combines the desired direct effect of mother's height on child height (β_1) with the indirect effect that mothers with shorter height are likely to have faced with lack of health care access and hence they might have shorter children. For example, if one cm increase in height of a mother is found to be associated on average with a 0.2 cm increase in height of a child then we are not sure how much of this increase is due to maternal height and how much is due to mothers with taller height having higher access to health care facilities. Hence, H_{itj} is endogenous as it is correlated with the error term. This can be corrected by using instrumental variables methods. IV estimation provides a consistent estimator under the very strong assumption that valid instruments exist. I use the Great Famine in China that occurred early in the life of the mother which affected her height at maturity as an instrument.

An exposure to the famine in childhood can affect height of an individual in different ways. For instance, the famine in 1959-1961 created a large undernourished population. As a result, malnutrition and exposure to famine related diseases affected the health of the surviving population. Moreover, medical and epidemiological research has shown that exposure to famine during fetal period and early childhood has significant long-term health effects (Barker, 1989). It is likely that children who were born or conceived during the famine years may have adverse health outcomes. In addition, the famine may have reduced the quality or quantity of other forms of investment into child health by reducing health status of parents. Thus, it is very likely that people who were exposed to the famine had adverse health effect which is captured by height. Using the CHNS data set Chen and Zhou (2002) has shown that on, average, in the absence of the famine individuals of age 2 in 1961 would otherwise have grown 3.35 cm taller. Therefore, it is reasonable to use famine as an instrument because most of the women used in the sample were either directly or indirectly exposed to the famine so the famine may have exerted a significant effect on the height of these women but it has no direct effect on the height of their children except through their own height. Using IV approach, the parameter of interest in this model is the intergenerational coefficient β_1. I expect this coefficient to be positive and statistically significant.

6 Identification Strategy

Using the identification strategy of Duflo (2001) I linked height of the 1077 mothers born between 1943-1970 with community-level data on the number of births between 1959-1961 (famine years) and between 1943-1958 (pre-famine years) in her region of birth. The exposure of an individual to the famine is determined by both region and year of birth. The OLS specification uses a simple fixed effects model. For example, there may be some regions with bad institutions that are more vulnerable to famines and since institutions do not change over short periods of time, the differences in institutions will be controlled for by region fixed effects. After controlling for region of birth and year of birth effects, interactions between dummy variables indicating the year of birth of the individual and the intensity of the famine in her region of birth are plausibly exogenous variables and are used as an instrument in height equation.

The intensity of the famine varied across different cohorts. The effect of the famine should be close to zero for women 16 years or older in 1959 and increasing for younger children. For instance, for younger cohorts who were conceived, born or up to 16 years old during the famine, it is likely that their height attainment was affected by the famine. Medical and epidemiological literature shows evidence that under-nutrition in early life may permanently change the body's structure and also increase susceptibility to disease in adult life (Barker, 1989). It has also been shown that when malnutrition occurs, it affects pubertal growth (see for example Styne 2003). Furthermore, some studies have shown that the final height and earlier pubertal maturation depends on socioeconomic status and differences in growth and maturation between ethnic and social groups is caused by nutrition and infections (Proos, 1993; Yip et al, 1993). Research has also shown that the exposure to the famine during fetal period may exert significant effect on body composition and growth after birth, including height attainment (Zhen and Chou 2002). Based on the existing literature in medical and epidemiology we can expect to find the greater effect of the famine on health outcomes of those cohorts who were exposed to the famine during the prenatal and early periods of childhood compared to those who were exposed later on. I expect to see a greater effect of the famine on the height of individual who were born between 1959-1962 compared to those who were born between 1943-1958. On the other hand, people who were born between 1962-1970 were not directly affected by the famine and serve as a control group.

Table 2 shows the average height of all individuals born between 1943-1970 and separately for males and females. We can see that average height attainment increased over time for all individuals, males and females. The average height increased from 159.85cm to 161.12cm for individuals born between 1943-1950 and 1963-1970 which is an increase of 0.79 percent.The increase in average height over time most probably reflects the advancement of science and technology over time that affected height of individual in general. This does not necessarily suggest that people who were born closer to the famine years and were exposed to the famine have shorter height compared to others who were born after the famine.Therefore, we should further investigate the difference in average height of individuals for cohorts living in different famine intensity areas.

The intensity of the famine not only varied across different cohorts but also across communities. As mentioned earlier, famine intensity is measured by the ratio of the logarithm of cohort size from 1959-1961 to the cohort size from 1943-1958 for individuals born in that community and birth year. Based on this measure of the famine intensity, I take the median value and divide the communities into low and high famine intensity areas.If the ratio is smaller than the median value then the area is high intensity area and vice versa. Table 3 shows the average height attainment in low and high famine intensity communities for all three cohorts.We can see that the average height attainment is higher in low famine intensity areas for all individuals, males and females. This suggests that famine had an adverse effect on the health of those individuals born in higher intensity area compared to those born in lower intensity areas.

As we have mentioned above, an individual's exposure to the famine is jointly determined by the year of birth and region of birth. We can show the identification strategy using a two-by-two difference-in-differences tables. In Table 4, Panel A shows the average height for individuals who were exposed to the famine(born between 1943-1962) and for those who were not exposed to the famine (born after the famine 1963-1970). Columns 1 and 2 show the average height for individuals in high and low famine intensity areas, respectively. The average height attainment is lower for cohorts that were exposed (159.81, 161.15)compared to those that were not exposed (160.91,161.31)to the famine in both high and low intensity areas. The difference-in-differences estimator shows a decline of 0.94 cm of height for the exposed cohort in the high famine intensity areas. Similarly, for Panels B and C we see a smaller difference-in-differences estimate for exposed females (-0.10) and a larger estimate for males(-0.48).The difference in these differences can be interpreted as the causal effect of the famine, under the assumption that in the absence of the famine, the decline in height attainment would not have been different in high and low famine areas.

Similarly,Table 5 shows the difference-in-differences estimate for the height attainment of children of exposed compared with unexposed mothers in high and low famine intensity areas.Columns 1 and 2 show the average height of children whose mothers were born in high and low famine intensity areas, respectively.We see that the average height of children whose mothers were exposed to the famine and were born in high famine intensity area is lower (92.45cm) than the average height of children whose mothers were exposed but born in low famine intensity areas (94.76cm). This is true for all children, males and females. In the case of unexposed cohorts, there is not much difference in the height of children whose mothers were born in high and low famine intensity areas.However, the surprising result is that the average height is lower for those children whose mothers were unexposed to the famine compared to those who were exposed. The difference in differences estimator does not show a decline in the height of the children whose mothers were exposed to the famine and born in high intensity area. The difference between exposed and unexposed has a wrong sign in all cases. This is not consistent with my expectation.Thus, further investigation is needed.

7 Identification issue

The major concern in this paper is that I assume that the region of birth and region of residence at the time of the survey is the same. I make this assumption because of the limitation of the dataset. CHNS data does not provide names of the communities where the individuals were born due to their privacy policy. So it is not possible to find the region of birth for the individuals in the data set. Hence, I assume that the region of birth and residence is same. However, this assumption is plausible and will not bias the empirical results because China had strong migration and relocation laws, before 1990s due to which these individuals are likely to have the same region of birth and residence. Migration had to be approved by authorities on a case by case basis(Chen and Zhou). However,even with the strict laws, in some parts government-planned migration still occurred. But Liang and White (1996) provides evidence that the magnitude of these migrations before 1978 was very small.[2]. Even with the strict migration laws, when the great famine occurred it could have caused panic among the individuals and people might have fled to other non famine stricken areas. However, we do not observe this in China because all residents were organized into huge People's communes that were managed by military and fleeing was monitored and prohibited. Any attempt to flee was met by harsh punishment (Chen and Zhou).Therefore, because of the strict laws in China before 1990's, we can assume that region of birth and region of residence is the same and based on this we can determine the exposure to the famine of each individual.

A second concern is the assumption of similar human development trends in high and low famine intensity communities. The difference-in-differences estimator in equation (2) below is interpreted as a causal effect of the famine on the height of the individual under the assumption that there were similar underlying trends in human development in each community such that if there was no famine then the average height attainment should not be different in high and low famine intensity communities. However, if high famine intensity communities had lower levels of human development than low intensity communities before 1959 when the famine first started, then lower average height of the cohort who were exposed in high intensity communities may not capture the direct impact of the famine. The lower average height attainment might be the result of incapabilities of poor communities to cope with the famine because of the lower levels of their human development. Since the CHNS data set does not allow identification of the communities it is not possible to find community level data on human development before the famine years. Therefore, my empirical analysis is based on the assumption of similar human development trends in all communities.

8 Empirical Analysis I

Table 6 shows the descriptive statistics for the variables used in the model. The sample consists of 1395 children and their parents. The average age of women is 30 and children is 4 in 1989. The average height of women is 155 cm and children is 90 cm. The average age for women to have children is 26. The average level of education for both men and women is close to 2, which means the average level of education is lower middle school degree. However, women are slightly less educated than men.

Assuming a similar human development trend in high and low famine intensity communities, I first estimate the difference-in-differences equation for all individuals(both male and female)

[2]According to Liang and White, the interprovincial migrants accounted for only 0.3 percent to 0.7 percent of the population at risk during 1959-1963

who were exposed to the famine and were born in high famine areas:

$$\log(H_{itj}) = A + \delta_1 HFI_j + \delta_2(HFI_j) * birthyr_{it} + \alpha_j + \gamma_t + \mu_{itj} \tag{2}$$

H_{ijt} is the attained height in 1989 of individual i born in community j in year t, measured in centimeters;A is a constant; HFI_j is an indicator for living in a high famine intensity area and $birthyr_{it}$ is an indicator for being born between 1958 and 1962. People who were born between 1958-1962 are the cohorts exposed to the worst period of the famine. I include 1958 because although famine started in 1959 and ended in 1961, it is likely that people who were born immediately before and after the famine were also affected almost as badly as people who were born during the famine due to some prior and afterward shocks of famine. The variable of interest is the interaction of these two indicators $(HFI_j) * birthyr_{it})$. μ_{itj} is a random, idiosyncratic error term.γ_t and α_j are birth year and community fixed effects, respectively as mentioned in equation (1) above.

Table 7 presents regression results for Equation 2 using log of height as the dependent variable. The difference-in-differences estimate is the coefficient of the interaction between an indicator for the exposed cohort (individuals born between 1958 and 1962) and an indicator for whether or not the individual lived in a high famine intensity area. The difference-in-differences coefficient is -0.0035 and is significant at 5 percent level.This shows that there is a negative impact of the famine on the height of the individuals who were born between 1958-1962 and who lived in the high famine area.This difference-in-difference estimator is much smaller than the corresponding estimate in Table 4 (-0.94). The exposed group consisted of individuals born between 1943-1962 in Table 4 and lived in a high famine area. Here I only examine the effect on individuals who were born between 1958-1962, lived in a high famine area, and were most badly affected by the famine. However, they both have same sign which is the key point because it shows that famine had a negative effect on height of exposed individuals who lived in high famine area.

Next, using the sample size of women born between 1943-1970 who lived in either high famine or low famine communities, I estimate the effect of famine intensity on height holding everything else constant:

$$\log(H_{itj}) = C + \delta FamineIntensity_j + \sum_{t=1943}^{1970} \eta_t \log(FamineIntensity_j) * birthyr_{it} + \alpha_j + \gamma_t + \mu_{itj} \tag{3}$$

C is a constant, $famineintensity_j$ denotes the intensity of famine in the region of birth, $birthyr_{it}$ is a dummy indicating whether an individual i was born in year t, α_j is community/region fixed effect, γ_t denotes birth year fixed effects. μ_{itj} is the error term. The coefficient of interaction between the famine intensity and birth year dummy measures the causal effect of the famine on height attainment. I expect the magnitude of these coefficients to vary across birth year. Moreover, I expect to see greater effect of famine on height of relatively younger individuals. For instance, η_t should be negative for individuals who were conceived or born during and just prior to famine years. On the other hand, the coefficient η_t should not be statistically different from zero for individuals born after the famine i.e. $t > 1962$.

Table 8 presents the regression estimates for the full sample of women in this study. The dummy variables for birth years from 1943 to 1970 and dummies for 180 communities are controlled in the regression but their coefficients are not reported due to the limitation of space. The coefficients of interest in this regression are the coefficients of interaction terms between famine intensity and birth year which measures the causal effect of famine on height attained. The negative coefficients on the interaction terms shows that famine-affected birth cohorts have in general shorter height compared with the case if famine had not occurred. Among the cohorts with negative effects of famine, we can see that the cohorts of 1958, 1961 and 1962 have slightly more severe and statistically significant effects compared to other cohorts. But the coefficients are very close to each other so in general the result indicates similar effect of famine on all birth cohorts from 1945-1969 which is opposite to what I have expected to find. The R-Squared is 0.4334 which indicates that 43.34 percent of the variance in women's height can be predicted from the famine intensity and the interaction of famine intensity and birth year dummies.

From the above analysis, we see that famine had negative effect on the height of the individuals, which is consistent with the findings in the literature. I then performed 2sls regression using the baseline model (1) described above. Table 9, shows the result. In the first stage regression the coefficients of the interaction terms of the famine intensity and the birth year dummies have negative sign as expected. Furthermore, R-squared is 0.5862 which indicates that 58.62 percent of the variance in women's height can be predicted from the explanatory variables. I do not report the results for the first stage due to the limitation of space. The second stage regression shows that an increase in maternal age by one year will decrease the height of the child by 0.002 cm. This is reasonable because older women are more likely to have less healthier child compared to younger women. Similarly, we see that on average the height of a male child is 0.007 cm higher than the female child. Mothers with middle school degree and fathers with college and master's level degree has a significant effect on the height of the child. However, the second stage regression shows a surprising result. I find that the regressor of interest which is maternal height is not significantly different than zero. This is opposite to what I have expected to find. Having experimented with a number of variables such as (controlling for only mother's education, without controlling for any other variables mentioned above), 2sls method does not show significant effect of maternal height on child height. Hence, I use a reduced form equation to investigate this relationship further.

Reduced form equation estimates, with using other exogenous regressors mentioned above

$$\log(Y_{imtj}) = B + \lambda_1 FamineIntensity_j + \sum_{t=1943}^{1970} \lambda_{2t} \log(FamineIntensity_j) * birthyr_{it} + \alpha_j + \gamma_t + \upsilon_{itj} \tag{4}$$

Table 10 reports regression results for reduced form estimation. We see that the interaction term is negative and statistically significant for all birth year. This implies that famine intensity has a negative effect on the height of children whose mothers were exposed to the famine in their childhood. For example, a unit increase in famine intensity will reduce the height of a child by 0.328 cm if his/her mother was born in 1959. The results show that the coefficient of the interaction term is very similar for all women born between 1943-1970. Since the effect of the famine might have lasted for few years even after it ended in 1961, it is obvious that the height of children whose mothers were born after 1962 were also affected. The results basically shows that famine had an adverse effect on height of children whose mothers were directly or indirectly exposed to the famine in their childhood compared to the case if there was no famine.

9 Empirical Analysis II

As an extension, I further examine whether the results provided above is consistent for all indicators of child health. Using reduced form regression, I now find the effect of maternal height on child weight.

The baseline model is

$$\log(w_{imtj}) = C + \beta \log(H_{itj}) + \alpha_j + \gamma_t + \epsilon_{itj} \tag{5}$$

where w_{imtj} is the weight of a child i born to mother m in community j in year t, measured in kilogram. α_j and γ_t are community and birth year fixed effects as described in equation (1).

The first stage equation estimates

$$\log(H_{itj}) = A + \delta FamineIntensity_j + \sum_{t=1943}^{1970} \eta_t \log(FamineIntensity_j) * birthyr_{it} + \alpha_j + \gamma_t + \mu_{itj} \tag{6}$$

Reduced form equation estimates

$$\log(w_{imtj}) = B + \lambda_1 FamineIntensity_j + \sum_{t=1943}^{1970} \lambda_{2t} \log(FamineIntensity_j) * birthyr_{it} + \alpha_j + \gamma_t + \upsilon_{itj} \quad (7)$$

Table 11 reports regression results for reduced form equation for weight. We see that the interaction term is negative and statistically significant for almost all birth year. This implies that famine intensity has a negative effect of the weight of children whose mothers were exposed to the famine in their childhood. For example, a unit increase in famine intensity will reduce the weight of a child by 0.328 cm if his/her mother was born in 1959.

10 Conclusion

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12 Appendix

Table 1: Sample Population by Birth Year in 1989

BirthYear	Population
1943	175
1944	126
1945	174
1946	210
1947	202
1948	194
1949	231
1950	187
1951	248
1952	267
1953	261
1954	274
1955	288
1956	279
1957	259
1958	227
1959	211
1960	197
1961	163
1962	314
1963	389
1964	347
1965	294
1966	311
1967	281
1968	348
1969	317
1970	321

Table 2: Height Attainment in centimeters

	Born 1943-1950	Born 1951-1962	Born 1963-1970
Panel A: All Individuals			
Average Height	159.85	160.74	161.12
Observations	1057	2400	1645
Panel B: Males only			
Average Height	165.35	166.57	166.81
Observations	527	1109	782
Panel C: Females Only			
Average Height	154.39	155.73	155.97
Observations	530	1290	863

Table 3: Height Attainment(cm): Low and High Famine Intensity Areas

Low Famine Intensity Areas			
	Born 1943-1950	Born 1951-1962	Born 1963-1970
Panel A: All Individuals			
Average Height	160.15	161.47	161.31
Observations	413	1288	860
Panel B: Males only			
Average Height	165.58	167.27	167.23
Observations	210	607	390
Panel C: Females Only			
Average Height	154.52	156.28	156.39
Observations	203	680	470
High Famine Intensity Areas			
	Born 1943-1950	Born 1951-1962	Born 1963-1970
Panel A: All Individuals			
Average Height	159.66	159.90	160.91
Observations	644	1112	785
Panel B: Males only			
Average Height	165.19	165.71	166.38
Observations	317	502	392
Panel C: Females Only			
Average Height	154.30	155.12	155.46
Observations	327	610	393

Table 4: Difference-in-Differences Comparing Exposed with Unexposed Cohorts in High and Low Famine Intensity Areas:Height(cm)

	High Famine Intensity Areas	Low Famine Intensity Areas	Difference (High-Low)
Panel A: All Individuals			
Born 1943-1962 (Exposed)	159.81	161.15	-1.34
			(0.2736)***
Born 1963-1970 (Unexposed)	160.91	161.31	-0.4
			(0.3899)
Difference (Exposed - Unexposed)	-1.1	-0.16	-0.94
	(0.3438)*	(0.3297)	(0.4763)
Panel B: Males only			
Born 1943-1962 (Exposed)	165.51	166.84	-1.84
			(0.3110)
Born 1963-1970 (Unexposed)	166.38	167.23	-0.85
			(0.4378)
Difference (Exposed - Unexposed)	-0.87	-0.39	-0.48
	(0.3850)	(0.3744)	(0.5371)
Panel C: Females Only			
Born 1943-1962 (Exposed)	154.84	155.87	-1.03
			(0.2647)
Born 1963-1970 (Unexposed)	155.46	156.39	-0.93
			(0.3664)
Difference (Exposed - Unexposed)	-0.62	-0.52	-0.1
	(0.3313)	(0.3076)	(0.4521)

Table 5: Difference-in-Differences for Children of Exposed and Unexposed Cohorts in High and Low Famine Intensity Areas:Height(cm)

	High Famine Intensity Areas	Low Famine Intensity Areas	Difference (High-Low)
Panel A: All Children			
Mother Born 1943-1962 (Exposed)	92.45	94.76	-2.31
Mother Born 1963-1970 (Unexposed)	83.11	83.12	-0.01
Difference (Exposed - Unexposed)	9.34	11.64	-2.3
Panel B: Male children only			
Mother Born 1943-1962 (Exposed)	93.33	94.09	-0.76
Mother Born 1963-1970 (Unexposed)	84.4	84.48	-0.08
Difference (Exposed - Unexposed)	8.93	9.61	-0.68
Panel C: Female Children Only			
Born 1943-1962 (Exposed)	91.39	95.54	-4.15
Born 1963-1970 (Unexposed)	81.68	81.46	0.22
Difference (Exposed - Unexposed)	9.71	14.08	-4.37

Table 6: Summary Statistics for Mothers and Children

Variable	N	Mean	Std.Dev	Min	Max
Child Attained height in 1989(cm)	1331	90.351	14.909	49	136.5
Child Weight in 1989 (kg)	1365	13.580	4.030	4	28.5
Gender(Male = 1, Female=2)	1395	1.458	.498	1	2
Child Birth Year	1394	1985.917	1.929	1982	1989
Mother Attained height in 1989(cm)	1281	155.589	5.432	140	175
Mother Birth Year	1393	1959.469	4.747	1943	1970
Famine Intensity	1395	-1.528	2.275	-8.491	0.125
Log of Mother height	1281	2.192	0.015	2.146	2.243
Log of child height	1331	1.949	0.746	1.690	2.135
Log of child weight	1365	1.113	0.137	0.602	1.455
Mother education	1044	1.893	0.999	0	5
Mother Age at child birth	1392	26.450	4.535	16	44
Total Parental Wage Income(Yuan per day)	637	9.421	20.117	0.1	198
Father education	1250	2.003	1.035	0	6

Education is measured as the highest level attained.
0-None
1-finished primary school
2-lower middle school degree
3-upper middle school degree
4-middle technical, professional, or vocational degree
5-3 or 4-year college degree
6-master's degree or more

Table 7: Difference-in-Differences Regression Results For Comparing Exposed with Unexposed Cohorts in High and Low Famine Intensity Areas

Dependent Variable: Log(Height)		
High Famine Intensity Area (HFI)	-0.005	(0.008)
(Born 1958-1962) * (HFI)	-0.003	(0.002)**
Observations:5102		
R-squared:0.15		

Note: Robust standard errors are reported in parentheses.
The dummies for birth year and community dummies are controlled in the regression.
$*$ Significant at 10 percent level.
$**$ Sugnificant at 5 percent level.
$***$ Significant at 1 percent level

Table 8: The Effect of Famine on the Attained Height of Mothers

Dependent Variable: Log(Mothers Height)

Famine Intensity	0.095	(0.092)
Intensity Birthyear45	-0.051	(0.024)**
Intensity Birthyear46	-0.049	(0.024)**
Intensity Birthyear47	-0.050	(0.024)**
Intensity Birthyear48	-0.094	(0.048)
Intensity Birthyear49	-0.049	(0.024)**
Intensity Birthyear50	-0.049	(0.024)**
Intensity Birthyear51	-0.051	(0.024)**
Intensity Birthyear52	-0.050	(0.024)**
Intensity Birthyear53	-0.050	(0.024)**
Intensity Birthyear54	-0.048	(0.024)**
Intensity Birthyear55	-0.049	(0.024)**
Intensity Birthyear56	-0.048	(0.024)**
Intensity Birthyear57	-0.049	(0.024)**
Intensity Birthyear58	-0.050	(0.024)**
Intensity Birthyear59	-0.048	(0.024)
Intensity Birthyear60	-0.037	(0.024)
Intensity Birthyear61	-0.051	(0.025)**
Intensity Birthyear62	-0.050	(0.024)**
Intensity Birthyear63	-0.049	(0.024)**
Intensity Birthyear64	-0.051	(0.024)**
Intensity Birthyear65	-0.049	(0.024)**
Intensity Birthyear66	-0.051	(0.024)**
Intensity Birthyear67	-0.049	(0.024)**
Intensity Birthyear68	-0.050	(0.024)**
Intensity Birthyear69	-0.054	(0.024)**
Observations:1281		
R-squared:0.43		

Note: Robust standard errors are reported in parentheses.
The dummies for birth year and community dummies are controlled in the regression.
** Significant at 5 percent level.

Table 9: 2sls Regression Results to show the effect of maternal height on child height using IV method

Dependent Variable: Log(Child height(cm))

Mother Attained Height	0.219	(0.419)
Mother Age at child birth	-0.002	(0.001)***
Parental Wage Income	0.0002	(0.0001)***
Male	0.007	(0.002)***
Mother no edu	0.002	(0.007)
Mother primary degree	0.009	(0.005)*
Mother lower middle school	0.005	(0.005)
Mother upper middle school	0.014	(0.005)**
Mother middle school	0.014	(0.007)**
Mother college	0.005	(0.009)
Father no edu	0.003	(0.007)
Father primary degree	0.001	(0.005)
Father lower middle school	0.002	(0.005)
Father upper middle school	-0.003	(0.005)
Father middle school	0.002	(0.007)
Father college	0.013	(0.006)**
Father masters	0.028	(0.012)**
Observations:566		
R-squared:0.93		

Note: Robust standard errors are reported in parentheses.
The dummies for birth year and community dummies are controlled in the regression.
∗ ∗ ∗ Significant at 1 percent level.
∗∗ Significant at 5 percent level.
∗ Significant at 10 percent level.

Table 10: Reduced Form regression:The effect of maternal height on child height

Dependent Variable: Log(Child weight)

Famine Intensity	0.860	(0.292)
Intensity Birthyear44	-0.460	(0.111)
Intensity Birthyear45	-0.327	(0.025)
Intensity Birthyear46	-0.326	(0.025)*
Intensity Birthyear47	-0.234	(0.058)**
Intensity Birthyear48	-0.233	(0.143)
Intensity Birthyear49	-0.322	(0.025)
Intensity Birthyear50	-0.313	(0.025)
Intensity Birthyear51	-0.323	(0.025)
Intensity Birthyear52	-0.326	(0.025)
Intensity Birthyear53	-0.324	(0.025)
Intensity Birthyear54	-0.322	(0.024)
Intensity Birthyear55	-0.320	(0.024)
Intensity Birthyear56	-0.321	(0.024)
Intensity Birthyear57	-0.322	(0.024)
Intensity Birthyear58	-0.325	(0.024)
Intensity Birthyear59	-0.328	(0.026)
Intensity Birthyear60	-0.318	(0.037)
Intensity Birthyear61	-0.319	(0.036)
Intensity Birthyear62	-0.322	(0.024)
Intensity Birthyear63	-0.321	(0.024)
Intensity Birthyear64	-0.325	(0.024)
Intensity Birthyear65	-0.325	(0.025)
Intensity Birthyear66	-0.325	(0.024)
Intensity Birthyear67	-0.323	(0.025)
Intensity Birthyear68	-0.323	(0.024)
Intensity Birthyear69	-0.321	(0.026)
Observations:1330		
R-squared:0.90		

Note: Robust standard errors are reported in parentheses.
The dummies for birth year and community dummies are controlled in the regression.
*** Significant at 1 percent level.
** Significant at 5 percent level.
* Significant at 10 percent level.
All coefficients are significant at one percent level except for the ones shown with asteriks above.

Table 11: Reduced Form regression:The effect of maternal height on child weight

Dependent Variable: Log(Child weight)

Famine Intensity	1.08	(0.587)
Intensity Birthyear44	-0.601	(0.201)
Intensity Birthyear45	-0.669	(0.159)
Intensity Birthyear46	-0.664	(0.159)
Intensity Birthyear47	0.509	(0.167)
Intensity Birthyear48	-0.891	(0.213)
Intensity Birthyear49	-0.655	(0.159)
Intensity Birthyear50	-0.648	(0.159)
Intensity Birthyear51	-0.660	(0.159)
Intensity Birthyear52	-0.654	(0.159)
Intensity Birthyear53	-0.658	(0.159)
Intensity Birthyear54	-0.658	(0.159)
Intensity Birthyear55	-0.656	(0.159)
Intensity Birthyear56	-0.658	(0.159)
Intensity Birthyear57	-0.659	(0.159)
Intensity Birthyear58	-0.664	(0.159)
Intensity Birthyear59	-0.667	(0.152)
Intensity Birthyear60	-0.648	(0.160)
Intensity Birthyear61	-0.657	(0.161)
Intensity Birthyear62	-0.658	(0.159)
Intensity Birthyear63	-0.661	(0.159)
Intensity Birthyear64	-0.665	(0.159)
Intensity Birthyear65	-0.662	(0.159)
Intensity Birthyear66	-0.663	(0.159)
Intensity Birthyear67	-0.658	(0.159)
Intensity Birthyear68	-0.667	(0.159)
Intensity Birthyear69	-0.653	(0.159)
Observations:1371		
R-squared:0.84		

Note: Robust standard errors are reported in parentheses.
The dummies for birth year and community dummies are controlled in the regression.
All coefficients are significant at 1 percent level.

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