Inter-generational Effects of Early Childhood Shocks on Human Capital: Evidence from Ethiopia

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Abstract

This paper investigates the intergenerational effects of maternal early childhood shocks on the human capital outcomes of their children. I exploit the 1983-1985 Ethiopian famine as an exogenous source of variation to study the effects of exposure to severe shocks during developmental plasticity on cognitive, non-cognitive and health capabilities of children of mothers who were exposed to the shocks in early childhood. Using data that track children from early childhood through adolescence, I estimate the effects of maternal early childhood shock over their children's life cycle. I find that the famine has a lasting effect on the children of mothers who suffered the famine in their first three years of life. Maternal early childhood famine exposure reduces their children's height-for-age z-score, schooling, locus of control and self-esteem. These effects are persistent and worsen from age one through early adolescence. The main inter-generational transmission channel of the shock is children's maternal human capital endowment. Mothers who suffered the famine in early childhood are shorter and have less schooling. I also find a critical maternal shock duration threshold of three months. These findings point to ineffectiveness of remediation once the damage is done to mothers as young girls. The policy implication is that girls under the age of three with high likelihood of crossing the critical famine duration threshold should be targeted for health and nutritional interventions.

Key words: Intergenerational shocks, Famine, Human capital, Fetal origins hypothesis, Ethiopia

JEL Codes: D03, I00, J24, O12, Y40

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1 Introduction

Climate change-related rise in temperatures has increased the frequency and intensity of extreme weather events in the last few decades. The sharp increase in incidents of droughts, heat waves, flooding, and storms has been associated with surge in economic and social costs of natural disasters (WMO, 2014). In much of the developing world where a significant share of household income is sourced in the agricultural sector, such events will have adverse welfare consequences due to loss of productive assets, disruptions in nutrition, health, and schooling, among others. Within the household unit, the effect of weather shocks may differ based on individuals' characteristics. Shocks experienced in early childhood have greater detrimental impact on human capital and labor market outcomes (Ampaabeng & Tan, 2013; Maccini & Yang, 2009; Cunha & Heckman, 2007; Alderman, Hoddinott, & Kinsey, 2006).

Since the early studies in epidemiology by Barker (1995, 1990) on the fetal origins of disease, there has been a growing body of literature in economics investigating the effects of adverse exposure during the prenatal (Currie, 2011; Almond, Chay, & Lee, 2005) and at various stages in the postnatal (Shah & Steinberg, 2013; Currie & Almond, 2011) periods on health, schooling and labor market outcomes. These studies typically leverage exogenous sources of variation (natural experiments) to circumvent the complications of potential confounding between unobserved individual and family characteristics and early childhood environments (Black, Devereux, & Salvanes, 2016; Currie & Rossin-Slater, 2013; Shah & Steinberg, 2013; Akresh, Bhalotra, Leone, & Osili, 2012; Scholte, Van den Berg, & Lindeboom, 2012; Kelly, 2011; Almond, Edlund, Li, & Zhang, 2010; Alderman et al., 2006; Almond, 2006).

Much of the literature on early childhood shocks focuses on the prenatal period, which is perhaps the most sensitive period for child development. Disruption during this period may delay or retard the expression of parts of the genome that are crucial for cognitive and motor functions (Petronis, 2010) and lead to a lasting impact on childhood and adulthood outcomes (Black et al., 2016; Currie, 2011; Almond, 2006; Almond et al., 2005). Recent studies show that the adverse effects of such shocks is greater for females (Caruso & Miller, 2015; Tan, Zhibo, & Zhang, 2014; Almond et al., 2010). Irreversible physiological adaptations to nutritional stress during the critical (prenatal and postnatal) period may set growth parameters of girls (Almond & Mazumder, 2011; Gluckman & Hanson, 2004), which may predetermine their offspring's developmental trajectory and later life outcomes (Osmani & Sen, 2003). This intergenerational aspect of shocks is surprisingly understudied.

This paper presents one of the first estimates of the intergenerational effects of early childhood shocks on human capital. Other recent papers that study the intergenerational transmission of shocks include Caruso and Miller (2015), who study the effects of the 1970 Ancash earthquake in Peru on schooling and child labor. They find that maternal *in utero* exposure has a negative effect on child schooling and child labor. Tan et al. (2014) study how parental exposure to the 1959-1961 Chinese famine affects the cognitive outcomes of their children. They find that the daughters of fathers who suffered the famine as young boys perform worse in cognitive tests. This paper extends this emerging literature by looking at a broad range of human capital measures over children's life cycle in a context of an African country where agriculture is the prime source of sustenance. In this setting, weather shocks can have destructive lasting effect on the human capital of individuals who suffer the shocks directly and their offspring.

Ethiopia suffered a catastrophic famine in 1983-1985 as rains failed in successive cropping seasons between 1983 and 1985 in most parts of the country, especially the northern provinces of Tigray, Wello and Eritrea.[1] The central highlands and western parts of the country were largely unaffected. I exploit the geographic variation of the famine, parents' age at the onset of the famine, and unique data that track children from the age of 6-18 months through early adolescence to explore whether shocks in early childhood have a lasting impact on the health, cognitive and non-cognitive human capital of the children of mothers who suffered the shocks as young girls. In a previous study, Dercon and Porter (2014) find a negative longterm impact of same shock on the height of young adults who were 12-36 months old at the peak of the famine. They do not examine the intergenerational effects of the famine.

The analysis in this paper goes beyond the extensive margin and examines variation in famine durations (in months) to determine whether shocks of certain duration are more damaging than others. Understanding the role of famine duration is important for identifying groups with the greatest need for an efficient targeting. The panel nature of the data permits exploring the effects of maternal early childhood shocks on children's human capital over their life cycle. I evaluate the effect size from age 1 through age 12 in a three-year interval. This provides important evidence on the malleability of early disadvantages through remediation efforts for devising relevant policies to reduce intergenerational transmission of shocks.

This paper also seeks to determine intergenerational shock transmission mechanisms. To this end, it focuses on children's maternal human capital endowment and parental invest-

[1]Eritrea has since become an independent state.

ments. Maternal human capital is an essential input in the human capital production of children. Negative shocks to mothers' human capital may lead to persistent impact through generations in a complex feedback processes (Cunha, Heckman, & Schennach, 2010; Cunha & Heckman, 2007; Heckman, 2007). Likewise, early childhood shocks may impair mothers' adulthood earnings and schooling and health investments in their children.

This paper contributes to two sets of literatures. First, it contributes to the early childhood development literature by extending the study of the impacts of adverse early childhood exposure on outcomes in childhood and adolescence to intergenerational transmission of the effects of exposure to severe shocks. Second, this paper provides an indirect test of the intergenerational persistence of poverty. The presence (or absence) of intergenerational persistence of effects of childhood shocks will point to early conditions (e.g., family income, education) as one of the potential causes (or not) of poverty persistence across generations (Bevis & Barrett, 2015; Lefgren, Lindquist, & Sims, 2012; Black, Devereux, & Salvanes, 2009).

I find that the 1983-1985 Ethiopian famine has had a negative intergenerational effect on the human capital outcomes of children of mothers who were exposed to the famine *in utero* or in their first three years of life after birth. The effect is particularly strong on the health human capabilities of children. At the mean level of famine intensity and duration, the famine reduces height-for-age (zhfa) by about 0.07 standard deviations (about 5%) relative to the World Health Organization (WHO) reference population. The effect on schooling is small, yet statistically significant. At mean famine intensity and duration, children's schooling decreases by about 0.05 grades. The key transmission channels of the shock are maternal human capital outcomes. I find that mothers exposed to the famine during developmental plasticity are shorter and have less schooling.

This paper is organized as follows. The next section provides a brief background on the Ethiopian famine. Section 3 presents the theoretical framework of the paper. Section 4 discusses the data, the measurement of the various famine and human capital measures and summary statistics. Section 5 presents the empirical strategy. Section 6 discusses the main results of the paper. Section 7 concludes.

2 Background

The agricultural sector is the mainstay of the Ethiopian economy and accounts for 40% of GDP and 80% of employment (World Bank, 2016a). It is dominated by subsistent rain-fed smallholder agriculture and limited market participation. The production environment is characterized by increasing land degradation and erratic weather conditions. Variability in the amount and seasonal distribution of precipitation has been a major cause of crop failure and food shortages. The frequency of irregular rainfall patterns and droughts has increased over the recent decades (Di Falco & Veronesi, 2013; Viste, Korecha, & Sorteberg, 2013). In some cases, the food shortages associated with droughts have led to catastrophic famines.

In the last half century alone, there have been at least three famines in Ethiopia, of which the 1983-1985 famine is widely considered the worst.[2] Estimates of the number of people killed range between 400,000 and over a million. Devereux (2000) estimates that between 600,000 and one million people were killed due to the famine. de Waal (1991) puts the figure closer to 400,000, though he notes that is likely to be a lower bound. Kidane (1990) argues the true figure of the casualties of the famine is 700,000. Despite the differences in the estimates of famine casualties, there is no doubt that the famine had a devastating impact. Indeed, Ó Gráda (2007) notes that in terms of the number of deaths relative to the Ethiopian population of the time, the 1983-1985 famine ranks as one of the worst in the world in recent history.

2.1 Ethiopian 1983-1985 Famine

The rainfall pattern in Ethiopia is characterized by a bi-modal distribution. In the predominantly crop producing central and northern areas of the country, the main rainy season (*meher*) is in June-September and accounts for 85-90% of annual agricultural output nationwide. Some central and eastern highlands areas also receive rainfall during a short rainy season (*belg*) between March and May. In the southern parts of the country, where the primary source of livelihood is pastoralism, the main rainy season is in March-May, followed by a short rainy season in October-November.

The famine started 1983 when the *meher* rains failed in Tigray and Wello. It quickly spread

[2]For a complete chronology of droughts and famines in Ethiopia, see Webb, Von Braun, and Yohannes (1992).

to the rest of the country when the 1984 *belg* rains failed in the *belg* growing highland areas in central Ethiopia (de Waal, 1991). The drought condition continued in *meher* 1984 through *belg* 1985. The famine was most severe in 1984. Using historical rainfall data for the 1961-1999 period for the *meher* season, Segele and Lamb (2005) show that 1984 was by far the driest year.[3] Low pre-*meher* rains were followed by early onset of *meher* rains, which quickly dried up. The extended dry spell led to a very short effective growing season and widespread crop failures throughout the country. The famine ended with the return of normal *meher* rains in 1985.

The famine condition was further exacerbated by insurgencies and the government's counter-insurgency strategies in northern Ethiopia. To counter the rebel movements, the government had mobilized large military campaigns, which diverted resources from relief efforts.[4] The government had also restricted access to relief aid in rebel controlled areas in Tigray and Eritrea (de Waal, 1991). There was limited access to food and medicine to people (especially women and children) severely weakened by the famine in a handful of relief centers in government controlled areas. While the move to relief centers allowed access to much needed food, poor health facilities and hygiene conditions led to the rapid spread of infectious diseases in the centers and the death of thousands. Further, restrictions on movement of people and goods in the northern provinces constrained migration of able bodied individuals to relatively less affected parts of the country in search of employment and limited commercial imports of food from surplus growing areas, compounding the impacts of the famine.

In terms of age distribution, children under the age of 10 and adults of age 60 and above were disproportionately affected by the famine. Kidane (1990) shows that among households displaced from the two most famine-affected provinces of Tigray and Wello, about 26% of children under the age of 5 and 14% of children between age 5 and 9 died during the famine. For the 0-4 age group, males were slightly more likely to die (27% vs. 24%). In the 5-9 age bracket, the female mortality rate was much higher than that of males (19% vs. 9%). Likewise, 20% of people in the 60 plus age group perished, with females most affected than males.[5] Though it is not clear that famine was the sole driver of the high mortality, the fact

[3]Using annual rainfall data (including both *meher* and *belg* rains) for the 1961-1987 period, Webb et al. (1992) report similar results. They show 1984 was the driest year for the whole of Ethiopia, as well as the northern provinces of Wello and Tigray, and Hararghe in the east.

[4]In 1984 the government had allocated 46% of the national budget to military spending (Webb & von Braun, 1994).

[5]Note, however, that these are likely to be upper bound estimates of famine-related excess death as migration often tends to be a last resort option after households exhaust their food reserves and selling off

that compared to 1981, the share of 0-14 and 65+ age groups in the population significantly decreased in 1984-1985 suggests that the famine was perhaps the prime cause of the rise in mortality of these groups (Kidane, 1989). The key implication of the high incidence of famine-related excess mortality among children in the 0-4 age group is that estimates of the impact of the famine are likely to be attenuated downwards. The problem is further compounded by the fact that children in the reference (control) group for the purpose of this paper (age 4-7 at the start of the famine) were also affected, albeit less, by the famine.

3 Theoretical Framework

I use the dynamic model of human capital development by Cunha et al. (2010); Heckman (2007) and Cunha and Heckman (2007) to study the effects of parental exposure to severe shocks (famine) on the human capital of their offspring. The starting point in this framework is the multi-dimensional nature of human capital. At any given time t, the human capital vector is given as $\theta_t = (\theta_{c,t}, \theta_{n,t}, \theta_{h,t})$, where θ_c, θ_n, and θ_h are cognitive, non-cognitive/socio-emotional, and health capabilities, respectively. The formation of capabilities (skills) follows a multistage technology in the sense that skills at one stage of the life cycle serve as inputs at a later stage. Investments in skills will, therefore, have lasting effect by increasing the stock of skills, which will be used as inputs in the formation of future skills.

In this framework, early life adverse exposure may have persistent negative impact on outcomes later in life for at least two reasons. First, skills are dynamically self-reinforcing. High cognitive skill in one period leads to higher cognitive skill in a later period, and a higher health capability cross fertilizes (i.e., creates a conductive environment for acquisition of) cognitive skill. Heckman and co-authors refer to this effect as "self-productivity"; it includes own and cross capability effects. Famines affect human capital by reducing the stock of skills available for self-production. Second, shocks reduce the productivity of future investments in human capital, a process called "dynamic complementarity." Shocks to a child's health, for example, will have a negative effect on returns to investment on future learning (Cunha et al., 2010; Cunha & Heckman, 2007).

There are multiple sensitive periods in a child's life that are critical to the development of human capital. Some skills are more readily acquired at one stage than another, and some

assets (Pankhurst, 1992).

skill deficits are more malleable at one stage than another. The most important period in a child's development is the period *in utero* (Almond, 2006). Adverse experiences at this stage are known to cause significant damages to birth weight, cognitive ability, later life height and weight, and lead to various diseases (Rosales, 2014; Gluckman & Hanson, 2004; Barker, 1995). Even within the prenatal period, early exposure may have a different impact than exposure later during pregnancy. Rosales (2014) shows that exposure to shocks during the first two trimesters has adverse effect on cognitive ability, whereas exposure during the third trimester reduces child height.

The fist two–three years after birth are also critical for the formation and shaping of skills that determine later life outcomes. Children who are exposed to shocks during this period tend to perform relatively poorly in school and labor markets (Shah & Steinberg, 2013). Cunha, Heckman, Lochner, and Masterov (2006) find similar results in a randomized evaluation of the Abecedarian program in the US. They find significant cognitive and non-cognitive gains for children who enrolled in the program early (4 months), but not for those who only experienced the intervention later (age 5). Some studies document even early adolescence years (age 10-12) can be crucial to the development of certain dimensions of human capability. Newport (1990) finds a negative relationship between age of acquisition of primary and secondary languages and language proficiency, with the relationship flattening out around the age of 12. Likewise, the fact that IQ scores tend to stabilize around age 10 (Schuerger & Witt, 1989) suggests that the critical period for acquisition of cognitive capability is before age 10. Non-cognitive skills are malleable even after age 20 (Dahl, 2004). Once critical periods are missed, remediation interventions may not reverse the damages already done.

Following Cunha et al. (2010); Heckman (2007); Cunha and Heckman (2007), the technology summarizing the formation of skill $k \in \{c, n, h\}$ is given as:

$$\theta_{k,t+1} = f_k(\theta_t, I_t, \theta_p, \eta_t) \tag{1}$$

where, $\theta_{k,t}$, I_t, θ_p, and η_t denote the stock of skill k at time t, parental investments in children at time t, parental endowments, and shocks at time t. The skill production function, f_k, is monotonically increasing in all of its arguments, twice differentiable, and concave in I. After solving recursively, (1) can be rewritten as:

$$\theta_{k,t+1} = f_k(\theta_0; I_0, I_1, ..., I_t; \theta_p; \eta_0, \eta_1, ..., \eta_t) \tag{2}$$

where θ_0 is the initial skill endowment of the child and is determined by both genetic and environmental factors. Equation (2) shows that the stock of skills at any given time t depends on endowment as well as investments and shocks at different stages in the life cycle. Early shocks are more destructive than shocks in adolescence, and more so for disadvantaged children, since early disadvantages persist through the self productivity and dynamic complementarity processes (Heckman, 2007; Cunha et al., 2006).

For ease of exposition, I divide the developmental periods of a child in two: early childhood, including the period *in utero*, denoted period 0; and late childhood, which constitutes the rest of childhood, denoted period 1. Adulthood is denoted period 2. Following Cunha et al. (2010), the process of human capital development can be described by an overlapping generations model, in which each individual lives for three periods $t \in [0, 2]$ in a household consisting of an adult and a child–the first two periods ($t = 0$ and $t = 1$) as a child and $t = 2$ as a parent. As shown in Figure 1, the adulthood period of the parent coincides with the two childhood periods of the child.[6] In each period, θ_t is stock of skills at the start of time t and I_t and η_t are investments and shocks between t and $t + 1$.

Figure (1) about here

The primary interest of this paper is in childhood outcomes. Thus, I focus on the first two periods of the life cycle. The stock of skills in late childhood can be described by[7]

$$\theta_{k,1} = f_k(\theta_0, I_0, \theta_p, \eta_0) \tag{3}$$

where, θ_0, I_0, and η_0 are vectors of skill endowment, parental investments, and shocks on cognitive, non-cognitive, and health capabilities. Parental investments and early childhood skills are endogenous and are affected by shocks. Parental investment in skill k is given as:

$$I_{k,0} = g_k(\theta_0, \theta_p, \eta_0). \tag{4}$$

Similarly, parental endowment, $\theta_p = \theta_2^p$ (parents' stock of skills in adulthood), depends on

[6]The early childhood period is defined as the entire period between conception and second birthday. This is just meant to capture the "first 1,000 days" commonly taken as the most important period for childhood development. The definition can be relaxed as necessary.

[7]I assume that investments and shocks in adulthood have little impact on human capital. Several empirical studies find small/insignificant returns to investment in adolescence and adulthood (see Cunha et al. (2006) for discussion).

parents' late childhood capabilities, θ_1^p, late childhood investments, I_1^p, parental endowment at childhood, θ_g, and late childhood shocks, η_1^p.[8]

$$\theta_p = q(\theta_1^p, I_1^p, \theta_g, \eta_1^p). \tag{5}$$

This framework can be used to study the effects of parental shocks at different stages of the life cycle on the human capital of children. For analytical ease, I use a compact form of the skills vector, which can easily be extended to look at shocks to a specific skill type.[9]

The effect of a parent's late childhood shock on her offspring's human capital can be stated as:[10]

$$\frac{\partial \theta_{k,1}}{\partial \eta_1^p} = \frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_1^p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_1^p}. \tag{6}$$

Early childhood investments in parent's capabilities, I_1^p, is endogenous, i.e., $I_1^p = g(\theta_1^p, \theta_g, \eta_1^p)$. Thus, $\frac{\partial \theta_p}{\partial \eta_1^p}$ in (6) can be rewritten as:

$$\frac{\partial \theta_p}{\partial \eta_1^p} = \frac{\partial \theta_p}{\partial \eta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \eta_1^p}. \tag{7}$$

Substituting (7) in (6), we find a decomposable impact of parental childhood shocks on child outcomes as:

$$\begin{aligned} \frac{\partial \theta_{k,1}}{\partial \eta_1^p} &= \left(\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\right)\left(\frac{\partial \theta_p}{\partial \eta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \eta_1^p}\right) \\ &= \underbrace{\frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_1^p}}_{\text{Self Productivity}} + \underbrace{\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_1^p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \eta_1^p}}_{\text{Mixed channel}} + \underbrace{\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \eta_1^p}}_{\text{Dynamic complementarity}}. \end{aligned} \tag{8}$$

[8] I follow similar indexing notation for both the child and the parent. To distinguish between generations, I index (superscript) parent skills with p and grand parents skills with g.

[9] The effect of a shock to a parent's skill $m \in \{c, n, h\}$, on a child's capability k can be stated as:

$$\frac{\partial \theta_{k,1}}{\partial \eta_{m,1}^p} = \sum_{l=c,n,h}\sum_{j=c,n,h}\frac{\partial \theta_{k,1}}{\partial I_{l,0}}\frac{\partial I_{l,0}}{\partial \theta_{j,p}}\frac{\partial \theta_{j,p}}{\partial \eta_{m,1}^p} + \sum_{j=c,n,h}\frac{\partial \theta_{k,1}}{\partial \theta_{j,p}}\frac{\partial \theta_{j,p}}{\partial \eta_{m,1}^p}.$$

[10] Here, I show only the effect of parents' late childhood shocks on their children's human capital. See Appendix 1, for results on parental early childhood shocks.

Equation (8) presents a compact solution of the effects of parental shock exposure on a child's human capital k. It includes both direct (effect of a shock to a parent's health in childhood on her child's health) and cross (effect of shocks to a parent's health in childhood on her child's cognitive capabilities) effects. The first term measures the pure self-productivity effect of parental exposure to adverse shocks. Shocks experienced by a parent reduce the parent's capabilities, which in turn reduce a child's human capital through the "skill begets skill" notion. It is, therefore, expected to be negative.

The last term in (8) is the pure dynamic complementarity effect. Parents' childhood shock exposure reduces the return on investments in their human capital, and hence the stock of parents' stock of skills at adulthood. Low parental skills (children's parental endowment), in turn, leads to low child capabilities. The sign of the dynamic complementarity effect is, however, not straight forward due to competing mechanisms. Even though $\frac{\partial \theta_{k,1}}{\partial I_0}$ and $\frac{\partial \theta_p}{\partial I_1^p}$ are both positive, the signs of $\frac{\partial I_0}{\partial \theta_p}$ and $\frac{\partial I_1^p}{\partial \eta_1^p}$ are ambiguous. First, famine can have general equilibrium wage and relative price effects (Rosales, 2014). A fall in wage rates reduces the opportunity cost of time invested in child care, and conceivably lead to increase in time investments (Shah & Steinberg, 2013). By contrast, a rise in the relative price of food may have a negative real income effect and retard investments on children. Second, the income effect of a fall in agricultural outputs during famines may reduce investments in children for farm households. Moreover, parental remediation of adverse exposures can compensate for the effects of shock if parents invest more in the affected child or reinforce the effect if, rather, investments are directed to the unaffected child to maximize returns. These combine to generate an ambiguous dynamic complementarity effect.

The two middle terms in (8) constitute a mixed channel, which emanates from the intergenerational nature of the mechanism driving the effects of shocks. The second term measures the effect of a parent's childhood shock exposure on her child that is transmitted through the child's indirect investment channel. Though $\frac{\partial \theta_{k,1}}{\partial I_0} > 0$ and $\frac{\partial \theta_p}{\partial \eta_1^p} < 0$, the sign of $\frac{\partial I_0}{\partial \theta_p}$ is ambiguous leading to an ambiguous sign for this term. The third term captures the effect of parental shock exposure channeled through the child's indirect parental endowment channel. Its sign is, however, ambiguous since $\frac{\partial I_1^p}{\partial \eta_1^p}$ cannot be readily signed, leaving the mixed channel effect ambiguous. Therefore, the theoretical predictions of the impacts of early parental shocks on the human capital of children are not clear.

In this paper I use exogenous exposure to famine in Ethiopia in the early 1980s to identify the causal effects of parental early childhood shocks on their children's outcomes. I use rich panel data to estimate the *net* effects of the famine on cognitive and health outcomes of the children of parents who were exposed. The correspondence between a child's human capital and her outcomes can be thought to be defined by the function $h(.)$ (Ben-Porath, 1967), which translates human capital stock in a given period t into performance Y in the same period. Measured performance in time t for some dimension j is $Y_{t,j} = h(\theta_t)$. To identify mechanisms, I estimate the effects on parental cognitive, non-cognitive (socio-emotional) and health outcomes, are other parental inputs such as health, schooling, and food expenditure.

4 Data

I use information on mothers' age to recover their birth cohort during the 1983-1985 Ethiopian famine. I combine the birth cohort data with a plausibly exogenous geographic variation in the intensity and duration of drought condition during the famine to identify the causal impacts of maternal famine exposure on the human capital of children. The Ethiopia Young Lives (YL) data track children from early childhood through early adolescence over a 12 year period. In 2002, a baseline survey was conducted on a sample of 2,000 children born in 2001-2002 (6-18 months old) living in 20 sites across Addis Ababa, Amhara, Oromia, Southern Nations and Nationalities Region (SNNPR), and Tigray regions. Follow up surveys were conducted in 2006, 2009, and 2013.

The survey has child, household, and community modules. In the household module, data on household composition, parental background, assets, food and non-food consumption, expenditure, social capital, child care, child health and exposure to various shocks were collected. Caregiver perceptions, attitudes and aspirations for child and family were also covered. Data on time use of family members, child weight and height were also collected. The child module asks children about their attitudes to work and school, perception of how they were treated by others, as well as their hopes and aspirations for the future. Data on children's test scores (language comprehension and math) was been collected beginning in round 2. The community survey provides information on the economic, social, and environmental context of each community. It asks questions on access to various services (such as education, health, electricity, telephone etc.), population, religion, and ethnicity, language, political representation, crimes, environmental changes, and community networks. Table 2 presents a list of key variables and the survey round in which they were collected.

The household survey data are matched with weather (rainfall) data. The weather data are from NASA's AgMERRA[11] climate dataset, which provides daily time series over the 1980-2010 period (Elliott et al., 2014; A. Ruane & Goldberg, 2014; A. C. Ruane et al., 2015). The data are originally provided at 0.25 degree (≈25km×25km) resolution. These data are converted to *wereda* level rainfall data by applying weights based on the area size of the grid cell relative to the *wereda*, i.e., percentage of each *wereda*'s area occupied by the grid cell. All grid cells that fully fall within a *wereda* receive equal weights whereas intersected cells (grids that fall between two or more *wereda*s) receive smaller weight proportional to area size.

4.1 Measuring Famine Magnitude

The main cause of the famine was an extended drought that lasted several crop growing seasons. Thus, geographic and temporal variation in the drought condition is used as a proxy for the famine. I compute two measures of the magnitude of the famine: the deviation of average rainfall during the 1983-1985 famine period from historical average (*rdev*), and the number of months with rainfall shortage of half or higher standard deviation (*mdry*). While these measures are likely to be correlated, they measure different aspects of a famine condition. The first measures the intensity of famine (the extent of dryness), whereas the second measures duration of a dry spell. A famine can be deep (extremely dry weather condition) but of short duration, or vise versa. The nature of interventions called for by the two dimensions of famine may accordingly differ.

Both measures reflect the seasonality of agriculture in Ethiopia and the geographic variability of rainfall. The famine started in the *meher* season of 1983 and ended by the start of *meher* rains of 1985. Some of the *wereda*s covered in the Young Lives survey receive rainfall in both *meher* and *belg* seasons, while others get only *meher* rains. The famine measures are constructed to reflect these facts. Accordingly, the rainfall deviation measure captures

[11] AgMERRA stands for Agricultural Modern-Era Retrospective analysis for Research and Applications. The AgMERRA dataset provides daily, high-resolution meteorological time series by combining daily resolution data from retrospective analysis with ground level and remotely-sensed observational datasets for temperature, precipitation and solar radiation. It gives particular consideration to agricultural areas, and agronomic factors that affect plant growth such as mean growing season temperature and precipitation, seasonal cycles, inter-annual variability, the frequency and sequence of rainfall events, and the distribution of sub-seasonal extremes, leading to substantial reduction in bias (A. C. Ruane, Goldberg, & Chryssanthacopoulos, 2015).

wereda-specific total monthly rainfall deviations during the *meher* and/or *belg* seasons.

The rainfall deviation measure *rdev* is constructed as:

$$rdev_{m,w,y} = \sum_{Jun-Sep1983}^{Mar-May1985} -\frac{rain_{w,m,y} - \overline{rain}_{w,m}}{sdrain_{w,m}} \tag{9}$$

where $rain_{m,w,y}$ is monthly precipitation in *wereda* w in the month of m in year y in millimeters, ($\overline{rain}_{w,m}$) is historical (1980-2010) average of rainfall in *wereda* w for month m, and $sdrain_{w,m}$ is standard deviation of monthly rainfall in *wereda* w in month m over the same 1980-2010 period.[12] If a *wereda* receives rainfall in both *meher* and *belg* seasons, the deviation measure would cover *meher* 1983, *belg* 1984, *meher* 1984 and *belg* 1985. If, on the other hand, a *wereda* gets rainfall only during the *meher* season, the relevant measure would cover *meher* 1983 and *meher* 1984.

The famine measure in equation 9 captures the *wereda* level famine conditions for everyone in 1983-1985 irrespective of their age. The obvious candidate to capture the differential impacts due to exposure in early childhood is an interaction term between this *wereda*-specific measure and a dummy variable that takes value 1 if the famine took place during early years of childhood. The extent of famine exposure in early childhood, however, varies depending on when the mother was born within the famine period. Using mother's age, I construct an individual specific measure ("interaction term") that better reflects the extent of exposure. A mother born in 1981 would experience the famine at age 2 in 1983, a mother born in 1983 would experience the full famine —*in utero* in 1983, at age 1 in 1984 and age 2 in 1985, whereas a mother born in 1985 would experience the famine only *in utero* in 1985. This measure is essentially the sum of interactions of famine year specific negative rainfall deviation and mother's birth year dummies (see panel (a) of Table 1 for details).

Because *rdev* is defined as a negative deviation, increase in its magnitude can readily be interpreted as worsening of the famine condition. This is essential to maintain consistency in the definition of the famine measures used in this paper. While this intensity measure is a good proxy of the depth of the famine, it does not fully reflect its breadth. The number of months with significant rainfall shortages during the famine period, addresses this duration issue.

[12]To avoid the effect of the outlier famine years, the 1983-1985 period is excluded in computing mean and standard deviation.

The famine duration measure, *mdry*, measures the number of months of famine exposure during the *meher* and/or *belg* growing seasons of 1983-1985. In *meher* and *belg* growing areas, the measure includes famine months in *meher* 1983, *belg* 1984, *meher* 1984 and *belg* 1985. In *meher*-only growing areas, it includes *meher* 1983 and *meher* 1984. The number of famine months is calculated as:

$$\begin{aligned} mdev_{w,m,y} &= \frac{rain_{w,m,y} - \overline{rain}_{w,m}}{sdrain_{w,m}} \\ mdry_{w,y} &= \sum_{Jun-Sep1983}^{Mar-May1985} 1(mdev_{w,m,y} < -0.5) \end{aligned} \tag{10}$$

where $mdev_{w,m,y}$ is deviation of *wereda* w rainfall in the month of m and year y from historical average rainfall for the month measured in standard deviations. The famine measure $mdry_{w,y} \in [0, 14]$ is computed by summing up the dummy variables for each month of the relevant *wereda* specific famine period. The dummy variable for a given month m takes the value 1 if rainfall for the month was 0.5 or higher standard deviation below historical average for the month over the 1980-2010 period, excluding 1983-1985, or 0 otherwise. By adding over the maximum of 14 months of the famine, I obtain a measure of the local duration of the famine.[13]

Like *rdev* above, *mdev* varies between *wereda*s, but not between individuals within a *wereda*. It measures common *wereda* famine duration effects —the number of famine months experienced by everyone in a given *wereda*. The actual famine duration experienced by a mother, however, is likely to vary by the mother's birth year within the famine period. To capture the differential effect of maternal early childhood exposure during the famine, I exploit mothers' birth year and *wereda*-year specific famine months. As shown in panel (b) of Table 1, a mother born in 1981 would experience the famine at age 2 in 1983 for the four *meher* growing months between June and September. Depending on the severity of the monthly rainfall deficit, her famine exposure duration would be between 0 and 4. A mother born in 1983 would experience the full famine —*in utero* in 1983, at age 1 in 1984 and age 2 in 1985. The individual specific rainfall deviation would depend on whether the *wereda* gets rainfall in only *meher* or both *belg* and *meher* seasons, and the severity of the monthly rainfall deficit. If for example, she were from a *wereda* with two annual growing seasons and the *wereda*

[13]The maximum number of famine months varies depending on whether a *wereda* is *belg* growing or not. In *meher* and *belg* growing areas, the maximum number of famine months is 14, whereas is *meher*-only growing areas, it is 8 months.

suffered rainfall shortage of $\geq |0.5|$ standard deviations for three months in *meher* 1984 and two months in *belg* 1985, the mother's famine duration would be 5 months (see panel (b) of Table 1 for details).

Figure (2) about here

Despite receiving average annual rainfall of over 700 mm, Ethiopia is extremely vulnerable to weather shocks.[14] This is mainly due to the uneven geographic distribution of rainfall and its considerable variation over time. Agricultural households who depend on rainfall for their livelihood, and with little means for self-insurance, find it difficult to adapt to drought conditions, especially during consecutive drought years as in the mid 1980s, leading to catastrophic crises. As shown in Figure 2, the 1983-1985 Ethiopian famine was associated with annual precipitation falling below historical average for four years in a row. The drop in annual rainfall was especially high in 1984, with rainfall levels of less than 80% of historical average for the whole country.

Figure (3) about here

The geographic variation of rainfall is shown in Figure 3. Among the four largest regions of Ethiopia, Oromia and SNNPR receive the highest amount of precipitation, whereas Tigray receives the least amount. The average annual precipitation was lowest in 1984 in all four regions. Low rainfall, however, does not necessarily translate into worse outcomes to the extent endogenous adaptation of farming practices and livelihood diversification is possible as a response to historical experiences of rainfall shortages. But, volatility of rainfall in areas with low rainfall, thus, little leverage in terms of minimum water requirements for plant growth, has been a cause of recurrent disasters. The SNNPR also displays considerable rainfall volatility in the 1980-1990 period.[15]

Figure 4 presents the deviation of the average annual rainfall during 1983-1985 from the historical average. The intensity of the famine was greater in the northeastern, southern, and western parts of Ethiopia, which saw rainfall drop of up to 5 standard deviations, on average. The northwestern and central parts of the country were largely spared, with some

[14] The average rainfall for years between 1901 and 2012 is 736 mm, and for the period covered in this study (1980-2010) it stands at 711 mm per annum (World Bank, 2016b).

[15] Like Segele and Lamb (2005) and Webb and von Braun (1994), Appendix Figures A1 and A3, show that the year 1984 had the worst *meher* and *belg* rains. The month of August and April, during which *meher* and *belg* rains peak, respectively, had the worst rainfall in recent history (Appendix Figures A2 and A4).

areas recording higher than normal rainfall. The northern, southern and east-central parts of the country were already getting low rainfall before the famine. The sharp decline in rainfall during the famine in these areas, therefore, had significant effects on peoples' livelihoods. Crop production is the main sources of sustenance in most of Ethiopia. Crop failure due to insufficient rains can have severe lasting consequences. During the 1983-1985 period, repeat exposure of adverse rainfall events led to livelihood collapse in many parts of Ethiopia.[16]

Figure (4) about here

Figure 5 reports the number of months with over one standard deviation rainfall shortfall during the famine period. It shows that in most of Ethiopia, rainfall was below historical averages for at least 3 of months in the 1983-85 famine period. Particularly, western and southwestern parts of the country suffered rainfall shortage for up to 16 months. The dry spell (of $\geq |1|$ SD) had relatively short duration in the central and northern parts of the country. Note, however, that because the northern parts were already receiving low rainfall prior to the famine, the effect of an additional month of dry weather might be more damaging in the north than in the central and western Ethiopia.

Figure (5) about here

The Young Lives study sites are located in geographic areas with varying degrees of famine exposure during the 1983-1985 period (Figure 6). Two sites are located in severely affected *wereda*s and six sites are in highly but relatively less severely affected *wereda*s. Seven study sites are in *wereda*s with no considerable change in rainfall during the famine period, and the remaining fives sites are in *wereda*s with positive rainfall deviations. I exploit this significant variation in famine intensity and duration as an exogenous source of variation to identify the causal impacts of childhood famine exposure of mothers on human capital outcomes of their children.

Figure (6) about here

[16]This, along with other political reasons, prompted the government into the now infamous resettlement program which led to the death of tens of thousands of people (Gill, 2010).

4.2 Measuring Human Capital

In line with the multidimensional nature of human capital (Heckman, 2007), I use several measures of cognitive, non-cognitive, and health capabilities of children as outcome variables. The cognitive capability of children is measured by grade achievement (years of schooling completed) and standardized scholastic aptitude test scores. The Peabody Picture Vocabulary Test (PPVT) is used to measure the receptive vocabulary of children and standardized Math test is used to measure the analytical ability of children. The PPVT measures scholastic (cognitive) ability, not reading ability (Dunn & Dunn, 1981). The Ethiopia Young Lives PPVT test consists of 204 stimulus words of increasing difficulty and corresponding 204 image plates each containing four black-and-white images. The interviewer reads a stimulus word from a list, and respondents are asked to select one of the four pictures that best describes the word. The starting point (and the level of difficulty) of the test is determined based on the respondent's age.[17] The PPVT raw score is the total number of correct answers by the respondent. Like the PPVT, the Math test is structured in an increasing order of difficulty for different age groups. The raw math score is the total number of correct answers by the respondent.

Since the starting point of the tests and the corresponding level of difficulty varies by age of respondents, raw PPVT and Math scores are not readily comparable across children of different ages. Thus, they do not accurately measure cognitive ability. By accounting for item difficulty, Rasch (logit) transformation of the raw scores provides linearly comparable measures of cognitive ability. This paper uses Rasch PPVT and Math test scores.

Children's non-cognitive human capital is measured by educational aspiration, locus of control and self-esteem. Educational aspiration is children's stated desired level of schooling if they faced no constraints and could study for as long as they liked, measured at age 12. The locus of control and self-esteem measures are constructed from four-scale responses (0=strongly disagree, 1=disagree, 2=agree, and 3=strongly agree) to various questions on perceptions and attitudes.[18] They are computed as $\theta_{nc} = \frac{\sum_{j=1}^{n} S_j}{n}$, where θ_{nc} is non-cognitive human capital, S_j is the reported score on question j, and n is the total number of questions included in computing each measure. To make the non-cognitive human capital measures

[17] See Dunn and Dunn (1981) for details on how PPVT tests are administered.

[18] These scales apply to positively coded questions such as "If I try hard I can improve my situation in life." If a question is rather negatively coded (such as "My teachers treat me worse than other children"), the order of the scores is reversed.

comparable across survey rounds, only responses to questions asked consistently in all rounds are included (3 questions for locus of control and 6 for self-esteem). Health human capital is measured by conventional height-for-age z-score computed based on World Health Organization (WHO) growth charts.

The mechanisms of mother-to-child transmission of famine exposure impacts explored in this paper are child maternal skill endowment, measured by mothers' schooling (cognitive human capital), educational aspirations for child, locus of control and self-esteem (non-cognitive human capital) and height (health human capital) and parental investments. As described by the multidimensional human capital production function in section 3, a mother's early childhood famine exposure is expected to impact negatively her adult human capital and labor market outcomes. These being inputs in her child's human capital production, they may have adverse consequences for the child's human capital. The effect on mothers' labor market outcomes of the famine, if any, may lead to reduced parental investments in children, measured by real total expenditure, and real expenditures on schooling and health, all measured in per capita adult equivalent scale. The focus on maternal outcomes is due to previous findings that early childhood shocks affect the adult outcomes of girls more than that of boys, which suggests that maternal channels are likely to be the prime mechanisms of parent-to-child shocks transmission (Almond et al., 2010; Maccini & Yang, 2009; Meng & Qian, 2009).

4.3 Descriptive Statistics

Table 2 presents summary statistics for key variables used in the analysis sample. The sample covers the children of mothers born between 1978 and 1988, which encompasses mothers born in the first three years before the famine (1978-1980), mothers born during the famine (1981-1985) and those born in the three years after the famine (1986-1988). Data on most of the key variables were collected in all four rounds. Data on some variables (e.g. mother's height), however, are available only in some rounds. Columns 2-5 indicate the round(s) in which data on specific variables were collected.

About 42% of the sample households are from urban areas and 81% of households are male headed. The average household head is about 38 years old and has 4.7 years of schooling, while the YL child's mother is 28 years old, 159 cm tall and has 3.2 years of schooling. The average household size and number of children are 5.4 and 3, respectively. There are slightly more boys in the sample (53%). The average age of children is 78 months and the average child is about 109 cm tall. He/she is typically a second child.[19] The average height-for-age z-score is 1.4 standard deviations below WHO's reference distribution, which indicates the high rate of stunting prevalent in the data. Thirty percent of children are stunted (<-2 SD) of which 10% are severely stunted (<-3 SD).

The average PPVT and Math scores are 47 and 8.5, respectively. The average desired level of schooling (child's educational aspiration) by children is about 14 years, which is equivalent to a diploma post high school completion. The locus of control variable measures the degree to which one feels he/she has control over happenings in one's own life. A high locus of control score represents greater control. The self-esteem variable measures one's overall sense of self-worth. A high self-esteem score indicates greater sense of self-worth. In the sample, the average locus of control and self-esteem scores are 1.9 and 1.7, respectively, with considerable variation across children. Mother's locus of control and self-esteem are similarly measured. The average scores are higher and variance much lower for mothers than children. Her desired level of schooling (educational aspiration) for her child is about 15 years, which amounts to an undergraduate degree.

The average monthly real expenditure per adult equivalent is Birr 155, of which Birr 90 is spent on food items and rest on non-food items. The average expenditure (nominal) on education and health per household is Birr 41 and Birr 21, respectively. Some 22% of cases (25% of households in round 3 and 19% of households in round 4) participate in the Productive Safety Net Program (PSNP).[20]

5 Empirical Strategy

The empirical strategy employed is as follows. First, I estimate the effects of mothers' early childhood famine exposure on the cognitive, non-cognitive and health human capital of their children. Findings of negative impacts point to intergenerational of persistence early childhood conditions. Second, to identify parent-to-child famine transmission mechanisms, I

[19] In the baseline, the YL child is a first child. However, during the course of the panel (12 years) sample households had an additional child, on average.

[20] PSNP is a large nationwide program that provides assistance to food insecure households to mitigate the effects of transitory shocks, while also building resilience to shocks through sustainable community development. It consists of conditional transfers through public works in climate-resilience building activities and unconditional transfers to households lacking in able bodies to engage in public works.

estimate the effects of the famine on the cognitive, non-cognitive and health human capital of mothers who suffered the famine during their developmental plasticity period. Negative and statistically significant effects of the famine on mothers' human capital would suggest that children's maternal skill endowment is a key parent-to-child shock transmission channel. To establish this is indeed the case, I re-estimate the children human capital regressions above by including mother human capital outcomes as a regressors. If the child intergenerational famine effects become statistically insignificant with the introduction of the mother's human capital into the child human capital regressions, it confirms that the mother-to-child channel is the prime mechanism of intergenerational shock transmission.

Third, mothers' early childhood shock exposure may also affect child human capital outcomes by reducing the mothers' adult income, which limits the amount they can invest in their children as parents. I use total household expenditure and expenditures on education and health to estimate whether and the extent to which child investments are affected by maternal early childhood shocks. Unless the adulthood earnings of mothers who suffered the famine in early childhood are systematically altered by marriage market outcomes, household expenditures are expected to reflect early childhood experiences of mothers. In this case, parental child investments mediate the parent-to-child famine transmission.

Fourth, to investigate whether, conditional on famine intensity, the effect of maternal famine early childhood exposure on their children varies by famine duration and to identify critical famine duration thresholds, the child human capital regressions are re-estimated by including dummy variables for each level (month) of famine duration.

Finally, the life cycle effects of maternal early childhood famine exposure on their children's human capital are explored by estimating the child human capital regressions by interacting the birth year specific *wereda* famine duration measure with survey round dummy. The estimates on this interaction term indicate whether the effect of the famine decays over the child's life cycle or not.

The famine event took place prior to survey data collection. The famine measures, thus, do not vary over the survey rounds, which precludes the application of standard fixed effects models to account for time invariant factors that are potentially correlated with regressors. To circumvent this constraint that is imposed by the nature of the data, I employ alternative estimators. The baseline model uses the standard pooled OLS method. This fails to take into account the temporal correlation of observations due to the panel nature of the data.

This is addressed using the random effects model. The random effects model, however, relies on the strong assumption that fixed effects are uncorrelated with regressors. To deal with the potential bias due to correlation between regressors and error terms containing time invariant child, parent and *wereda* fixed effects, among others, I turn to Mundlak's fixed effects approach (Mundlak, 1978) and the Hausman-Taylor random effects estimator (Hausman & Taylor, 1981).

5.1 Child Outcomes

To estimate the impacts of mothers' exposure to the 1983-1985 famine on the human capital outcomes of their children, I estimate:

$$\theta^k_{iwvt} = \beta_0+\beta_1 rdev_w+\beta_2 mom\_rdev_{iwt}+\beta_3 mdry_w+\beta_4 mom\_mdry_{iwt}+\mathbf{\Gamma}'\mathbf{X}_{iwv}+\pi+\lambda_w+\tau_v+\varepsilon_{iwvt} \tag{11}$$

where $\theta^k_{i,w,v,t}$ is the human capital outcome $k \in \{c, n, h\}$ of child i in wereda w, survey round v and mother birth year t within the famine cohort. A mother is considered to be in the "famine cohort" if she suffered the famine *in utero* or/and in the first three years of life after birth —born 1981-1985. The famine intensity measure $rdev_{w,t}$ is the total monthly rainfall deviation during *meher* and/or *belg* seasons in 1983-1985 from historical monthly averages, in SD. Higher $rdev$ represents exposure to more severe famine. It varies between *wereda*s but not between children within each *wereda*. The variable mom_rdev is the total rainfall deviation experienced by a mother during her early childhood period in *meher* and/or *belg* seasons in 1983-1985. It is similar in construction to an interaction term between $rdev$ and the famine cohort dummy π (=1 if born 1983-1985), but it is a more precise measure as it reflects the birth year of the mother during the famine.

Likewise, $mdry$ is the total number of months during *meher* and/or *belg* seasons of the famine years with rainfall half or greater SD below the historical monthly average in a *wereda*. It varies across *wereda*s, but is constant within each *wereda*. Higher $mdry$ means longer famine duration in a *wereda*. Mom_mdry is the number of months a mother was exposed to rainfall deviation of half or greater SD below the historical monthly average *in utero* or/and her first three years of life. It varies across children depending on mother's birth year, and *wereda* of residence. Its construction is similar to an interaction term between $mdry$ and π, but since it reflects mother's birth year, it offers a more precise birth year-specific measure of early childhood famine exposure duration.

$\mathbf{X}_{i,w,v}$ is a vector of child, parent and household characteristics. It includes household size, household head age, gender and schooling, wealth, income, shocks, child age, gender, age order, number of siblings, language, ethnicity, religion, and urban-rural dummy.[21] The *wereda* fixed effect, λ_w, controls for time invariant characteristics that are common to all children in the same village. In empirical estimation, however, I include region controls rather than *wereda* controls as standard errors are cluster bootstrapped at the *wereda* level (see discussion below). The survey round fixed effect τ_v controls for factors that are common to children surveyed in a given round. π is a famine cohort fixed effect and captures common shocks to all children born to parents of the famine cohort, and $\varepsilon_{i,w,v,t}$ is a random error term.

β_1 measures the average *wereda* level effect of a 1 standard deviation increase in famine intensity that is common to all children whose mothers were alive during the famine. Similarly, β_3 measures the average *wereda* level effect of an additional month of famine that is common to all children whose mothers were alive during the 1983-1985 famine. Both β_1 and β_3 are expected to be negative.

The primary coefficients of interest are β_2 and β_4, which measure the *net* differential effects of maternal famine exposure during the early periods of childhood on the human capital outcomes of children and are given as

$$\beta_j = \frac{\partial \theta_{k,1}}{\partial \eta^p_{1,j}}, \qquad j = 2, 4 \tag{12}$$

in equation (8), where $j \in (mom\_rdev, mom\_mdry)$ stands for the famine measure used. The coefficient on mom_rdev, β_2, measures the average effect of an increase in negative rainfall deviation; it is expected to be negative. A negative β_2 indicates that higher shortfall in rainfall during the mothers' early childhood of is associated with worse human capital outcomes for their children. The coefficient on mom_mdry, β_4, measures the average effect on child outcomes of an additional month of maternal famine exposure in early childhood; it too is expected to be negative.[22] To address the potential spatial correlation of famine due

[21]The wealth and shocks measures are composite indices constructed from a series of asset and shock indicators, respectively. Wealth index is a simple average of housing quality, consumer durables and access to services, which are all simple indices (mean) of component indicator dummies. The shock index is a simple average of crime, regulations, economic, environmental and family shocks, each of which being a composite measure of indicator dummies of components.

[22]Too much rainfall is not desirable for agricultural production. As a robustness check we include a quadratic famine severity term, which is be expected to have a negative coefficient, to test if excluding it

to the covariate nature of weather conditions, standard errors are clustered at the *wereda* level. To deal with the small number of clusters (*weredas*) problem in the data, I use the wild cluster bootstrap approach suggested by Cameron, Gelbach, and Miller (2008).

Previous studies have shown that the intergenerational effects of famine are not the same for males and females. Children born to mothers who experienced the famine *in utero* are likely to suffer more than those born to famine-affected fathers (Almond et al., 2010; Meng & Qian, 2009; Chen & Zhou, 2007). Moreover, data on fathers are missing for several key variables for a significant number of children. Thus, the intergenerational effects of parental shock exposure on child outcomes are estimated using maternal experiences of the famine.

The key identifying assumption required for consistent estimation of the causal effects of parents' early life famine exposure on the later life outcomes of their children is independence between measures of famine exposure ($rdev$ and $mdry$) and the error term, after controlling for *wereda*, survey round, and cohort fixed effects, and various child, parent and household characteristics. As long as there were no systematic differences in the growth rates of cognitive, non-cognitive, and health capabilities between villages affected more severely by the 1983-1985 famine and those that were less affected, the parameter estimates β_2 and β_4 are consistent.

5.2 Mechanisms

To identify the mechanisms through which maternal early childhood famine exposure affects the human capital of children, I investigate 1) the impact on child maternal endowment —mother's cognitive (years of schooling), non-cognitive (aspirations for child schooling, locus of control and self-esteem) and health human capital (height); 2) parental child investments measured by total expenditure and expenditures on schooling and health. Mothers' human capital serves as an input in child human capital production. Shocks experienced by the mother in early childhood may be transmitted to her child by reducing the parental skill endowment available to the child for skill production. The first set of mechanisms capture this effect. Maternal early childhood shocks may also affect child human capital outcomes by reducing parent's child investments. These, if any, will be reflected in the second set of mechanisms.

causes upward bias on β_2.

5.2.1 Mother Human Capital

I identify the effects of the famine on maternal skill endowment of the child by estimating the equation

$$\theta^{p,k}_{iwvt} = \alpha_0 + \alpha_1 rdev_w + \alpha_2 mom\_rdev_{iwt} + \alpha_3 mdry_w + \alpha_4 mom\_mdry_{iwt} + \mathbf{\Psi'X}_{iwv} + \phi + \delta_w + \kappa_v + \epsilon_{iwvt} \tag{13}$$

where $\theta^{p,k}_{iwvt}$ is mother i's human capital k ($k \in \{c, n, h\}$) in *wereda* w, survey round v and birth year t. The rest of the variables are as defined before. α_1 measures *wereda* level common effects of famine intensity, i.e., the average effect of an increase in negative monthly rainfall deviation in a *wereda* on maternal adult human capital outcomes. Similarly, α_3 measures common *wereda* effects of an increase in famine duration on maternal adult human capital outcomes. ϕ is famine cohort dummy taking value 1 if a mother is born during the famine, and δ_w, and κ_v, capture *wereda*, and survey round fixed effects.[23]

The average common *wereda* level effects of a 1 standard deviation increase in the intensity of the famine and a 1 month increase in the duration of the famine on the human capital outcomes of mothers who were alive during the famine are given by α_1 and α_3, respectively. Both coefficients are expected to be negative.

The key parameters of interest are α_2 and α_4. α_2 measures the effects of a 1 standard deviation increase in negative monthly rainfall deviation suffered by the mother in early childhood during the famine on her adult human capital outcomes after controlling for common *wereda* effects. Likewise, α_4 captures the average effects of an additional month of mother's early childhood famine exposure on her adult human capital outcomes.

The differential effects of mother's early childhood famine exposure captured by α_2 and α_4 are given in equation 7 as:

$$\alpha_j = \frac{\partial \theta_p}{\partial \eta^p_{1,j}}, \qquad j = 2, 4 \tag{14}$$

where $j \in (mom\_rdev, mom\_mdry)$ stands for the famine measure used.

[23]Standard errors are wild cluster bootstrapped at the *wereda* level. As a result, in empirical estimation, the *wereda* fixed effects are replaced by region fixed effects.

5.2.2 Parent Investments

The effects of the famine on parents' child investments are estimated in a similar fashion as

$$Y_{iwvt} = \sigma_0 + \sigma_1 rdev_w + \sigma_2 mom\_rdev_{iwt} + \sigma_3 mdry_w + \sigma_4 mom\_mdry_{iwt} + \mathbf{\Omega}'\mathbf{X}_{iwv} + \mu + \varphi_w + \rho_v + e_{iwvt} \tag{15}$$

where, Y^m_{iwvt}, $m \in$(total expenditure, education expenditure, health expenditure) is child i's household expenditure m in *wereda* w, survey round v for mother's born in year t of the famine period. μ, φ_w and ρ_v are mother famine cohort dummy (=1 if mother was born in 1983-1985), *wereda* fixed effects and survey round fixed effects, respectively.[24]

σ_1 and σ_3 measure the average common *wereda* level effects of a 1 standard deviation increase in famine intensity and a 1 month increase in famine duration suffered by mothers who were alive during the famine, respectively. The differential average effects of maternal exposure in early childhood on parental child investments are given by σ_2 and σ_4. σ_2 measures the effects of a 1 standard deviation increase in negative rainfall deviation experienced by the mother as a child on child investments. Similarly, σ_4 measures the effects of an additional month of maternal famine exposure in early childhood on parental child investments. Both σ_2 and σ_4 are expected to be negative.

5.3 Heterogeneous Effects

The effects of maternal early childhood shocks on child human capital outcomes may be non-linear in the sense that famine exposures of certain duration are more harmful than others. If this is so, identifying critical ranges of maternal early childhood famine duration is essential for targeting vulnerable groups. To this end, the child human capital regressions are estimates as

$$\theta^k_{iwvt} = \tilde{\beta}_0 + \tilde{\beta}_1 rdev_w + \tilde{\beta}_2 mom\_rdev_{iwt} + \tilde{\beta}_3 mdry_w + \sum_{g=1}^{7} \tilde{\beta}_{4g} D_{igwt} + \tilde{\mathbf{\Gamma}}'\mathbf{X}_{iwv} + \tilde{\pi} + \tilde{\lambda}_w + \tilde{\tau}_v + \tilde{\varepsilon}_{iwvt} \tag{16}$$

where, $D_g = \mathbf{1}\{mom\_mdry = g\}$, $g \in \{1, ..., 7\}$ is a dummy variable taking value 1 if the mother suffered famine duration of g months in early childhood, and 0 otherwise. The

[24] *Wereda* fixed effects are replaced by region fixed effects in empirical estimation as standard errors are wild cluster bootstrapped at the *wereda* level.

number of months of mothers' early childhood famine exposure during the growing seasons of 1983-1985 ranges between 0 and 7. The cohort with no famine exposure, D_0, is the reference group and omitted in the regression. The rest of the variables are as defined before.

The coefficients $\tilde{\beta}_{4g}$ measure the effects of maternal early childhood exposure of famine duration of g months on the human capital outcomes of children. These coefficient estimates are expected to vary non-linearly as the duration of famine exposure changes. The patterns of famine effects measured by $\tilde{\beta}_{4g}$ will be essential for efficient delivery of interventions aiming at minimizing the likelihood of irreversible shock effects. If, for example, the effect of maternal early childhood famine exposure on child outcomes steadily rises for famine durations represented by D_1 through D_g, but accelerates past durations of $g+1$ months, preventing girls' childhood famine exposure duration of $g+1$ or higher is crucial.

$$\theta^k_{iwvt} = \hat{\beta}_0 + \hat{\beta}_1 rdev_w + \hat{\beta}_2 mom\_rdev_{iwt} + \hat{\beta}_3 mdry_w + \hat{\beta}_{4v} mom\_mdry_{iwt} \times \tau_v + \hat{\mathbf{\Gamma}}'\mathbf{X}_{iwv} + \pi + \hat{\lambda}_w + \hat{\tau}_v + \hat{\varepsilon}_{iwvt} \tag{17}$$

The coefficients on the interaction term $mom_m dry \times \tau_v$, $\hat{\beta}_{4v}$ where $v \in \{1, ..., 4\}$, measure the effects of mothers' early childhood famine exposure on the human capital outcomes of their children at various stages in the life cycle. $\hat{\beta_{41}}$ measures the effect of the famine when the children were 6-18 months old, and $\hat{\beta_{44}}$ reflects the effect of the famine on children at age 12. The estimates provide evidence on the malleability (or lack of) of the different skill types over time to intergenerational shocks.

6 Results

6.1 Child Outcomes

This section presents estimates of the intergenerational effects of mother's early childhood exposure to the 1983-1985 Ethiopian famine on three dimensions of children's human capital: health, cognitive and non-cognitive (socio-emotional).

Table 3 presents regression results for children's health capability as measured by height-for-age z-score (zhfa). The choice of zhfa as a measure of child health is due to the established literature showing that height-for-age is a good summary measure of childhood nutrition and environmental factors (Guven & Lee, 2013; Case & Paxson, 2008a, 2008b). Estimates from pooled OLS (POLS), random effects (RE), Mundlak's pseudo fixed effects (MFE) and Hausman-Taylor random effects (HT) estimators are presented. In all models, controls for household characteristics including household size, household head age, gender and schooling, wealth, income (expenditure), shocks, and urban-rural dummy; child characteristics including age, gender, birth order, number of siblings, language, ethnicity and religion; mother birth cohort dummy (=1 if famine cohort) and survey round dummy variables are included. Standard errors are wild cluster bootstrapped at the *wereda* level.

Column (1) shows POLS regression results. Both the intensity of the famine experienced by the mother in early childhood and the number of months of famine exposure during the mother's developmental plasticity are statistically significant at the 1% significance level. These findings show that maternal exposure to severe shocks during the critical developmental period leaves lasting adverse health impacts on her children. The estimated coefficients indicate that a one standard deviation increase in famine intensity reduces child zhfa by 0.08, while an extra month of famine exposure reduces child zhfa by about 0.04. To put this in context, at the average negative rainfall deviation of 0.25 standard deviations and 1.1 months of famine duration, the effect of the famine on child zhfa is about 0.07 (approximately 5%) decrease in zhfa. As expected, the *wereda* level famine intensity measure shows that the children of mothers who were alive during the famine have lower zhfa. Yet, the effect is not statistically significant. Similarly, the common *wereda* level famine duration is statistically insignificant. Once the common *wereda* level, and mother birth year-specific famine intensity and duration measures are controlled for, whether a mother was born during the 1983-1985 famine period or not appears to have no discernible impact on children's health human capital. The consistency of the these estimates depends on the strong assumption of independence of observations, which is unlikely to hold in a panel data setting.

Column (2) presents RE estimates of the same model. The mother birth year-specific famine intensity and duration estimates are comparable to the POLS estimates. The famine intensity measure is statistically significant while the duration measure is not. As in the POLS model, the common *wereda* famine intensity and duration effects as well as mother famine cohort dummy are statistically insignificant. RE estimates are, however, inconsistent if the individual effects in the error term are correlated with regressors. The coefficient estimates will be biased if, for example, mothers' location of birth, which is associated with the intensity of famine she is exposed to, is correlated with grandparents' economic status. That is, if the mother's place of birth was pre-determined by grandparents location choice in which poor households self-select into disease (e.g. malaria) vulnerable or food insecure areas, omitting these location specific factors in the regression will bias the estimated effects of the famine on child zhfa.

Columns (3) and (4) report results from MFE and HT estimators, both of which address the limitations of the RE results above. The MFE addresses the potential bias resulting from correlation between regressors and the error term by controlling for the averages of time varying variables in the regression (Mundlak, 1978), whereas the HT estimator employs step-wise generalized least squares (Hausman & Taylor, 1981). The coefficient of mother birth year-specific famine intensity is negative and statistically significant under both estimators. The mother birth year-specific famine duration has a negative but statistically insignificant coefficient in the MFE model. The effect sizes are comparable to the of POLS and RE estimates. The stability of the coefficients across estimators gives confidence as to the reliability of the estimates of the effects of early childhood maternal famine exposure on children's health capability. The common *wereda* famine intensity and duration effects, and mother famine cohort dummy are statistically insignificant under both estimators.

Table 4 shows the effects of maternal early childhood famine exposure on the cognitive capabilities of her children —child schooling. Column (1) reports POLS results. RE, MFE and HT results are reported in columns (2)-(4). Both the intensity of the famine mothers suffered in early childhood and the duration of the famine have the expected signs (the only exception is famine intensity in MFE). The coefficients of famine intensity are negative, but statistically insignificant. Maternal famine exposure duration has a negative and statistically significant effect on children grade achievement in all models. The POLS results show that an additional month of maternal early childhood famine exposure reduces child schooling by about 0.04 grades. At the average duration of 1.1 months, this translates to about 0.05 less child years of schooling. The estimated effects are comparable across the various estimators.

The common *wereda* level famine intensity and duration measures have positive and statistically significant coefficients in the MFE and HT models. The results are inconsistent with the hypothesized impacts of famine intensity and duration. These seemingly puzzling results may partly be explained by a range of post-famine emergency development activities. The coefficient of mother famine cohort dummy is negative in all models suggesting that children of mothers born during the famine have less schooling. Yet, the effects are statistically insignificant.[25]

Table 5 provides estimates of the effects of maternal early childhood famine exposure on children's non-cognitive human capital. Column (1) reports results for children's educational aspirations using OLS. The estimated coefficients on maternal early childhood famine intensity and duration as well as *wereda* famine intensity and duration have the expected negative sign. All of the estimates, however, are statistically insignificant. Columns (2)-(5) present estimates of the effects of maternal famine exposure on children's locus of control. The duration of maternal early childhood famine exposure has negative and statistically significant effect on locus of control, whereas the coefficients on famine intensity are statistically indistinguishable from zero. These findings suggest that forward looking attitude of children is more shaped by experiences of long episodes of adverse events than short but deep shock events to parents in their early childhood.These results are consistent with the theory of learned helplessness, in which mothers' early experiences of adverse shocks leads to increased probability of interpreting events as beyond one's control (Chorpita & Barlow, 1998). Mothers' diminished locus of control could then be passed on to their children (Morton, 1997). Columns (6)-(9) report the effects of early childhood maternal shocks on child self esteem. The results show that the famine had no statistically significant effect on children's self esteem.

The results presented in Tables 3-5 show that mother's early childhood exposure to the 1983-1985 Ethiopian famine has had a lasting negative impact on children's health, cognitive and non-cognitive human capital. The results also show that the duration of mother's early childhood famine exposure matters more to child human capital outcomes than famine intensity. This is understandable in the context of the study area. In many parts of Ethiopia the pre-famine conditions were such that rural households were already food insecure for parts of the year. In these settings, exposure to extended period of famine chips away at any chance of recovery from early disadvantages during the narrow critical developmental period, absent outside relief aid or assistance through informal social networks. The results are robust to model specification and estimation strategy, which gives credence to the estimated effects.

[25] Maternal early childhood famine exposure does not appear to have statistically significant effect on child test scores (see Table A1). The estimates from POLS, RE, MFE and HT models of the intergenerational effects of the famine using on child PPVT and Math test scores show no discernible impact.

6.2 Mechanisms

6.2.1 Maternal Human Capital Outcomes

Table 6 presents estimates of the effects of the 1983-1985 famine on the health and cognitive human capital outcomes of mothers who suffered the famine in early childhood. Column (1) reports OLS estimates of maternal health (as measured by mothers' adult height) impacts. Both the intensity of famine experienced in early childhood and its duration have statistically significant effect on mothers' adult height. A one standard deviation increase in famine intensity reduces mothers' height by about 0.6 centimeters, while an extra month of famine exposure leads to 0.25 centimeters decrease in height. These results indicate that at the mean famine intensity and duration, mothers who experienced the famine in early childhood are about 0.43 centimeters shorter than those that experienced it later. The maternal height effect found in this paper is much less than that reported by Dercon and Porter (2014), who use self-reported binary drought measure to identify the effect of the famine on the height of survivors of the famine.[26] The *wereda* level famine intensity and duration effects are positive but statistically insignificant, whereas the famine dummy has the expected sign but is statistically insignificant.

Columns (2)-(5) report the effects of the famine on mothers' schooling using POLS, RE, MFE and HT estimators. The POLS estimates of maternal early childhood famine intensity and duration measures as well as the *wereda* famine intensity and duration measure have the expected negative sign. Increase in the intensity of famine suffered before age three by one standard deviation leads to a 0.44 grades drop in mothers' schooling. Early childhood famine exposure duration and *wereda* famine intensity and duration are statistically insignificant. Mothers in the famine cohort have less schooling compared to their non-famine counterparts. Despite the generally low level of schooling in the sample (2.8 years), disruptions caused by the famine have left irreparable impact on mothers' schooling. The RE, MFE and HT model results in column (3)-(5) show comparable early childhood famine intensity impacts on mothers' schooling.

Estimates of the effects of early childhood famine exposure on the non-cognitive human

[26] Dercon and Porter (2014) report that people who suffered the famine between the age of 12-36 months are 5.3 centimeters shorter than the reference group. This is an estimate of "average treatment effect on treated", and not "average treatment effect". The corresponding figure in this paper is about 1.1 centimeters, which is still less than the Dercon and Porter (2014) estimates.

capital of mothers are given in Table 7. Columns (1)-(4) report locus of control results, whereas columns (5)-(8) report self-esteem results. The locus of control regression results show that the *wereda* level famine intensity and duration effects are negative and statistically significant, which indicates that mothers who were alive during the famine in more severely affected areas report lower locus of control as adults. There is, however, no especial effect due to exposure in early childhood (as opposed to later in life). These effects are fairly consistent across the four estimators. The coefficient of famine cohort dummy is negative, but statistically insignificant. The self-esteem regressions, on the other hand, produce no statistically significant causal relationship between maternal shock exposure and adult self-esteem under POLS, RE and MFE. The *wereda* level HT results are slightly inconsistent with expectations in that they are positive and statistically significant.[27]

To ascertain that mothers' adult human capital is indeed the main parent-to-child shock transmission channel, the effects on child human capital in Table 3 are re-estimated after partialling out the direct famine effects on mothers' human capital. To that end, I include mothers' health, cognitive and non-cognitive human capital in the child human capital regressions. Table 8 reports the new POLS estimates. The negative effects of maternal early childhood shocks on child zhfa reported in Table 3 become much smaller and statistically insignificant once mothers' human capital outcomes are controlled for. The coefficients on mothers' health (adult height) and schooling are positive and statistically significant. This points to maternal human capital, especially maternal health, being the prime parent-to-child health shock transmission pathway.

The results for the other human capital dimensions, however, rather suggest that maternal human capital does not play significant role in the intergenerational transmission of shocks to cognitive and non-cognitive human capital. The estimates in Tables 4 and 5 change little due to the inclusion of maternal human capital in the child human capital regressions.[28] These results seem to suggest the main intergenerational transmission channels of the effects of the famine on child cognitive and non-cognitive outcomes are perhaps parental child investments. The next section explores these potential channels.

[27] Regression results of the effects of maternal early childhood famine exposure on mothers' educational aspirations for their children produced no statistically significant impacts. The use of alternative estimators makes no discernible difference to the estimated impacts. These results are given in Table A2.

[28] The coefficient on *wereda* level famine duration measure becomes significant when mothers' human capital is included in the child regressions. This is perhaps due to better improvement in access to schooling facilities in more severely affected areas in the post-famine years.

In terms of policy, the implication is that prevention of early childhood shock exposure of girls needs to be given the utmost attention to minimize lasting intergenerational impacts. A large body of evidence lends support to interventions of this nature. This is due childhood zhfa (height) being a good predictor of not only adult health but also of cognitive, non-cognitive and labor market outcomes (Maluccio et al., 2009; Maccini & Yang, 2009; Hoddinott, Maluccio, Behrman, Flores, & Martorell, 2008; Case & Paxson, 2008a; Alderman et al., 2006). The targeting of girls for early intervention, however, poses an ethical dilemma about gender fairness. Practical implementation may call for a balancing act between efficiency and fairness.

6.2.2 Parental Investments

Tables 9-10 present the effects of maternal early childhood famine exposure on parental child investments. Table 9 reports the results of household expenditure regressions using alternative estimators. The results show that the 1983-1985 famine had no statistically discernible impact on the household expenditure of mothers who were affected as young girls. This may be because mothers are not the main income earners in the majority of households in the data. In 86% of households, males are household heads and tend to be the main breadwinners of the family.

The effects of maternal early famine exposure on education and health expenditures are reported in Table 10. The results are similar to the total expenditure regressions above. Maternal early childhood famine exposure has no statistically significant effect on the amount of money households spend on education and health. The common *wereda* level famine intensity and duration measures are positive and weakly statistically significant in the health regressions using HT model, however. These results suggest that parental investments are unlikely to be key parent-to-child famine transmission channel.

6.3 Heterogeneous Effects

While exposure to extended famine periods is expected to be more damaging, it is not obvious whether increase in famine duration leads to increasing or decreasing effects on child human capital outcomes, at the margin. Critical shifts in famine effect regimes, if any, provide crucial inputs in the design of efficient interventions. To this effect, each additional month of maternal early childhood famine exposure is allowed to have a unique effect. Results for health, cognitive and non-cognitive human capital of children using POLS are reported in Table 11.[29]

The estimates in column (1) show that the effects of maternal early childhood famine exposure on children's height-for-age z-score depends non-linearly on the duration of exposure. Famine impacts are generally increasing in famine duration. The effects of the famine become worse for famine durations of four months and higher. Similar results are obtained for child schooling. As shown in column (2), the maternal early childhood famine exposure effects increase with the length of famine duration. The estimated coefficients jump at famine duration of four months. To test the statistical significance of the difference in coefficient size between famine durations less than four months and four months and higher, I re-estimate the model by including a dummy variable that takes value 1 for famine duration of four months and higher. The results confirm that the differences the coefficients are indeed statistically significant (-0.193(**) for height-for-age z-score and -.289(***) for child schooling).[30] The effects on test scores (PPVT and Math) and non-cognitive human capital are, however, statistically insignificant. These results point to a critical maternal famine exposure threshold of about three months, beyond which the effects of the famine become severe.

Table 12 reports the life cycle effects of maternal early childhood famine exposure on the human capital outcomes of children using POLS.[31] Column (1) reports results for height-for-age z-score. Height-for-age is measured in the data from age one through age 12 in about three year intervals. The results show that the effects of maternal childhood shocks are greater (and statistically significant) in early childhood (age one) and early adolescence (age 12). While the effect is negative throughout, it is statistically insignificant at ages five and eight. The estimated effect size drops off after year one, but gradually rises though age 12. These findings suggest that the effect of early intergenerational disadvantages on health does not decay but worsen over the child's life cycle, which points to the likely ineffectiveness of remediation efforts in late childhood.

The evolution of the effects of the famine on children's schooling displays a similar pattern. However, data on child schooling were collected only in rounds 3 and 4 as the Young Lives

[29]Estimates from RE, MFE and HT models are given in Table A3 in the Appendix. The findings are consistent with POLS estimates.

[30]These results can be obtained upon request.

[31]See Table A4 in the Appendix for RE, MFE and HT model estimates.

children were too young to enroll in school in rounds 1 and 2. The results shown in column (2) indicate that the famine effect worsens over time. The life cycle effects on test scores are statistically insignificant, however. In the locus of control and self-esteem regressions, on the other hand, the famine effect is statistically significant at age eight.

The results presented thus far point to the limited malleability of health and cognitive (grade completed) human capital thorough late remediation once the damage has been done to mothers in early childhood. This effect is especially greater for children born to mothers who were exposed to the famine as young girls for over three months. This has a crucial policy implication to the timing and targeting of interventions. To maximize the impacts of interventions in communities that are vulnerable to severe shocks, emphasis should be placed on reaching young girls before they are exposed to shocks of three months or longer.

7 Conclusion

This paper investigates the intergenerational effects of maternal early childhood famine exposure on the human capital outcomes of children. The 1983-1985 Ethiopian famine is used as an exogenous source of variation to identify the effects of exposure to severe shocks during developmental plasticity on the health, cognitive and non-cognitive human capital of children whose mothers suffered the famine as young girls. There is paucity of empirical work in this area. This is one of the first papers to look at the intergenerational effects of severe shocks (Caruso & Miller, 2015; Tan et al., 2014). The paper seeks to determine potential parent-to-child shocks transmission channels. In particular, it determines whether the effects of a mother's famine exposure on the human capital of her offspring decays over time. It also identifies critical famine duration thresholds.

I find that maternal early childhood famine exposure has a negative effect on children's health (height-for-age z-score), cognitive (number of years of schooling) and non-cognitive (locus of control) human capital. At the sample average famine intensity and duration, the 1983-1985 famine led to a 5% decrease in height-for-age z-score and a 0.05 grades decrease in the number of years of schooling of children born to mothers affected by the famine *in utero* and/ or before age three. The main parent-to-child shock transmission channel is found to be children's maternal human capital endowment. Mothers who were exposed to the famine early in childhood are about 0.4 centimeters shorter. This estimate is much less than that obtained by Dercon and Porter (2014) for Ethiopia. The effect on mothers' schooling is a decrease of about 0.5 grades. The paternal shock transmission channel, however, is found to be insignificant.

The effect of the famine on children's height-for-age z-score and schooling depends non-linearly on maternal famine exposure duration. While the adverse impacts of the famine worsen with increase in famine duration, it sharply rises after three months of famine. This suggests existence of a critical maternal famine duration threshold at about three months of famine exposure. The effects of the famine on height-for-age z-score and schooling persist through children's life cycle from age one through early adolescence (age 12). In fact, the negative effect sizes become greater over time. This seems to suggest remediation may not be effective in mitigating the impacts of maternal early childhood famine exposure on child human capital.

The findings of the paper point to a few policy implications. First, shocks experienced early in childhood have impacts that last through generations. To minimize the adverse effects of shocks, health and nutritional interventions to children in the developmental plasticity is crucial. Since the effects of the famine are primarily channeled through maternal outcomes (Caruso and Miller (2015); Tan et al. (2014) find similar results), girls should be targeted for intervention during natural disasters. This is further reinforced by the persistence of the effects of shocks through children's life cycle. Second, to achieve maximum impact, the focus should be on girls under three years old with the highest likelihood of crossing the critical famine duration threshold of three months. That is, primacy should be given to girls who have suffered two or three months of severe shock in the delivery of assistance.

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Figures

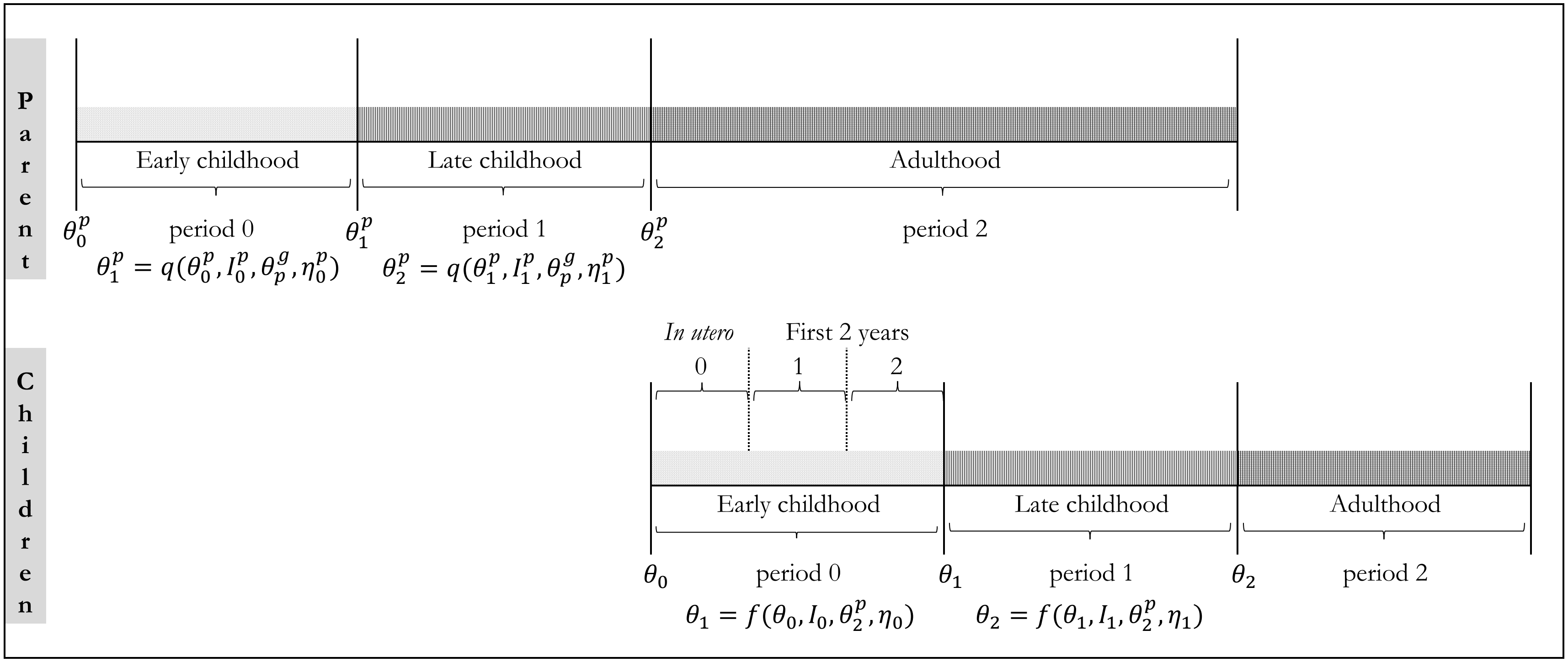

Figure 1: Intergenerational evolution of human capital

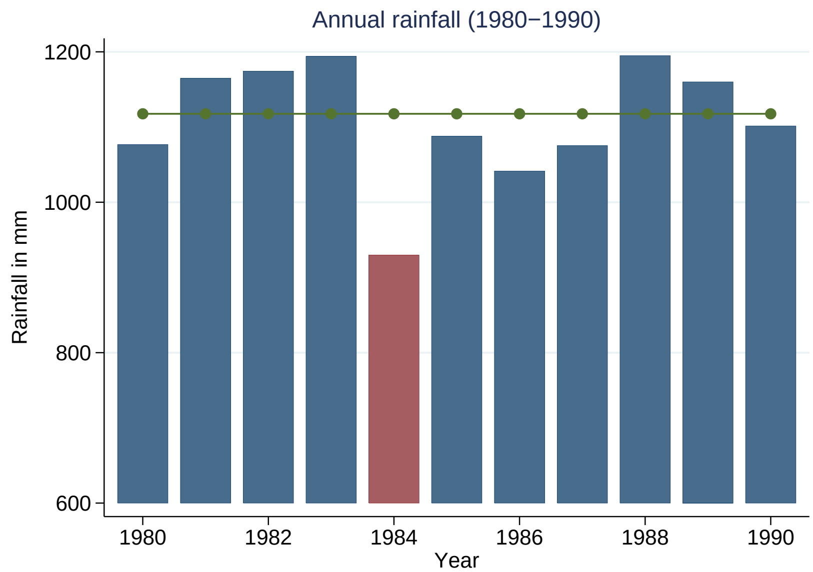

Figure 2: Patterns of annual rainfall in 1980-1990
The bars measure the annual rainfall for each year. For clarity, the bar for 1984 is colored in red. The green horizontal line over the bars shows the historical average rainfall for the 1981-2010 period.

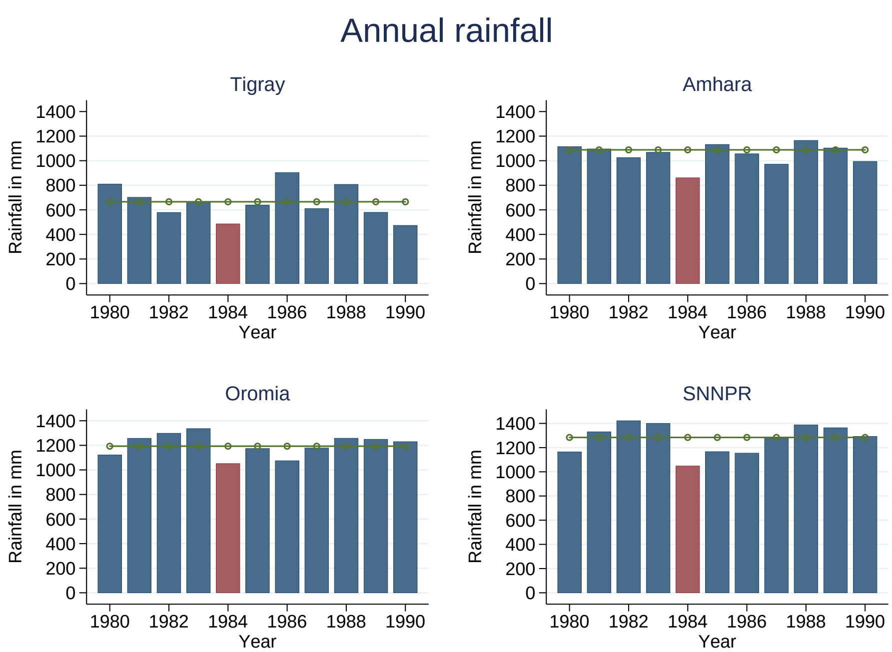

Figure 3: Patterns of annual rainfall in 1980-1990 by Region
The bars measure annual rainfall for each year. For clarity, the bar for 1984 is colored in red. The green horizontal line over the bars shows the historical average rainfall for the 1981-2010 period.

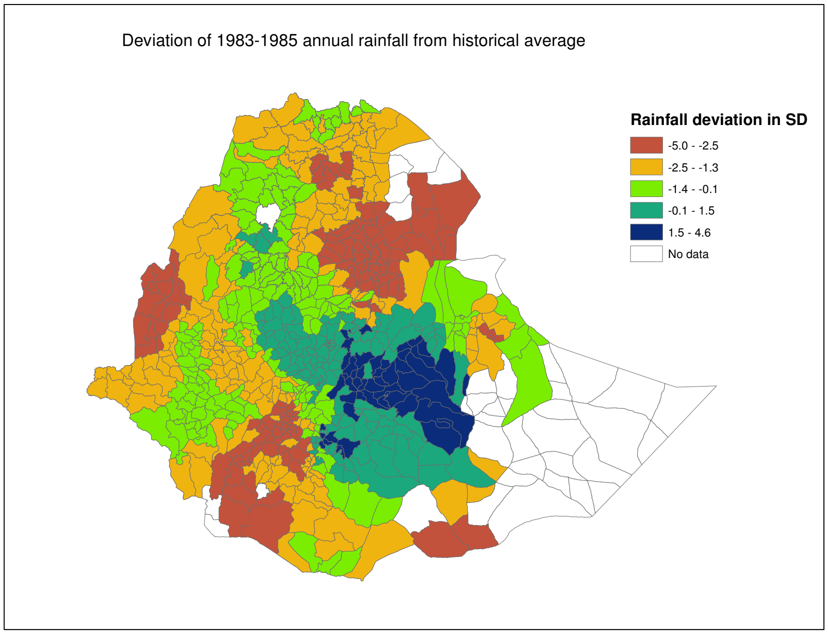

Figure 4: Deviation of annual 1983-1985 annual rainfall from historical averages in SD

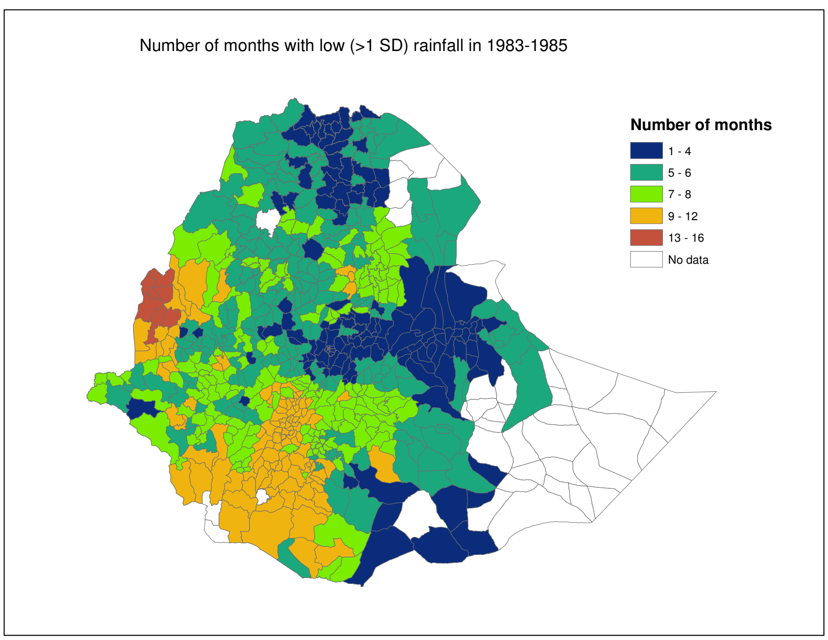

Figure 5: Number of months with low rainfall (< -1 SD) in 1983-1985

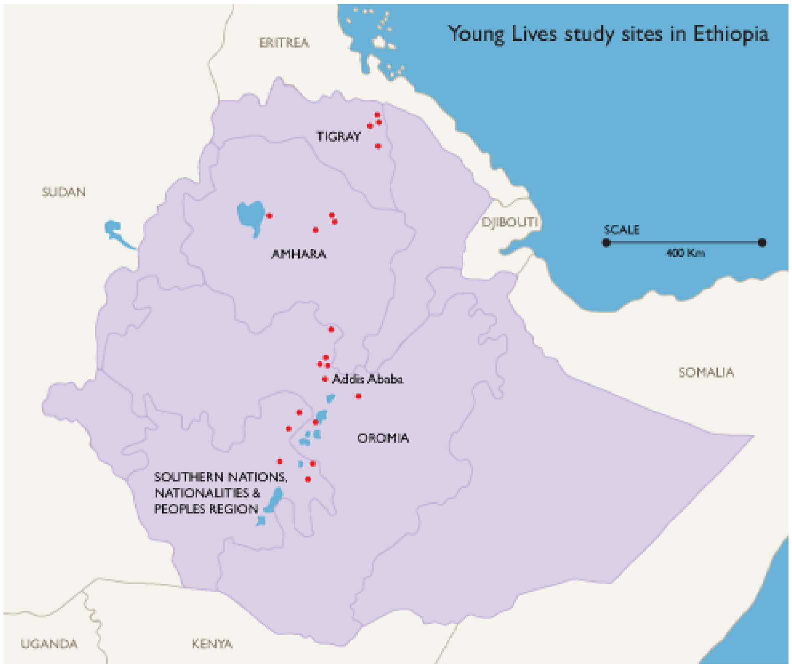

Figure 6: Young Lives study sites
This figure shows the distribution of Young Lives study sentinels (sites) across Tigray, Amahara, Oromia, SNNPR regions and Addis Ababa. *Source: Young Lives.*

Tables

Table 1: Individual specific famine measure

Birth year	Age at baseline (2002)	*in utero*	Famine exposure	Famine measure
			a) Famine intensity	
1980	23	1980	None	0
1981	22	1981	1983 (age 2)	$\sum_{Jun-Sep1983} -\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}}$
1982	21	1982	1983 (age 1) and 1984 (age 2)	$\sum_{Jun-Sep1983}^{Jun-Sep1984} -\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}}$
1983	20	1983	1983 (age 0 - *in utero*), 1984 (age 1) and 1985 (age 2)	$\sum_{Jun-Sep1983}^{Mar-May1985} -\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}}$
1984	19	1984	1984 (age 0 - *in utero*) and 1985 (age 1)	$\sum_{Jun-Sep1984}^{Mar-May1985} -\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}}$
1985	18	1985	1985 (age 0 - *in utero*)	$\sum_{Mar-May1985} -\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}}$
1986	17	1986	None	0
			b) Famine duration	
1980	23	1980	None	0
1981	22	1981	1983 (age 2)	$\sum_{Jun-Sep1983} 1(\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}} < -0.5)$
1982	21	1982	1983 (age 1) and 1984 (age 2)	$\sum_{Jun-Sep1983}^{Jun-Sep1984} 1(\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}} < -0.5)$
1983	20	1983	1983 (age 0 - *in utero*), 1984 (age 1) and 1985 (age 2)	$\sum_{Jun-Sep1983}^{Mar-May1985} 1(\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}} < -0.5)$
1984	19	1984	1984 (age 0 - *in utero*) and 1985 (age 1)	$\sum_{Jun-Sep1984}^{Mar-May1985} 1(\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}} < -0.5)$
1985	18	1985	1985 (age 0 - *in utero*)	$\sum_{Mar-May1985} 1(\frac{rain_{w,m,y}-\overline{rain}_{w,m}}{sdrain_{w,m}} < -0.5)$
1986	17	1986	None	0

Table 2: Summary statistics

Variables	Survey round 1	2	3	4	Obs.	Mean	Sd	Min	Max
Child outcomes									
Height-for-age z-score	✓	✓	✓	✓	3459	-1.36	1.26	-4.98	4.92
Child height (cm)	✓	✓	✓	✓	3494	108.89	26.50	55.30	178.00
Child stunted (<-2 SD)	✓	✓	✓	✓	3493	0.30	0.46	0.00	1.00
Child severely stunted (<-3 SD)	✓	✓	✓	✓	3493	0.10	0.30	0.00	1.00
Child schooling (year)			✓	✓	1559	2.29	1.96	0.00	8.00
PPVT score (raw)		✓	✓	✓	2472	46.88	37.33	0.00	196.00
Math score (raw)				✓	1602	8.51	6.14	0.00	28.00
Child education aspiration (year)				✓	851	13.88	2.53	0.00	17.00
Child locus of control		✓	✓	✓	2606	1.94	1.49	0.00	4.00
Child self esteem		✓	✓	✓	2606	1.67	1.30	0.00	4.00
Mother outcomes									
Mother height(cm)		✓			804	158.78	5.81	133.35	178.20
Mother schooling (year)	✓	✓	✓	✓	3187	3.22	4.02	0.00	16.00
Mother's education aspiration for child (year)		✓	✓	✓	2583	15.32	2.44	0.00	18.00
Mother locus of control		✓	✓	✓	2606	2.35	0.91	0.25	4.00
Mother self esteem		✓	✓	✓	2606	2.69	0.65	0.22	4.00
Child and household characteristics									
Child gender (male=1)	✓	✓	✓	✓	3523	0.53	0.50	0.00	1.00
Child age (months)	✓	✓	✓	✓	3523	78.29	49.12	6.02	154.00
Child age order	✓	✓	✓	✓	3523	1.87	1.12	1.00	9.00
Child number of siblings	✓	✓	✓	✓	3523	3.02	1.71	1.00	11.00
Household head age	✓	✓	✓	✓	3521	38.13	11.03	5.00	110.00
Household head gender (male=1)	✓	✓	✓	✓	3522	0.81	0.39	0.00	1.00
Household head schooling (year)	✓	✓	✓	✓	3522	4.70	4.56	0.00	25.00
Household size	✓	✓	✓	✓	3523	5.39	1.83	2.00	15.00
Mother age	✓	✓	✓	✓	3523	28.07	5.02	18.00	47.00
Father age	✓	✓	✓	✓	2989	36.60	7.31	19.00	86.00
Father schooling (year)	✓	✓	✓	✓	2680	5.04	4.40	0.00	18.00
Other controls									
Urban-rural dummy (urban=1)	✓	✓	✓	✓	3523	0.42	0.49	0.00	1.00
Shock index	✓	✓	✓	✓	3523	0.11	0.11	0.00	0.68
Wealth index		✓	✓	✓	3523	0.31	0.18	0.01	0.90
Food expenditure per month (Birr)		✓	✓	✓	3484	96.92	57.50	8.38	744.66
Non-food expenditure per month (Birr)		✓	✓	✓	3484	73.84	130.56	0.26	4,325.19
Total expenditure per month (Birr)		✓	✓	✓	3484	168.07	153.27	9.70	4,280.61
Education expenditure per year (Birr)		✓	✓	✓	3484	493.45	1,456.56	0.00	35,558.00
Health expenditure per year (Birr)		✓	✓	✓	3484	249.40	2,801.31	0.00	144,000.00
Drought measures (external data)									
Negative rainfall deviation (SD)					3523	0.25	1.41	-2.63	2.07
Negative rainfall deviation in early childhood (SD)					3523	0.07	0.89	-2.63	2.07
Mother's # months of famine					3364	3.87	2.00	1.00	7.00
Mother's # months of famine in early childhood					3514	1.10	1.89	0.00	7.00

Note: Check marks in columns 2-5 indicate whether data on a variable in column 1 were collected in survey rounds 1-4. Food, non-food and total expenditure are measured in real 2006 Birr per capita. Education and health expenditures are measured in nominal Birr. The drought measures are limited to growing seasons (as opposed to full year) specific to *weredas*. In *belg* and *meher* growing *weredas*, the drought measures reflect the condition for the two seasons. For *meher*-only growing areas, it covers the *meher* season only.

Table 3: Effects of maternal famine exposure on child health

	(1)	(2)	(3)	(4)
Dependent variable: zhfa	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	-0.015	-0.011	-0.011	0.005
	(0.067)	(0.099)	(0.089)	(0.062)
Rain shortage × famine cohort	-0.083***	-0.087**	-0.080**	-0.096*
	(0.032)	(0.043)	(0.040)	(0.053)
Famine months (#)	0.043	0.041	0.039	0.057
	(0.043)	(0.094)	(0.072)	(0.038)
Famine months × famine cohort	-0.040***	-0.042	-0.038	-0.047*
	(0.015)	(0.028)	(0.029)	(0.024)
Famine cohort (famine=1)	0.047	0.017	0.043	0.025
	(0.060)	(0.084)	(0.082)	(0.087)
Household size	0.019	0.008	-0.000	0.012
	(0.021)	(0.022)	(0.024)	(0.015)
Age of household head	0.000	-0.002	-0.005	-0.003
	(0.002)	(0.002)	(0.003)	(0.003)
Gender of household head (male=1)	0.033	0.118**	0.123**	0.169**
	(0.061)	(0.049)	(0.057)	(0.072)
Household head schooling	0.005	-0.003	-0.010	-0.018
	(0.007)	(0.008)	(0.009)	(0.011)
Urban/rural (urban=1)	-0.257**	-0.148	-0.366	-0.013
	(0.111)	(0.239)	(0.235)	(0.111)
Shock index	-0.150	-0.128	-0.101	-0.110
	(0.236)	(0.167)	(0.200)	(0.237)
Wealth index	1.092***	0.714***	0.251	0.337
	(0.215)	(0.244)	(0.295)	(0.218)
Gender of child (male=1)	-0.211***	-0.223***	-0.231***	-0.206***
	(0.045)	(0.056)	(0.061)	(0.064)
Age of child (months)	-0.030***	-0.026***	-0.026**	-0.022***
	(0.008)	(0.010)	(0.012)	(0.008)
Child birth order	-0.052*	-0.034	-0.016	-0.032*
	(0.028)	(0.021)	(0.016)	(0.018)
Number of siblings of child	-0.011	-0.032	-0.058	-0.037*
	(0.022)	(0.020)	(0.038)	(0.022)
Ethnicity	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes
Observations	3,259	3,259	3,259	3,259
R-squared	0.110	0.108	0.118	
Number of children	838	838	838	838

Cluster bootstrap standard errors in parentheses in (1)-(3) and bootstrap standard errors in (4):
*** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present results using Mundlak (1978) estimator and Hausman-Taylor (1981) estimator, respectively. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 4: Effects of maternal famine exposure on child schooling

	(1)	(2)	(3)	(4)
Dependent variable: child grade	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	0.187	0.213	0.197*	0.275***
	(0.188)	(0.135)	(0.115)	(0.081)
Rain shortage × famine cohort	-0.020	-0.023	0.000	-0.037
	(0.039)	(0.038)	(0.031)	(0.061)
Famine months (#)	0.270*	0.287*	0.249*	0.345***
	(0.157)	(0.156)	(0.136)	(0.055)
Famine months × famine cohort	-0.042**	-0.043***	-0.046***	-0.051*
	(0.017)	(0.013)	(0.013)	(0.027)
Famine cohort (famine=1)	-0.038	-0.032	-0.030	-0.009
	(0.052)	(0.050)	(0.054)	(0.106)
Household size	0.008	0.006	0.002	0.004
	(0.028)	(0.024)	(0.036)	(0.029)
Age of household head	-0.001	-0.001	-0.003	-0.002
	(0.003)	(0.003)	(0.007)	(0.005)
Gender of household head (male=1)	0.293***	0.281***	0.284***	0.263**
	(0.084)	(0.101)	(0.097)	(0.116)
Household head schooling	0.038***	0.038***	0.029***	0.028
	(0.008)	(0.006)	(0.007)	(0.028)
Urban/rural (urban=1)	0.082	0.133	-0.097	0.304*
	(0.317)	(0.452)	(0.409)	(0.181)
Shock index	0.333	0.800*	1.298**	2.078***
	(0.601)	(0.439)	(0.518)	(0.516)
Wealth index	1.037***	1.015***	-0.008	0.836*
	(0.282)	(0.268)	(0.504)	(0.451)
Gender of child (male=1)	-0.169**	-0.174**	-0.179**	-0.165**
	(0.075)	(0.070)	(0.080)	(0.068)
Age of child (months)	0.055***	0.053***	0.031	0.076***
	(0.010)	(0.009)	(0.026)	(0.022)
Child birth order	0.027	0.021	0.005	0.013
	(0.021)	(0.016)	(0.024)	(0.033)
Number of siblings of child	-0.103***	-0.108***	-0.148***	-0.112***
	(0.031)	(0.034)	(0.057)	(0.038)
Ethnicity	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes
Observations	1,501	1,501	1,501	1,501
R-squared	0.679	0.678		
Number of children	829	829	829	829

Cluster bootstrap standard errors in (1)-(3) and bootstrap standard errors in (4) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present results using Mundlak (1978) estimator and Hausman-Taylor (1981) estimator, respectively. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 5: Effects of maternal famine exposure on child non-cognitive human capital

	aspirations	locus of control				self esteem			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dep. var.: education aspirations, locus of control & self esteem	OLS	POLS	RE	Mundlak	Hausman-Taylor	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	0.012	0.015	0.015	0.019	0.016	0.013	0.014	0.016	0.014
	(0.299)	(0.038)	(0.033)	(0.030)	(0.022)	(0.047)	(0.043)	(0.048)	(0.021)
Rain shortage × famine cohort	-0.138	0.002	0.002	0.003	0.001	0.016	0.016	0.016	0.017
	(0.120)	(0.015)	(0.010)	(0.011)	(0.017)	(0.014)	(0.011)	(0.011)	(0.017)
Famine months (#)	-0.263	0.006	0.005	0.010	0.008	-0.024	-0.022	-0.021	-0.024*
	(0.306)	(0.026)	(0.040)	(0.034)	(0.016)	(0.035)	(0.035)	(0.041)	(0.014)
Famine months × famine cohort	-0.043	-0.013**	-0.013**	-0.012**	-0.014*	-0.008	-0.008	-0.008	-0.008
	(0.051)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.007)	(0.006)	(0.008)
Famine cohort (famine=1)	0.143	0.047	0.047**	0.037*	0.050	0.032	0.033	0.030	0.037
	(0.223)	(0.031)	(0.022)	(0.021)	(0.032)	(0.030)	(0.029)	(0.031)	(0.031)
Household size	0.073	-0.010	-0.010	-0.004	-0.006	-0.009	-0.009	-0.015	-0.008
	(0.058)	(0.010)	(0.008)	(0.013)	(0.009)	(0.009)	(0.007)	(0.015)	(0.010)
Age of household head	-0.011**	0.002	0.002	0.001	0.001	0.0004	0.000	0.002	0.001
	(0.006)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Gender of household head (male=1)	0.345*	0.027	0.027	0.029	0.042	0.064***	0.064***	0.061***	0.060*
	(0.185)	(0.030)	(0.023)	(0.026)	(0.039)	(0.025)	(0.024)	(0.023)	(0.034)
Household head schooling	-0.037**	-0.001	-0.001	-0.003	-0.002	0.001	0.001	-0.001	0.007
	(0.017)	(0.004)	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.003)	(0.006)
Urban/rural (urban=1)	0.874*	-0.033	-0.033	-0.078	0.019	0.084	0.081	0.041	0.104**
	(0.454)	(0.059)	(0.108)	(0.099)	(0.050)	(0.073)	(0.076)	(0.087)	(0.052)
Shock index	-1.343	-0.162	-0.163	-0.166	-0.167	-0.256	-0.252*	-0.235	-0.308
	(1.852)	(0.222)	(0.183)	(0.187)	(0.180)	(0.231)	(0.135)	(0.163)	(0.194)
Wealth index	1.769***	0.072	0.073	-0.222	-0.156	0.372***	0.369***	0.059	0.157
	(0.686)	(0.117)	(0.110)	(0.153)	(0.138)	(0.115)	(0.131)	(0.133)	(0.138)
Gender of child (male=1)	-0.024	-0.031	-0.031	-0.031	-0.030	-0.042*	-0.040***	-0.041***	-0.042**
	(0.142)	(0.026)	(0.020)	(0.023)	(0.021)	(0.022)	(0.015)	(0.016)	(0.019)
Age of child (months)	0.062***	-0.001	-0.001	0.006**	0.000	0.002	0.002	0.006*	0.002
	(0.022)	(0.003)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.003)	(0.005)
Child birth order	-0.022	0.000	0.000	0.001	0.001	0.013	0.013	0.011	0.013
	(0.062)	(0.013)	(0.012)	(0.016)	(0.013)	(0.014)	(0.013)	(0.014)	(0.014)
Number of siblings of child	0.018	0.015	0.015*	0.049**	0.014	-0.004	-0.004	0.001	-0.003
	(0.096)	(0.013)	(0.009)	(0.021)	(0.012)	(0.012)	(0.009)	(0.022)	(0.013)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	813	2,484	2,484	2,484	2,484	2,484	2,484	2,484	2,484
R-squared	0.164	0.879	0.880	0.880		0.862	0.861	0.863	
Number of children	813	838	838	838	838	838	838	838	838

Cluster bootstrap standard errors in (1)-(4), (6)-(8) and bootstrap standard errors in (5) & (8) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. PPVT is a short-form for Peabody Picture Vocabulary Test. Columns (3) and (7) present results using Mundlak (1978) estimator, while columns (4) and (8) presents results of the Hausman-Taylor (1981) estimator. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 6: Effects of maternal famine exposure on maternal health and schooling

	Health	Schooling			
	(1)	(2)	(3)	(4)	(5)
Dep. var.: mother height & schooling	OLS	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	0.391	-0.187	0.026	-0.032	0.078
	(3.565)	(0.129)	(0.314)	(0.196)	(0.171)
Rain shortage × famine cohort	-0.614***	-0.437***	-0.512***	-0.451***	-0.537***
	(0.168)	(0.080)	(0.133)	(0.127)	(0.163)
Famine months (#)	0.639	-0.003	-0.041	-0.033	-0.045
	(7.048)	(0.099)	(0.406)	(0.309)	(0.106)
Famine months × famine cohort	-0.230*	-0.028	-0.068	-0.012	-0.069
	(0.122)	(0.043)	(0.074)	(0.072)	(0.095)
Famine cohort (famine=1)	-0.094	-0.677***	-0.350	-0.810***	-0.316
	(0.517)	(0.180)	(0.233)	(0.270)	(0.320)
Household size	-0.130	-0.116***	-0.030	-0.029	-0.031*
	(0.098)	(0.044)	(0.020)	(0.020)	(0.016)
Age of mother	0.019	-0.099***	-0.037*	-0.028	-0.033*
	(0.117)	(0.030)	(0.021)	(0.018)	(0.018)
Gender of household head (male=1)	-0.738*	0.109	-0.007	-0.024	-0.003
	(0.434)	(0.162)	(0.052)	(0.052)	(0.073)
Urban/rural (urban=1)	-0.033	1.295***	3.510***	0.319	3.766***
	(9.958)	(0.447)	(1.003)	(0.859)	(0.439)
Shock index	3.663	0.755	0.363***	0.389**	0.376**
	(3.249)	(0.652)	(0.133)	(0.156)	(0.187)
Wealth index	2.924	8.940***	0.917***	0.423***	0.453**
	(1.945)	(0.702)	(0.208)	(0.158)	(0.219)
Ethnicity	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes
Observations	766	2,995	2,995	2,995	2,995
R-squared	0.078	0.473	0.408	0.523	
Number of mothers	766	835	835	835	835

Cluster bootstrap standard errors in (1)-(4) and bootstrap standard errors in (5) in parentheses: Yes
*** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present results using Mundlak (1978) estimator and Hausman-Taylor (1981) estimator, respectively. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 7: Effects of famine exposure on mother's non-cognitive human capital

	locus of control				self-esteem			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.: mothers' locus of control & self esteem	POLS	RE	Mundlak	Hausman-Taylor	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	-0.083*	-0.083***	-0.075***	-0.093***	0.037	0.038	0.036	0.043*
	(0.043)	(0.025)	(0.025)	(0.027)	(0.037)	(0.038)	(0.042)	(0.024)
Rain shortage × famine cohort	0.015	0.015	0.012	0.017	-0.008	-0.009	-0.006	-0.010
	(0.019)	(0.021)	(0.022)	(0.023)	(0.021)	(0.012)	(0.013)	(0.017)
Famine months (#)	-0.056*	-0.056***	-0.047***	-0.061***	0.035	0.036	0.031	0.042***
	(0.033)	(0.017)	(0.017)	(0.019)	(0.030)	(0.035)	(0.050)	(0.014)
Famine months × famine cohort	-0.005	-0.005	-0.003	-0.004	-0.007	-0.007	-0.008	-0.008
	(0.011)	(0.010)	(0.010)	(0.011)	(0.006)	(0.008)	(0.009)	(0.008)
Famine cohort (famine=1)	-0.019	-0.019	-0.025	-0.045	0.040	0.041	0.043	0.047
	(0.051)	(0.047)	(0.047)	(0.060)	(0.034)	(0.028)	(0.028)	(0.043)
Household size	0.037***	0.037***	0.029*	0.042***	0.016*	0.017**	0.026**	0.022**
	(0.011)	(0.011)	(0.016)	(0.013)	(0.009)	(0.007)	(0.013)	(0.009)
Age of mother	-0.001	-0.001	-0.003	-0.004	-0.000	-0.000	0.000	0.001
	(0.007)	(0.007)	(0.007)	(0.010)	(0.006)	(0.005)	(0.005)	(0.007)
Age of household head	-0.006***	-0.006***	-0.009***	-0.007***	-0.002*	-0.002**	-0.002	-0.003**
	(0.002)	(0.001)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Gender of household head (male=1)	0.124***	0.124***	0.136***	0.163***	0.183***	0.183***	0.181***	0.206***
	(0.042)	(0.037)	(0.038)	(0.049)	(0.033)	(0.025)	(0.028)	(0.041)
Household head schooling	0.009**	0.009**	0.008**	0.000	0.004	0.004*	0.002	-0.001
	(0.004)	(0.004)	(0.004)	(0.008)	(0.002)	(0.002)	(0.002)	(0.006)
Urban/rural (urban=1)	-0.074	-0.074	-0.084	-0.023	-0.123	-0.122	-0.156	-0.065
	(0.095)	(0.051)	(0.054)	(0.070)	(0.080)	(0.107)	(0.123)	(0.057)
Shock index	-0.315	-0.314*	-0.485**	-0.494**	-0.324	-0.315***	-0.189	-0.180
	(0.305)	(0.188)	(0.209)	(0.228)	(0.201)	(0.114)	(0.136)	(0.171)
Wealth index	0.185	0.185	-0.005	0.112	0.540***	0.536***	0.325**	0.375**
	(0.125)	(0.120)	(0.201)	(0.198)	(0.110)	(0.092)	(0.152)	(0.148)
Household expenditure (real)	0.00002	0.00002	-0.00002	-0.00002	0.00005***	0.00005**	0.00003	0.00003*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Number of children	-0.012	-0.012	-0.031	-0.018	-0.002	-0.002	-0.009	-0.006
	(0.013)	(0.013)	(0.030)	(0.016)	(0.010)	(0.009)	(0.027)	(0.014)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,484	2,484	2,484	2,484	2,484	2,484	2,484	2,484
R-squared	0.501	0.500	0.504		0.426	0.426	0.429	
Number of mothers	838	838	838	838	838	838	838	838

Cluster bootstrap standard errors in (1)-(3) and bootstrap standard errors in (4) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present results using Mundlak (1978) estimator and Hausman-Taylor (1981) estimator, respectively. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 8: Effects of maternal famine exposure on child human capital after controlling for direct mother human capital effects

	(1) Zhfa	(2) Years of Schooling	(3) PPVT	(4) Math	(5) Educational aspirations	(6) Locus of control	(7) Self-esteem
Rain shortage (SD)	-0.023	0.255	1.432	-0.026	0.164	0.015	0.003
	(0.079)	(0.192)	(2.971)	(0.480)	(0.260)	(0.039)	(0.045)
Rain shortage × famine cohort	-0.036	-0.033	-1.334	0.042	-0.108	0.006	0.010
	(0.032)	(0.043)	(0.954)	(0.277)	(0.119)	(0.016)	(0.015)
Famine months (#)	0.044	0.352**	0.770	-0.190	-0.111	0.016	-0.025
	(0.046)	(0.158)	(1.975)	(0.424)	(0.312)	(0.027)	(0.034)
Famine months × famine cohort	-0.018	-0.049**	0.223	0.039	0.025	-0.023***	-0.016*
	(0.016)	(0.020)	(0.524)	(0.126)	(0.077)	(0.008)	(0.009)
Famine cohort (famine=1)	0.051	-0.040	-2.440	-0.366	-0.067	0.100***	0.050
	(0.061)	(0.070)	(1.822)	(0.416)	(0.250)	(0.033)	(0.033)
Household size	0.002	0.026	-0.006	0.150	0.131*	-0.005	-0.007
	(0.019)	(0.035)	(0.418)	(0.116)	(0.076)	(0.011)	(0.009)
Age of household head age	0.002	-0.004	0.069	0.015	0.002	0.000	-0.001
	(0.003)	(0.004)	(0.068)	(0.020)	(0.007)	(0.001)	(0.001)
Gender of household head (male=1)	0.003	0.280***	-0.059	0.526	-0.039	0.049	0.073**
	(0.054)	(0.089)	(1.141)	(0.346)	(0.212)	(0.031)	(0.032)
Household head schooling	-0.000	0.035***	0.478**	0.186***	-0.028	-0.003	-0.001
	(0.006)	(0.008)	(0.212)	(0.041)	(0.024)	(0.004)	(0.003)
Urban/rural (urban=1)	-0.319**	-0.081	3.722	3.161***	0.732	-0.004	0.124
	(0.126)	(0.273)	(4.108)	(0.900)	(0.539)	(0.075)	(0.080)
Shock index	-0.305	0.499	-23.600**	-2.975**	-0.186	-0.142	-0.237
	(0.284)	(0.593)	(11.390)	(1.430)	(1.370)	(0.214)	(0.213)
Wealth index	0.665***	1.186***	14.040**	4.891***	1.751**	0.039	0.161
	(0.214)	(0.335)	(6.712)	(1.151)	(0.825)	(0.131)	(0.118)
Household expenditure (real)	0.000	0.000	0.000	0.000	-0.000*	-0.000***	-0.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Gender of child (male=1)	-0.160***	-0.174**	-1.093	0.042	0.031	-0.038	-0.044*
	(0.041)	(0.080)	(0.925)	(0.237)	(0.149)	(0.028)	(0.022)
Age of child (months)	-0.011*	0.064***	1.191***	0.188***	0.048**	0.001	0.003
	(0.007)	(0.009)	(0.215)	(0.032)	(0.024)	(0.003)	(0.002)
Child birth order	-0.036	0.021	-1.413**	-0.261*	-0.030	0.002	0.014
	(0.025)	(0.020)	(0.590)	(0.137)	(0.064)	(0.014)	(0.013)
Number of siblings of child	0.002	-0.126***	-0.435	-0.231	-0.011	0.019	-0.007
	(0.022)	(0.032)	(0.548)	(0.147)	(0.094)	(0.013)	(0.012)
Mother height (cm)	0.040***	-0.002	0.005	-0.008	-0.027	0.000	-0.002
	(0.004)	(0.006)	(0.089)	(0.020)	(0.019)	(0.002)	(0.001)
Mother schooling	0.016**	-0.007	0.326	0.068	0.003	0.005	0.002
	(0.008)	(0.009)	(0.209)	(0.047)	(0.029)	(0.004)	(0.004)
Mother's child schooling aspiration	-0.012	0.063***	0.688**	0.180***	0.273***	0.000	-0.000
	(0.010)	(0.024)	(0.268)	(0.065)	(0.036)	(0.008)	(0.005)
Mother locus of control	0.042	0.053	2.119**	0.554***	0.335**	0.026	-0.009
	(0.035)	(0.056)	(1.065)	(0.209)	(0.158)	(0.028)	(0.019)
Mother self-esteem	0.004	-0.127**	2.744**	-0.187	0.268**	0.075**	0.216***
	(0.041)	(0.064)	(1.186)	(0.253)	(0.122)	(0.035)	(0.032)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,085	1,225	2,013	1,260	645	2,090	2,090
R-squared	0.169	0.699	0.594	0.507	0.238	0.890	0.875

Cluster bootstrap standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: This table presents pooled OLS estimates of the effects of maternal famine exposure on child human capital outcomes after direct maternal human capital effects are controlled for. "Rain shortage" and "Famine months" are total negative monthly rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. Ethnicity, religion, region and survey round are all vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 9: Effects of maternal famine exposure on household expenditure

Dependent variable: real expenditure	(1) POLS	(2) RE	(3) Mundlak	(4) Hausman-Taylor
Rain shortage (SD)	27.002	45.278	38.683	126.842
	(69.804)	(388.766)	(426.076)	(143.395)
Rain shortage × famine cohort	7.448	5.502	10.875	6.246
	(28.382)	(36.237)	(39.477)	(77.606)
Famine months (#)	7.736	12.773	-0.853	14.993
	(36.612)	(232.486)	(250.203)	(118.103)
Famine months × famine cohort	3.808	5.121	4.084	13.161
	(8.824)	(11.419)	(10.516)	(35.035)
Famine cohort (famine=1)	13.917	3.572	12.876	-50.645
	(36.446)	(46.311)	(48.369)	(140.578)
Household size	113.177***	103.321***	79.836***	83.488***
	(15.187)	(18.657)	(17.167)	(18.782)
Age of household head	3.357	4.321	6.499	6.227
	(2.316)	(3.206)	(5.894)	(5.749)
Gender of household head (male=1)	86.449*	115.270*	108.056*	166.509***
	(48.646)	(63.884)	(63.019)	(57.446)
Household head schooling	39.100***	39.666***	33.141*	41.038*
	(6.870)	(10.315)	(20.080)	(22.115)
Urban/rural (urban=1)	427.142***	452.334	423.727	573.010
	(110.720)	(342.440)	(364.689)	(434.739)
Shock index	-277.371	-71.435	114.352	272.732**
	(227.579)	(207.091)	(203.111)	(132.515)
Ethnicity	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes
Observations	2,484	2,484	2,484	2,484
R-squared	0.208	0.206	0.212	
Number of children	838	838	838	838

Cluster bootstrap standard errors in (1)-(3) and bootstrap standard errors in (4) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table 10 presents the effects of maternal famine exposure on real total expenditure. "Rain shortage" and "Famine months" are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present Mundlak (1978) pseudo fixed effects and Hausman-Taylor (1981) results, respectively. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 10: Effects of maternal famine exposure on household education expenditure

	Education expenditure				Health expenditure			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable: education expenditure	POLS	RE	Mundlak	Hausman-Taylor	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	140.370	145.772	139.465	126.841	277.650	277.650	282.006	293.584*
	(90.446)	(330.682)	(342.798)	(143.395)	(203.787)	(188.302)	(176.055)	(177.777)
Rain shortage × famine cohort	-12.412	-13.777	-0.209	6.246	-11.280	-11.280	-9.062	-13.858
	(30.204)	(45.940)	(49.616)	(77.606)	(40.364)	(43.813)	(48.342)	(40.230)
Famine months (#)	6.275	8.967	-6.907	14.993	160.111	160.111	154.517*	174.168*
	(54.815)	(185.996)	(184.379)	(118.103)	(119.340)	(115.072)	(81.252)	(103.400)
Famine months × famine cohort	16.992	16.802	18.810	13.161	-25.468	-25.468	-24.644	-26.056
	(15.243)	(20.510)	(20.589)	(35.035)	(42.291)	(32.658)	(32.328)	(36.797)
Famine cohort (famine=1)	-91.652*	-95.571	-79.241	-50.645	-78.052	-78.052	-30.855	-73.767
	(54.850)	(87.335)	(94.632)	(140.578)	(74.125)	(68.853)	(75.744)	(107.934)
Household size	106.723***	102.509**	58.889	83.488***	-21.963	-21.963	-176.780	-26.568
	(37.755)	(45.015)	(70.694)	(18.782)	(39.909)	(48.146)	(195.239)	(61.155)
Age of household head	1.013	0.592	-4.509	6.227	8.565	8.565	7.096	9.074
	(3.358)	(3.847)	(5.298)	(5.749)	(8.532)	(7.717)	(8.414)	(5.820)
Gender of household head (male=1)	2.486	4.210	24.557	166.509***	-32.220	-32.220	-20.689	-59.599
	(57.262)	(73.421)	(79.982)	(57.446)	(131.730)	(130.496)	(133.546)	(357.166)
Household head schooling	67.629***	67.020***	30.844	41.038*	51.958	51.958	45.610	59.271
	(12.708)	(16.241)	(18.937)	(22.115)	(40.425)	(36.026)	(32.040)	(63.097)
Urban/rural (urban=1)	377.814**	390.176	335.266	573.010	364.510	364.510	346.457	346.965
	(156.169)	(347.026)	(349.357)	(434.739)	(292.867)	(281.229)	(276.970)	(452.655)
Shock index	-203.551	-45.706	346.682	272.732**	1,246.987**	1,246.987**	1,457.608**	1,705.817**
	(306.470)	(364.737)	(376.441)	(132.514)	(537.269)	(585.130)	(694.513)	(750.214)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,484	2,484	2,484	2,484	2,484	2,484	2,484	2,484
R-squared	0.189	0.189	0.194		0.016	0.016	0.02	
Number of children	838	838	838	838	838	838	838	838

Cluster bootstrap standard errors in (1)-(3) and (5)-(7) and bootstrap standard errors in (4) and (8) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table 11 presents the effects of maternal famine exposure on annual household education and health expenditures. “Rain shortage” and “Famine months” are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. The results under “Mundlak” and “Hausman-Taylor” columns obtained using Mundlak (1978) pseudo fixed effects and Hausman-Taylor (1981) estimators, respectively. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 11: Heterogeneous effects of maternal famine exposure duration on child human capital

Dependent variables	(1) zhfa	(2) child schooling	(3) PPVT	(4) Math	(5) locus of control	(6) self-esteem
Rain shortage (SD)	-0.023	0.178	0.834	-0.456	0.020	0.019
	(0.069)	(0.191)	(2.878)	(0.421)	(0.037)	(0.047)
Rain shortage × famine cohort	-0.088**	-0.062	-0.231	0.156	0.002	0.021
	(0.041)	(0.041)	(0.877)	(0.239)	(0.020)	(0.019)
Famine months (#)	0.037	0.266*	0.402	-0.440	0.008	-0.024
	(0.044)	(0.158)	(1.785)	(0.311)	(0.024)	(0.034)
1 Famine month × famine cohort	0.016	0.050	-2.490	-0.089	0.002	-0.032
	(0.110)	(0.105)	(1.751)	(0.580)	(0.036)	(0.043)
2 Famine months × famine cohort	-0.143	-0.050	1.406	-0.640	-0.024	-0.023
	(0.090)	(0.133)	(1.841)	(0.395)	(0.038)	(0.045)
3 Famine months × famine cohort	-0.055	-0.039	2.375	0.946	-0.057	-0.001
	(0.083)	(0.146)	(3.749)	(0.641)	(0.043)	(0.054)
4 Famine months × famine cohort	-0.234*	-0.340**	0.506	1.904***	-0.068	-0.098
	(0.133)	(0.146)	(2.990)	(0.581)	(0.058)	(0.066)
5 Famine months × famine cohort	-0.022	-0.509***	6.053	0.236	-0.087	0.019
	(0.171)	(0.191)	(3.687)	(0.878)	(0.078)	(0.053)
6 Famine months × famine cohort	-0.251*	-0.129	4.770	0.829	0.015	0.061
	(0.151)	(0.266)	(4.842)	(0.607)	(0.065)	(0.119)
7 Famine months × famine cohort	-0.312***	-0.310	0.649	-0.176	-0.115**	-0.078
	(0.107)	(0.225)	(4.179)	(0.703)	(0.055)	(0.071)
Famine cohort (famine=1)	0.045	-0.057	-1.857	-0.780**	0.047	0.033
	(0.064)	(0.057)	(1.251)	(0.318)	(0.032)	(0.031)
Household size	0.018	0.011	0.159	0.143*	-0.010	-0.008
	(0.021)	(0.028)	(0.418)	(0.082)	(0.010)	(0.009)
Age of household head	0.000	-0.003	0.027	-0.007	0.002	0.000
	(0.002)	(0.003)	(0.059)	(0.014)	(0.001)	(0.001)
Gender of household head (male=1)	0.044	0.377***	2.024	1.111***	0.025	0.067***
	(0.059)	(0.084)	(1.339)	(0.307)	(0.026)	(0.024)
Urban/rural (urban=1)	-0.245**	0.133	4.558	3.367***	-0.032	0.088
	(0.110)	(0.342)	(4.437)	(0.711)	(0.057)	(0.072)
Shock index	-0.174	0.253	-34.256***	-5.366***	-0.168	-0.276
	(0.237)	(0.605)	(11.729)	(1.579)	(0.219)	(0.223)
Wealth index	1.145***	1.402***	26.610***	7.790***	0.064	0.384***
	(0.201)	(0.304)	(6.111)	(0.910)	(0.101)	(0.103)
Gender of child (male=1)	-0.212***	-0.172**	-0.944	-0.005	-0.032	-0.044**
	(0.043)	(0.075)	(0.919)	(0.234)	(0.025)	(0.022)
Age of child (months)	-0.030***	0.056***	1.167***	0.184***	-0.001	0.001
	(0.008)	(0.010)	(0.203)	(0.029)	(0.003)	(0.002)
Child birth order	-0.054*	0.025	-1.444**	-0.278**	0.000	0.013
	(0.028)	(0.020)	(0.610)	(0.116)	(0.013)	(0.015)
Number of siblings of child	-0.010	-0.108***	-0.475	-0.263**	0.015	-0.005
	(0.022)	(0.030)	(0.598)	(0.114)	(0.013)	(0.012)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,259	1,501	2,394	1,541	2,484	2,484
R-squared	0.111	0.675	0.590	0.476	0.879	0.862
Number of children	838	838	838	838		

Cluster bootstrap standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table 12 presents the heterogeneous effects of maternal famine exposure duration on child human capital using POLS. "Rain shortage" and "Famine months" are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. "# Famine month × famine cohort" represents the effects of maternal early childhood famine exposure duration of # months on children's human capital. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table 12: Child life-cycle effects of maternal early childhood famine exposure

Dependent variables	(1) zhfa	(2) child schooling	(3) PPVT	(4) Math	(5) locus of control	(6) self-esteem
Rain shortage (SD)	-0.018	0.166	0.384	-0.401	0.016	0.012
	(0.066)	(0.185)	(2.811)	(0.414)	(0.038)	(0.048)
Rain shortage × famine cohort	-0.084**	-0.024	-0.663	-0.002	0.002	0.016
	(0.033)	(0.038)	(0.717)	(0.221)	(0.016)	(0.014)
Famine months (#)	0.042	0.263*	0.325	-0.420	0.006	-0.024
	(0.043)	(0.158)	(1.770)	(0.311)	(0.026)	(0.035)
Famine month × famine cohort × round 1	-0.075**	-	-	-	-	-
	(0.033)	-	-	-	-	-
Famine month × famine cohort × round 2	-0.016	-	0.004	-	-0.009	0.002
	(0.021)	-	(0.531)	-	(0.007)	(-0.026)
Famine month × famine cohort × round 3	-0.031	-0.025	1.029	0.062	-0.021**	-0.026**
	(0.021)	(0.278)	(1.137)	(0.117)	(0.010)	(0.011)
Famine month × famine cohort × round 4	-0.040**	-0.055*	-0.140	0.065	-0.009	0.001
	(0.020)	(0.031)	(0.459)	(0.137)	(0.011)	(0.012)
Famine cohort (famine=1)	0.045	-0.062	-1.652	-0.718**	0.047	0.032
	(0.061)	(0.052)	(1.304)	(0.323)	(0.030)	(0.029)
Household size	0.018	0.010	0.116	0.127	-0.010	-0.009
	(0.021)	(0.028)	(0.413)	(0.079)	(0.010)	(0.009)
Age of household head	0.000	-0.003	0.028	-0.006	0.002	0.000
	(0.002)	(0.003)	(0.061)	(0.014)	(0.001)	(0.001)
Gender of household head (male=1)	0.048	0.381***	2.031	1.092***	0.025	0.068***
	(0.058)	(0.083)	(1.354)	(0.302)	(0.026)	(0.024)
Urban/rural (urban=1)	-0.254**	0.128	4.286	3.291***	-0.033	0.083
	(0.111)	(0.342)	(4.438)	(0.714)	(0.057)	(0.073)
Shock index	-0.183	0.310	-33.366***	-5.275***	-0.163	-0.265
	(0.233)	(0.620)	(11.654)	(1.552)	(0.219)	(0.224)
Wealth index	1.143***	1.406***	27.243***	8.130***	0.063	0.381***
	(0.202)	(0.298)	(6.151)	(0.889)	(0.100)	(0.104)
Gender of child (male=1)	-0.210***	-0.163**	-0.982	-0.060	-0.031	-0.041*
	(0.045)	(0.076)	(0.909)	(0.234)	(0.025)	(0.022)
Age of child (months)	-0.030***	0.056***	1.174***	0.177***	-0.001	0.002
	(0.008)	(0.009)	(0.203)	(0.029)	(0.003)	(0.002)
Child birth order	-0.054*	0.022	-1.460**	-0.272**	0.001	0.013
	(0.028)	(0.020)	(0.620)	(0.115)	(0.013)	(0.015)
Number of siblings of child	-0.011	-0.110***	-0.377	-0.271**	0.015	-0.004
	(0.022)	(0.030)	(0.589)	(0.108)	(0.013)	(0.012)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,259	1,501	2,394	1,541	2,484	2,484
R-squared	0.111	0.675	0.590	0.476	0.879	0.862

Cluster bootstrap standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table 12 shows the evolution of the life cycle effects of maternal early childhood famine exposure on the child human capital. “Rain shortage” and “Famine months” are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. “Famine month × famine cohort × round #” represents the effects of the famine on child human capital measured in survey round #. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Appendix

A Effects of parents' early childhood shock on children's human capital

The effect of parental shocks early in childhood on their offspring's human capital can be written as:

$$\begin{aligned}\frac{\partial \theta_{k,1}}{\partial \eta_0^p} &= \frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_0^p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial \eta_0^p} \\ &= \left(\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\right)\frac{\partial \theta_p}{\partial \eta_0^p}.\end{aligned} \tag{A1}$$

Early childhood investments in parent's capabilities, I_1^p, is endogenous, i.e., $I_1^p = g(\theta_1^p, \theta_g, \eta_1^p)$. Thus, $\frac{\partial \theta_p}{\partial \eta_0^p}$ in (16) can be rewritten as:

$$\begin{aligned}\frac{\partial \theta_p}{\partial \eta_0^p} &= \frac{\partial \theta_p}{\partial \theta_1^p}\frac{\partial \theta_1^p}{\partial \eta_0^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\frac{\partial \theta_1^p}{\partial \eta_0^p} \\ &= \left(\frac{\partial \theta_p}{\partial \theta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right)\frac{\partial \theta_1^p}{\partial \eta_0^p}\end{aligned} \tag{A2}$$

Since θ_1^p itself is endogenous, $\frac{\partial \theta_1^p}{\partial \eta_0^p}$ can be expressed as:

$$\frac{\partial \theta_1^p}{\partial \eta_0^p} = \frac{\partial \theta_1^p}{\partial \eta_0^p} + \frac{\partial \theta_1^p}{\partial I_0^p}\frac{\partial I_0^p}{\partial \eta_0^p}. \tag{A3}$$

Thus,

$$\frac{\partial \theta_p}{\partial \eta_0^p} = \left(\frac{\partial \theta_p}{\partial \theta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right)\left(\frac{\partial \theta_1^p}{\partial \eta_0^p} + \frac{\partial \theta_1^p}{\partial I_0^p}\frac{\partial I_0^p}{\partial \eta_0^p}\right). \tag{A4}$$

Substituting (A1) in (16), we find a decomposable impact of parental childhood shocks on child outcomes as:

$$
\begin{aligned}
\frac{\partial \theta_{k,1}}{\partial \eta_0^p} &= \left(\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\right)\left(\frac{\partial \theta_p}{\partial \theta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right)\left(\frac{\partial \theta_1^p}{\partial \eta_0^p} + \frac{\partial \theta_1^p}{\partial I_0^p}\frac{\partial I_0^p}{\partial \eta_0^p}\right) \\
&= \underbrace{\frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial \theta_1^p}\frac{\partial \theta_1^p}{\partial \eta_0^p}}_{\text{Self Productivity}} + \underbrace{\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\frac{\partial \theta_1^p}{\partial I_0^p}\frac{\partial I_0^p}{\partial \eta_0^p}}_{\text{Dynamic complementarity}} \\
&\quad + \underbrace{\left[\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p}\left(\frac{\partial \theta_p}{\partial \theta_1^p} + \frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right) + \frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right]\frac{\partial \theta_1^p}{\partial \eta_0^p}}_{\text{Mixed channel}} \\
&\quad + \underbrace{\left[\left(\frac{\partial \theta_{k,1}}{\partial I_0}\frac{\partial I_0}{\partial \theta_p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\right)\frac{\partial \theta_p}{\partial \theta_1^p} + \frac{\partial \theta_{k,1}}{\partial \theta_p}\frac{\partial \theta_p}{\partial I_1^p}\frac{\partial I_1^p}{\partial \theta_1^p}\right]\frac{\partial \theta_1^p}{\partial I_0^p}\frac{\partial I_0^p}{\partial \eta_0^p}}_{\text{Mixed channel}}.
\end{aligned} \tag{A5}
$$

B Appendix Figures

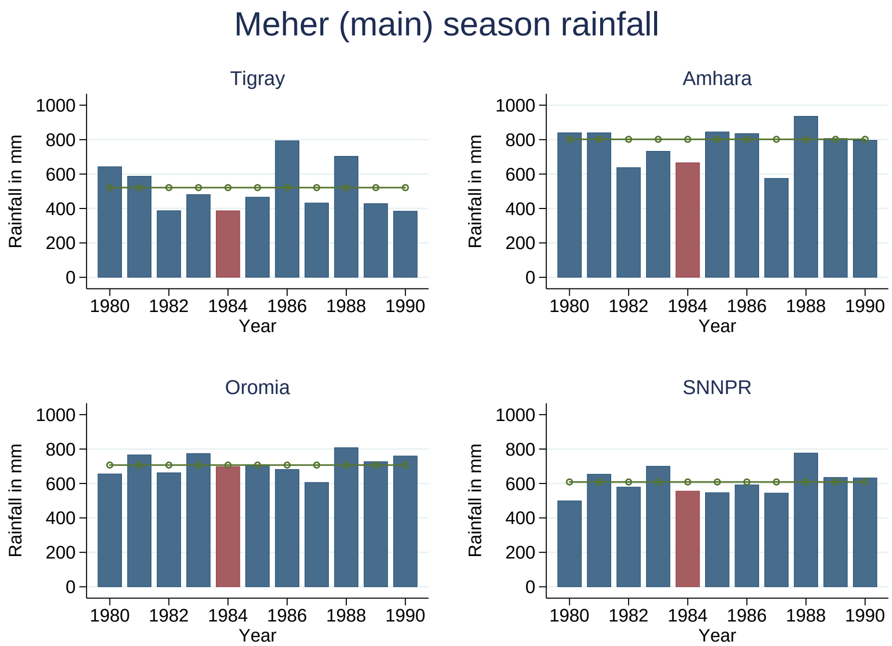

Figure A1: Patterns of Meher rains 1980-1990

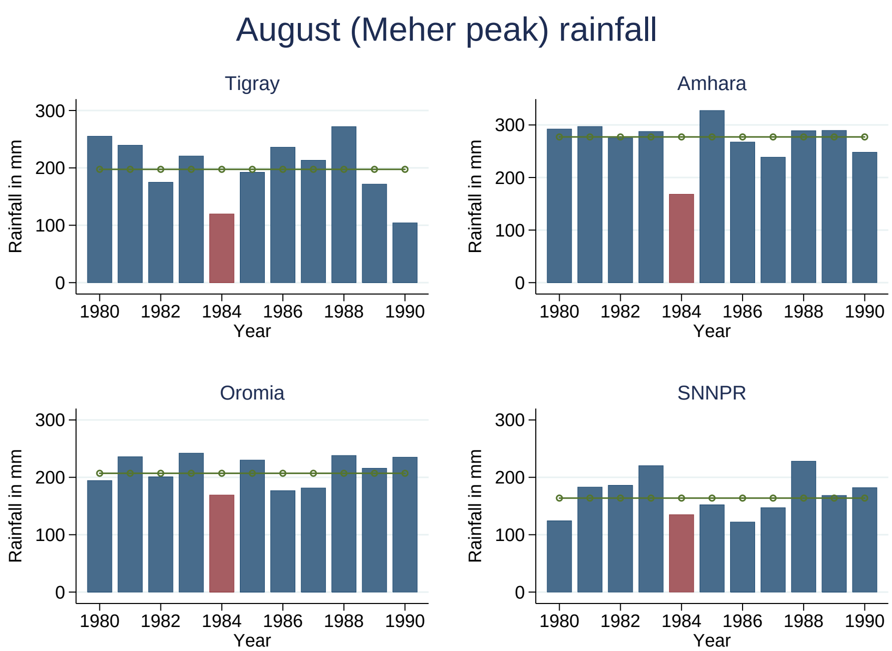

Figure A2: Patterns of August rains 1980-1990

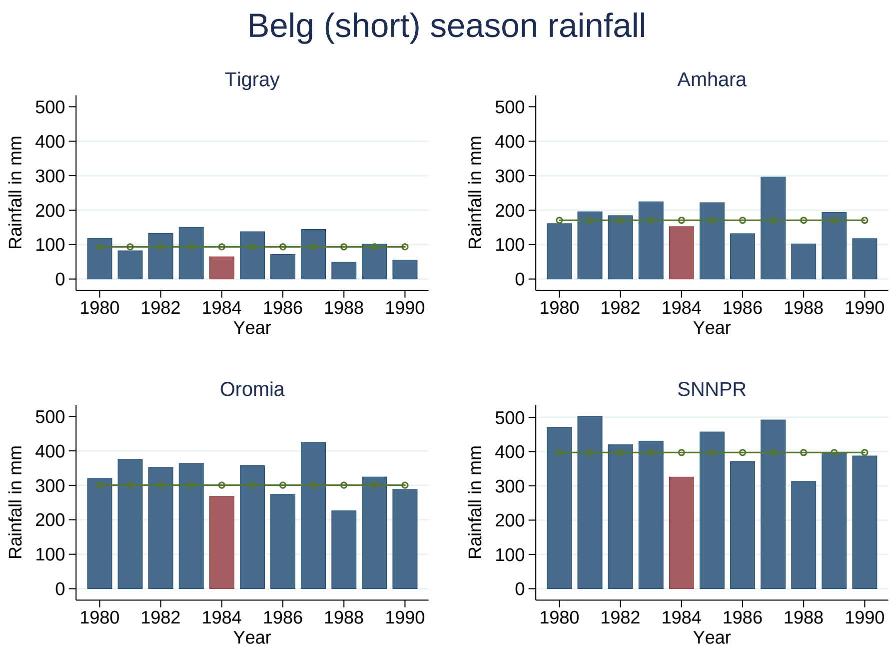

Figure A3: Patterns of Belg rains 1980-1990

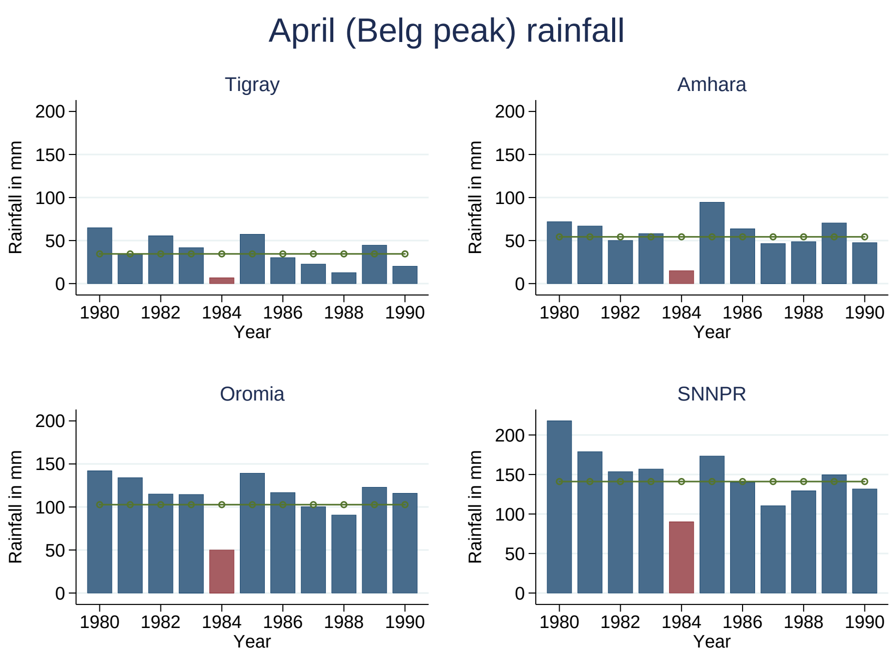

Figure A4: Patterns of April rains 1980-1990

C Appendix Tables

Table A1: Effects of maternal famine exposure on test scores

	PPVT score				Math score			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.: PPVT & Math test scores	POLS	RE	Mundlak	Hausman-Taylor	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	0.731	0.735	0.784	0.709	-0.280	-0.211	-0.288	-0.066
	(2.959)	(1.226)	(1.253)	(0.910)	(0.383)	(0.385)	(0.337)	(0.282)
Rain shortage × famine cohort	-0.606	-0.608	-0.530	-0.693	0.010	-0.026	0.041	-0.059
	(0.729)	(0.580)	(0.519)	(0.756)	(0.224)	(0.211)	(0.188)	(0.244)
Famine months (#)	0.428	0.434	0.444	0.551	-0.376	-0.305	-0.426	-0.051
	(1.845)	(1.458)	(1.655)	(0.586)	(0.276)	(0.570)	(0.490)	(0.190)
Famine months × famine cohort	0.323	0.322	0.344	0.241	0.065	0.047	0.045	-0.020
	(0.493)	(0.629)	(0.611)	(0.360)	(0.105)	(0.138)	(0.138)	(0.116)
Famine cohort (famine=1)	-1.239	-1.235	-1.086	-1.199	-0.602**	-0.525	-0.554	-0.369
	(1.309)	(1.430)	(1.501)	(1.355)	(0.305)	(0.425)	(0.418)	(0.433)
Household size	0.118**	0.118	0.566	0.502	0.126	0.127**	0.125	0.201**
	(0.399)	(0.317)	(0.484)	(0.445)	(0.077)	(0.063)	(0.120)	(0.101)
Age of household head	0.078	0.078	0.008	0.052	0.007	0.007	0.015	0.002
	(0.063)	(0.059)	(0.147)	(0.061)	(0.014)	(0.012)	(0.023)	(0.017)
Gender of household head (male=1)	0.102	0.102	0.255	1.896	0.594*	0.391	0.400	0.615
	(1.370)	(1.179)	(1.103)	(1.844)	(0.323)	(0.327)	(0.333)	(0.500)
Household head schooling	0.753***	0.753***	0.575***	0.412	0.220***	0.200***	0.143***	-0.020
	(0.190)	(0.108)	(0.106)	(0.333)	(0.039)	(0.046)	(0.043)	(0.119)
Urban/rural (urban=1)	3.516	3.513	0.487	8.103***	3.023***	3.294***	2.006**	4.859***
	(4.015)	(4.840)	(4.916)	(2.487)	(0.718)	(1.064)	(0.851)	(0.728)
Shock index	-31.914***	-31.900***	-31.557***	-33.739***	-4.959***	-2.739***	-0.770	1.030
	(11.405)	(9.245)	(10.437)	(8.383)	(1.571)	(1.009)	(1.053)	(1.705)
Wealth index	19.869***	19.859***	-4.944	1.563	5.978***	5.292***	0.585	2.252
	(5.071)	(4.714)	(6.978)	(6.910)	(0.891)	(0.946)	(1.277)	(1.535)
Gender of child (male=1)	-1.044	-1.039	-1.061	-0.972	-0.080	-0.088	-0.112	0.016
	(0.914)	(0.705)	(0.712)	(0.980)	(0.238)	(0.252)	(0.245)	(0.302)
Age of child (months)	1.146***	1.146***	1.388***	1.300***	0.172***	0.167***	0.223**	0.369***
	(0.200)	(0.089)	(0.202)	(0.225)	(0.029)	(0.029)	(0.095)	(0.092)
Child birth order	-1.313**	-1.315***	-0.961***	-1.355***	-0.249**	-0.191**	-0.118	-0.143
	(0.612)	(0.408)	(0.356)	(0.466)	(0.119)	(0.090)	(0.079)	(0.117)
Number of siblings of child	-0.269	-0.270	-1.244	-0.540	-0.240**	-0.242**	-0.191	-0.279*
	(0.616)	(0.433)	(0.873)	(0.505)	(0.111)	(0.112)	(0.242)	(0.144)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,394	2,394	2,394	2,394	1,541	1,541	1,541	1,541
R-squared	0.589				0.489			
Number of children	838	838	838	838	824	824	824	824

Cluster bootstrap standard errors in (1)-(3), (5)-(7) and bootstrap standard errors in (4) & (8) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. PPVT is a short-form for Peabody Picture Vocabulary Test. Columns (3) and (7) present results using Mundlak (1978) estimator, while columns (4) and (8) presents results of the Hausman-Taylor (1981) estimator. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table A2: Effects of maternal famine exposure on mothers' educational aspirations for child

	(1)	(2)	(3)	(4)
Dep. var.: mothers' educational aspirations for children	POLS	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	-0.163	-0.150	-0.153	-0.171
	(0.237)	(0.182)	(0.160)	(0.112)
Rain shortage × famine cohort	0.044	0.046	0.055	0.034
	(0.069)	(0.055)	(0.051)	(0.088)
Famine months (#)	-0.017	-0.012	-0.015	-0.008
	(0.146)	(0.187)	(0.146)	(0.075)
Famine months × famine cohort	0.004	0.003	0.008	-0.005
	(0.046)	(0.037)	(0.044)	(0.039)
Famine cohort (famine=1)	-0.028	-0.012	-0.033	-0.013
	(0.169)	(0.122)	(0.157)	(0.223)
Household size	0.021	0.028	0.098*	0.068*
	(0.038)	(0.031)	(0.053)	(0.039)
Age of mother	-0.002	-0.002	-0.006	0.002
	(0.018)	(0.014)	(0.015)	(0.035)
Age of household head	-0.009*	-0.008	-0.009	-0.013*
	(0.005)	(0.005)	(0.014)	(0.007)
Gender of household head (male=1)	0.093	0.029	0.052	0.261
	(0.097)	(0.084)	(0.096)	(0.173)
Urban/rural (urban=1)	0.325	0.314	0.123	0.740***
	(0.337)	(0.538)	(0.532)	(0.244)
Shock index	0.275	0.329	0.468	0.278
	(0.986)	(0.505)	(0.533)	(0.822)
Wealth index	2.183***	1.911***	0.740	0.838
	(0.444)	(0.352)	(0.609)	(0.684)
Household expenditure (real)	4.26e-06	-7.20e-06	-0.00001	7.94e-06
	(0.000)	(0.000)	(0.000)	(0.000)
Gender of child (male=1)	-0.143	-0.142	-0.145	-0.131
	(0.104)	(0.105)	(0.101)	(0.099)
Age of child (months)	-0.003	-0.004	-0.006	0.004
	(0.012)	(0.011)	(0.015)	(0.022)
Child birth order	0.028	0.039	0.107**	0.056
	(0.055)	(0.042)	(0.054)	(0.061)
Number of children	-0.014	-0.016	-0.024	-0.059
	(0.043)	(0.031)	(0.085)	(0.056)
Ethnicity	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes
Observations	2,461	2,461	2,461	2,461
R-squared	0.177	0.178	0.183	
Number of mothers	838	838	838	838

Cluster bootstrap standard errors in (1)-(3) and bootstrap standard errors in (4) in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: "Rain shortage" and "Famine months" stand for negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. POLS and RE stand for pooled OLS and random effects, respectively. Columns (3) and (4) present results using Mundlak (1978) estimator and Hausman-Taylor (1981) estimator, respectively. Controls included in all four models are household characteristics (household size, household head age, gender and schooling, wealth, income, shocks), child characteristics (age, gender, age order, number of siblings, language, ethnicity, religion), mother famine cohort dummies, urban-rural dummy, and survey round dummies. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table A3: Heterogeneous effects of maternal famine exposure duration on child human capital

Dependent variables	zhfa			child schooling			PPVT			Math			locus of control			self-esteem		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	-0.006	-0.007	0.011	0.206	0.189	0.274***	0.834	0.884	1.158	-0.351	-0.429	-0.102	0.020	0.023	0.022	0.019	0.021	0.019
	(0.121)	(0.118)	(0.066)	(0.183)	(0.141)	(0.084)	(1.700)	(1.468)	(0.945)	(0.450)	(0.357)	(0.298)	(0.034)	(0.029)	(0.024)	(0.043)	(0.049)	(0.023)
Rain shortage × famine cohort	-0.094*	-0.092*	-0.096*	-0.069*	-0.044	-0.089	-0.231	-0.164	-0.222	0.108	0.203	0.084	0.002	0.004	0.001	0.021	0.022	0.021
	(0.052)	(0.047)	(0.058)	(0.040)	(0.035)	(0.068)	(0.631)	(0.688)	(0.876)	(0.269)	(0.269)	(0.279)	(0.015)	(0.016)	(0.020)	(0.013)	(0.014)	(0.020)
Famine months (#)	0.045	0.042	0.055	0.287	0.247	0.350***	0.402	0.374	0.710	-0.342	-0.482	-0.058	0.008	0.012	0.010	-0.024	-0.024	-0.023
	(0.103)	(0.096)	(0.040)	(0.187)	(0.159)	(0.056)	(1.746)	(1.531)	(0.598)	(0.440)	(0.351)	(0.191)	(0.035)	(0.030)	(0.017)	(0.036)	(0.040)	(0.015)
1 Famine month × famine cohort	0.023	0.049	0.011	0.079	0.130	0.102	-2.490**	-2.027	-2.917*	-0.141	-0.041	-0.154	0.002	0.006	-0.003	-0.032	-0.035	-0.035
	(0.163)	(0.149)	(0.131)	(0.124)	(0.113)	(0.129)	(1.250)	(1.459)	(1.674)	(0.670)	(0.692)	(0.510)	(0.037)	(0.034)	(0.045)	(0.031)	(0.033)	(0.037)
2 Famine months × famine cohort	-0.129	-0.118	-0.128	-0.074	-0.106	-0.081	1.406	1.293	1.367	-0.699	-0.819**	-0.779	-0.024	-0.025	-0.025	-0.023	-0.027	-0.023
	(0.127)	(0.122)	(0.136)	(0.117)	(0.108)	(0.162)	(1.038)	(1.028)	(2.027)	(0.430)	(0.403)	(0.648)	(0.033)	(0.031)	(0.043)	(0.040)	(0.037)	(0.036)
3 Famine months × famine cohort	-0.057	-0.059	-0.040	-0.051	-0.065	-0.037	2.375	1.932	3.017	0.960	0.844	1.124	-0.057*	-0.061	-0.051	-0.001	-0.007	0.004
	(0.102)	(0.102)	(0.143)	(0.143)	(0.165)	(0.172)	(2.408)	(3.123)	(2.277)	(0.701)	(0.786)	(0.705)	(0.033)	(0.040)	(0.054)	(0.033)	(0.045)	(0.057)
4 Famine months × famine cohort	-0.223	-0.244	-0.211	-0.371**	-0.375**	-0.356	0.506	0.256	1.641	1.865***	1.845**	2.144**	-0.068	-0.069	-0.059	-0.098	-0.101	-0.089
	(0.217)	(0.235)	(0.183)	(0.183)	(0.171)	(0.222)	(3.594)	(3.539)	(3.394)	(0.718)	(0.846)	(0.932)	(0.066)	(0.064)	(0.062)	(0.085)	(0.078)	(0.065)
5 Famine months × famine cohort	-0.027	-0.010	-0.038	-0.501***	-0.465***	-0.584***	6.053	5.339	5.566	-0.034	-0.064	-0.516	-0.087	-0.070	-0.097	0.019	0.008	0.017
	(0.226)	(0.210)	(0.219)	(0.168)	(0.134)	(0.222)	(3.825)	(3.361)	(3.622)	(1.000)	(1.219)	(1.026)	(0.058)	(0.058)	(0.082)	(0.046)	(0.039)	(0.095)
6 Famine months × famine cohort	-0.245	-0.246	-0.245	-0.164	-0.176	-0.261	4.770	4.705	4.923	0.597	0.754	0.222	0.015	0.020	0.012	0.061	0.066	0.064
	(0.211)	(0.215)	(0.259)	(0.171)	(0.133)	(0.286)	(3.040)	(2.965)	(3.631)	(0.677)	(0.690)	(0.991)	(0.058)	(0.051)	(0.092)	(0.054)	(0.051)	(0.072)
7 Famine months × famine cohort	-0.361***	-0.309**	-0.396**	-0.318	-0.359	-0.403*	0.649	1.336	-0.997	-0.273	-0.254	-0.960	-0.115*	-0.104	-0.129**	-0.078	-0.071	-0.089
	(0.133)	(0.125)	(0.197)	(0.200)	(0.229)	(0.225)	(4.711)	(5.065)	(3.234)	(0.762)	(0.799)	(0.989)	(0.063)	(0.071)	(0.063)	(0.056)	(0.062)	(0.064)
Famine cohort (famine=1)	0.016	0.048	0.021	-0.046	-0.037	-0.021	-1.857	-1.540	-1.733	-0.678	-0.673*	-0.493	0.047*	0.038	0.050	0.033	0.032	0.034
	(0.093)	(0.089)	(0.091)	(0.055)	(0.055)	(0.106)	(1.420)	(1.411)	(1.425)	(0.421)	(0.406)	(0.434)	(0.024)	(0.024)	(0.032)	(0.033)	(0.031)	(0.032)
Household size	0.007	-0.000	0.011	0.009	0.007	0.009	0.159	0.585	0.587	0.145**	0.129	0.210**	-0.010	-0.004	-0.006	-0.008	-0.014	-0.007
	(0.023)	(0.024)	(0.015)	(0.025)	(0.033)	(0.028)	(0.322)	(0.457)	(0.442)	(0.059)	(0.109)	(0.099)	(0.007)	(0.013)	(0.009)	(0.007)	(0.015)	(0.009)
Age of household head	-0.002	-0.004	-0.002	-0.004	-0.005	-0.003	0.027	-0.027	0.024	-0.005	0.004	0.003	0.002	0.002	0.002	0.000	0.002	0.000
	(0.002)	(0.003)	(0.003)	(0.003)	(0.007)	(0.004)	(0.059)	(0.142)	(0.057)	(0.010)	(0.022)	(0.015)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Gender of household head (male=1)	0.111***	0.103**	0.127**	0.364***	0.340***	0.336***	2.024*	1.631	3.043*	0.809***	0.684**	0.693	0.025	0.023	0.036	0.067***	0.057**	0.079***
	(0.043)	(0.048)	(0.064)	(0.097)	(0.087)	(0.096)	(1.118)	(1.090)	(1.584)	(0.264)	(0.299)	(0.468)	(0.022)	(0.023)	(0.033)	(0.024)	(0.023)	(0.029)
Urban/rural (urban=1)	-0.148	-0.359*	-0.052	0.196	-0.109	0.373**	4.558	0.494	9.377***	3.675***	2.010***	4.758***	-0.032	-0.077	0.014	0.088	0.047	0.129***
	(0.209)	(0.210)	(0.106)	(0.411)	(0.463)	(0.154)	(4.921)	(5.280)	(2.343)	(0.812)	(0.679)	(0.601)	(0.092)	(0.093)	(0.047)	(0.067)	(0.081)	(0.048)
Shock index	-0.139	-0.109	-0.125	0.782	1.322**	2.080***	-34.256***	-31.898***	-33.990***	-2.874**	-0.573	1.008	-0.168	-0.162	-0.165	-0.276*	-0.246	-0.310
	(0.174)	(0.213)	(0.238)	(0.554)	(0.584)	(0.517)	(10.246)	(11.961)	(8.348)	(1.166)	(1.211)	(1.709)	(0.188)	(0.196)	(0.180)	(0.147)	(0.181)	(0.194)
Wealth index	0.692***	0.245	0.317	1.331***	-0.037	0.933**	26.610***	-5.481	2.150	6.523***	0.395	2.325	0.064	-0.220	-0.161	0.384***	0.066	0.168
	(0.266)	(0.306)	(0.218)	(0.312)	(0.485)	(0.450)	(4.895)	(6.900)	(6.930)	(0.981)	(1.359)	(1.529)	(0.090)	(0.135)	(0.137)	(0.108)	(0.148)	(0.137)
Gender of child (male=1)	-0.218***	-0.227***	-0.207***	-0.176**	-0.184**	-0.168**	-0.944	-1.030	-0.837	0.005	-0.042	0.083	-0.032	-0.032	-0.031	-0.044***	-0.045***	-0.043**
	(0.054)	(0.058)	(0.065)	(0.069)	(0.081)	(0.069)	(0.675)	(0.788)	(0.991)	(0.239)	(0.245)	(0.295)	(0.022)	(0.022)	(0.022)	(0.016)	(0.016)	(0.019)
Age of child (months)	-0.026***	-0.026**	-0.023***	0.054***	0.032	0.079***	1.167***	1.411***	1.326***	0.180***	0.230***	0.369***	-0.001	0.006**	0.000	0.001	0.006	0.002
	(0.009)	(0.013)	(0.008)	(0.009)	(0.024)	(0.020)	(0.102)	(0.223)	(0.208)	(0.027)	(0.073)	(0.088)	(0.002)	(0.003)	(0.004)	(0.002)	(0.004)	(0.004)
Child birth order	-0.034	-0.015	-0.032*	0.018	0.005	0.012	-1.444***	-0.996***	-1.423***	-0.206**	-0.125	-0.155	0.000	0.001	0.001	0.013	0.011	0.012
	(0.022)	(0.015)	(0.018)	(0.015)	(0.023)	(0.033)	(0.367)	(0.356)	(0.465)	(0.090)	(0.079)	(0.117)	(0.011)	(0.016)	(0.013)	(0.012)	(0.014)	(0.014)
Number of siblings of child	-0.032	-0.059	-0.034	-0.113***	-0.151***	-0.115***	-0.475	-1.297	-0.711	-0.270**	-0.157	-0.275**	0.015*	0.049**	0.014	-0.005	0.001	-0.006
	(0.021)	(0.039)	(0.022)	(0.038)	(0.054)	(0.037)	(0.445)	(0.904)	(0.501)	(0.115)	(0.239)	(0.138)	(0.009)	(0.021)	(0.012)	(0.009)	(0.021)	(0.012)
Ethnicity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Religion	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Survey round	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,259	3,259	3,259	1,501	1,501	1,501	2,394	2,394	2,394	1,541	1,541	1,541	2,484	2,484	2,484	2,484	2,484	2,484
Number of children	838	838	838	829	829	829	838	838	838	824	824	824	838	838	838	838	838	838

Cluster bootstrap standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table A3 presents the heterogeneous effects of maternal famine exposure duration on children's human capital using random effects, Mundlak's pseudo fixed effects and Hausman-Taylor estimators. "Rain shortage" and "Famine months" are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).

Table A4: Heterogeneous effects of maternal famine exposure duration on child human capital

Dependent variables	zhfa			child schooling			PPVT			Math			locus of control			self-esteem		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor (RE)	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor	RE	Mundlak	Hausman-Taylor
Rain shortage (SD)	-0.007	-0.003	0.001	0.199	0.187	0.265***	0.384	0.526	0.512	-0.289	-0.341	-0.061	0.016	0.020	0.016	0.012	0.015	0.011
	(0.106)	(0.100)	(0.061)	(0.185)	(0.152)	(0.082)	(1.629)	(1.516)	(0.909)	(0.487)	(0.375)	(0.279)	(0.035)	(0.032)	(0.022)	(0.047)	(0.052)	(0.021)
Rain shortage × famine cohort	-0.088**	-0.081**	-0.090*	-0.027	-0.000	-0.039	-0.663	-0.532	-0.697	-0.048	0.037	-0.051	0.002	0.003	0.001	0.016	0.016	0.016
	(0.043)	(0.040)	(0.052)	(0.035)	(0.029)	(0.062)	(0.552)	(0.554)	(0.765)	(0.211)	(0.198)	(0.240)	(0.011)	(0.011)	(0.017)	(0.011)	(0.011)	(0.017)
Famine months (#)	0.046	0.046	0.051	0.286	0.248	0.347	0.325	0.335	0.548	-0.322	-0.443	-0.050	0.006	0.011	0.008	-0.024	-0.023	-0.024*
	(0.101)	(0.088)	(0.038)	(0.199)	(0.174)	(0.056)	(1.984)	(1.963)	(0.588)	(0.631)	(0.509)	(0.186)	(0.042)	(0.038)	(0.016)	(0.041)	(0.047)	(0.014)
Famine months × famine cohort× round 1	-0.078*	-0.074	-0.079**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	(0.045)	(0.046)	(0.034)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Famine months × famine cohort× round 2	-0.017	-0.012	-0.009	-	-	-	0.004	-	-0.068	-	-	-	-	-	-0.005*	-	-	0.000
	(0.026)	(0.025)	(0.013)	-	-	-	(0.541)	-	(0.183)	-	-	-	-	-	(0.003)	-	-	(0.004)
Famine months × famine cohort× round 3	-0.038	-0.035	-0.013	-0.023	-0.029	-0.009	1.029	1.008	0.284	-	-	-0.003	-0.021***	-0.020**	-0.008*	-0.026**	-0.026**	-0.009**
	(0.025)	(0.026)	(0.009)	(0.026)	(0.030)	(0.009)	(1.112)	(1.145)	(0.237)	-	-	(0.038)	(0.008)	(0.008)	(0.004)	(0.011)	(0.011)	(0.004)
Famine months × famine cohort× round 4	-0.040	-0.034	-0.010*	-0.061**	-0.061**	-0.018**	-0.140	-0.063	-0.058	0.035	0.046	-0.005	-0.009	-0.008	-0.003	0.001	0.002	0.000
	(0.025)	(0.027)	(0.006)	(0.028)	(0.029)	(0.008)	(0.482)	(0.549)	(0.089)	(0.131)	(0.141)	(0.032)	(0.012)	(0.013)	(0.003)	(0.011)	(0.011)	(0.003)
Famine cohort (famine=1)	0.022	0.050	0.023	-0.053	-0.045	-0.022	-1.652	-1.396	-1.076	-0.622	-0.624	-0.390	0.047*	0.038*	0.054*	0.032	0.030	0.036
	(0.091)	(0.084)	(0.087)	(0.052)	(0.055)	(0.104)	(1.461)	(1.516)	(1.359)	(0.444)	(0.435)	(0.422)	(0.024)	(0.023)	(0.032)	(0.031)	(0.032)	(0.031)
Household size	0.007	-0.001	0.010	0.009	0.004	0.013	0.116	0.607	0.468	0.133**	0.125	0.206**	-0.010	-0.004	-0.006	-0.009	-0.015	-0.009
	(0.023)	(0.025)	(0.015)	(0.026)	(0.036)	(0.028)	(0.330)	(0.462)	(0.449)	(0.058)	(0.113)	(0.100)	(0.008)	(0.014)	(0.009)	(0.007)	(0.015)	(0.010)
Age of household head	-0.002	-0.004	-0.002	-0.004	-0.005	-0.004	0.028	-0.032	0.027	-0.005	0.005	0.003	0.002	0.002	0.002	0.000	0.002	0.000
	(0.002)	(0.003)	(0.003)	(0.003)	(0.007)	(0.004)	(0.060)	(0.147)	(0.059)	(0.011)	(0.021)	(0.015)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
Gender of household head (male=1)	0.114***	0.105**	0.132**	0.367***	0.343***	0.337***	2.031*	1.636	2.816*	0.797***	0.671**	0.620	0.025	0.024	0.036	0.068***	0.059**	0.082***
	(0.043)	(0.051)	(0.065)	(0.097)	(0.088)	(0.100)	(1.193)	(1.149)	(1.654)	(0.272)	(0.297)	(0.503)	(0.023)	(0.025)	(0.033)	(0.023)	(0.023)	(0.029)
Urban/rural (urban=1)	-0.157	-0.362	-0.070	0.190	-0.109	0.364**	4.286	0.281	8.779***	3.626***	1.943**	4.813***	-0.033	-0.077	0.014	0.083	0.042	0.127***
	(0.230)	(0.224)	(0.107)	(0.448)	(0.467)	(0.157)	(5.446)	(5.339)	(2.345)	(0.932)	(0.840)	(0.608)	(0.104)	(0.094)	(0.047)	(0.076)	(0.089)	(0.048)
Shock index	-0.170	-0.151	-0.170	0.834	1.372**	2.103***	-33.366***	-31.546**	-33.108***	-2.829**	-0.672	1.034	-0.163	-0.167	-0.174	-0.265*	-0.250	-0.322*
	(0.180)	(0.226)	(0.235)	(0.581)	(0.632)	(0.593)	(10.550)	(12.461)	(8.307)	(1.168)	(1.180)	(1.701)	(0.193)	(0.204)	(0.179)	(0.155)	(0.186)	(0.193)
Wealth index	0.698***	0.249	0.330	1.338***	0.004	0.947**	27.243***	-5.243	4.404	6.787***	0.524	2.228	0.063	-0.225	-0.169	0.381***	0.047	0.153
	(0.258)	(0.307)	(0.217)	(0.316)	(0.514)	(0.454)	(5.152)	(6.655)	(6.985)	(0.985)	(1.321)	(1.541)	(0.097)	(0.147)	(0.136)	(0.120)	(0.151)	(0.137)
Gender of child (male=1)	-0.217***	-0.225***	-0.211***	-0.166**	-0.175**	-0.163**	-0.982	-1.036	-0.993	-0.052	-0.093	0.021	-0.031	-0.031	-0.031	-0.041***	-0.043***	-0.041**
	(0.058)	(0.064)	(0.064)	(0.075)	(0.084)	(0.068)	(0.676)	(0.785)	(0.990)	(0.247)	(0.249)	(0.293)	(0.022)	(0.022)	(0.021)	(0.015)	(0.015)	(0.019)
Age of child (months)	-0.026***	-0.026**	-0.024***	0.054***	0.032	0.081***	1.174***	1.422***	1.297***	0.173***	0.229***	0.374***	-0.001	0.006**	0.001	0.002	0.006*	0.002
	(0.009)	(0.013)	(0.008)	(0.009)	(0.026)	(0.022)	(0.104)	(0.216)	(0.220)	(0.028)	(0.085)	(0.081)	(0.002)	(0.003)	(0.004)	(0.002)	(0.004)	(0.005)
Child birth order	-0.034	-0.016	-0.032*	0.015	0.002	0.008	-1.460***	-1.025**	-1.398***	-0.206**	-0.119	-0.158	0.001	0.002	0.002	0.013	0.013	0.013
	(0.022)	(0.017)	(0.018)	(0.017)	(0.029)	(0.034)	(0.405)	(0.411)	(0.464)	(0.085)	(0.080)	(0.118)	(0.013)	(0.017)	(0.013)	(0.014)	(0.016)	(0.014)
Number of siblings of child	-0.032	-0.059	-0.036	-0.115***	-0.146**	-0.120***	-0.377	-1.289	-0.568	-0.276***	-0.193	-0.273*	0.015	0.049**	0.014	-0.004	-0.001	-0.004
	(0.022)	(0.040)	(0.022)	(0.036)	(0.058)	(0.038)	(0.444)	(0.936)	(0.510)	(0.105)	(0.244)	(0.142)	(0.009)	(0.022)	(0.012)	(0.009)	(0.023)	(0.013)
Observations	3,259	3,259	3,266	1,501	1,501	1,504	2,394	2,394	2,398	1,541	1,541	1,545	2,484	2,484	2,488	2,484	2,484	2,488
Number of children	838	838	838	829	829	829	838	838	838	824	824	824	838	838	838	838	838	838

Cluster bootstrap standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Note: Table A4 shows the life-cycle effects of maternal famine exposure on children's human capital using random effects, Mundlak's pseudo fixed effects and Hausman-Taylor estimators. "Rain shortage" and "Famine months" are total monthly negative rainfall deviation during the 1983-1985 famine and the number of months a mother was exposed to the famine, respectively. Ethnicity, religion, region and survey round are vectors of dummy variables. The sample included in these results excludes mothers born before 1978 (three years before famine) and after 1988 (three years after the famine).