Rainfall Shocks and Learning Outcomes: Dynamic Persistence and the Role of Local Labour Demand

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Abstract

We present evidence on the role of local labour markets in driving the persistent and gendered impact of rainfall shocks on learning outcomes in rural India. We find contrasting impacts of rainfall shocks by variation in soil texture, which serves as an exogenous driver of female and children's labour force participation (LFP). Strikingly, in non-loamy (high female and child LFP) areas, exposure to positive shocks in early life is associated with a higher likelihood of dropping out of school and being in a lower grade than is age-appropriate, while effects are considerably attenuated in loamy areas. Furthermore, we examine dynamic complementarities and find that female children in non-loamy areas bear the highest learning losses from a positive rainfall shock in their school-going years, especially when they have faced positive shocks in early life. We investigate potential mechanisms by studying children's labour market response under rainfall shocks and show that the gains or losses in learning outcomes are systematic to local labour market conditions, which influence the opportunity cost of schooling under shocks.

JEL classification: I21, I24, I26, I18, J16, J22, J24

Keywords: Learning outcomes, Rainfall shocks, Gender gap, Female labour force participation, Child labour

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1 Introduction

The susceptibility of rural households in developing countries to climatic shocks often manifests in the form of disproportionate negative effects on children's human capital outcomes (Jacoby & Skoufias, 1997; Jensen, 2000). These impacts can multiply over time, through the channels of self-reinforcement and dynamic complementarity (Cunha & Heckman, 2007; Currie & Vogl, 2013). The vulnerability to climatic shocks can be gendered in nature, where, often, girl children's outcomes are more elastic to shocks than their male counterparts (Björkman-Nyqvist, 2013; Zimmermann, 2020). Beyond equity concerns, this vulnerability has far-reaching consequences, affecting fertility and intergenerational outcomes (Bloom et al., 2020; Chaaban & Cunningham, 2011; Gandhi Kingdon, 2002; Schultz, 2002).

Conceptually, a positive rainfall shock can have contrasting impacts on children's learning outcomes through the countervailing forces of income and the substitution effect. While a positive productivity shock increases the demand for agricultural workers and, thereby, the scope of household investments on children's education (Glick et al., 2016; Grimm, 2011; Jensen, 2000), it also increases the opportunity cost of schooling, with children spending less time on schooling or learning activities as opposed to working (Atkin, 2016; Dumas, 2020; Kruger, 2007; Nordman et al., 2022; Trinh et al., 2020). A priori, it is unclear which effect would dominate, and the literature provides mixed evidence on the impact of climate shocks on children's educational outcomes (Alam et al., 2022). Moreover, the timing of the shock matters in shaping learning outcomes, as children's outcomes are more sensitive to income fluctuations in the birth year and years immediately following birth, while the trade-off with paid work has more significance when children are of school-going age (Shah & Steinberg, 2021; Shah & Steinberg, 2017). In this paper, we posit that these effects of climate shocks are systematic to local labour markets in rural areas that differ in the extent of the market participation of women and children.

It is well documented in the literature that variation in soil texture guides the use of agricultural technology and, thus, the demand elasticities for agricultural wage work. Carranza (2014) shows that soil loaminess increases requirements for deep tillage, which, in turn, reduces the demand for agricultural tasks that have higher female participation. Afridi et al. (2023) find that since 1999, areas with loamy soil have witnessed more rapid agricultural mechanisation, which has led to a further decline in the use of women's labour in agriculture. Using data from four rounds of a nationally representative survey on employment, we show that loaminess corresponds to substantially lower female participation in paid work. We also demonstrate that it relates to lower child labour. To the best of our knowledge, there is no prior work that provides insight into the role of soil loaminess in driving children's participation in the agricultural workforce. To the extent that children are ill-suited to perform tasks related to deep tillage or those that are mechanised, we expect that the same reasons that reduce the demand for female labour in loamy areas would lead to the reduced demand for children's labour. Taking the differences in local labour market conditions that dictate the extent to which women and children participate in paid work as given, we study how they interact with rainfall shocks to produce differential effects on children's human capital attainment.

We use district-level differences in soil type – focusing on district areas under loamy soil – to account for systematic differences in labour demand elasticities that vary by agricultural technology. We use data on soil texture from Carranza (2014) to classify districts based on the share of area under loamy soil. We then compute the median share of loamy soil across all the districts in our sample and classify districts as loamy or non-loamy depending on whether the share of loamy soil is above or below the sample median. We also find empirically that, as predicted, there are no differences in the average employment share for adult males between the 'loamy' and 'non-loamy' districts. However, adult female employment and children's employment are systematically lower in the former.

Using this variation in the soil-texture in a region, we first develop a theoretical framework considering two types of districts (L and H) to examine the impacts of rainfall shocks on learning outcomes. Type L or 'loamy' districts are characterised by lower labour intensity in agriculture, and thus lower female and children's participation in the labour market. Type H or 'non-loamy' districts are characterised by relatively higher labour intensity in agriculture and therefore higher female and children's participation. We develop a basic model of human capital formation by embedding the features of the local labour market dynamics that are likely to evolve under shocks for these two types of districts. The timing of the shock plays an important role in our analytical analysis. In early-life, children's human capital depends on material inputs and parental time investments. In labour markets with high female and child labour participation, a positive productivity shock generates two opposing forces. Households are able to make more material investments in children due to the income effect, but the opportunity cost channel makes it more costly for mothers to stay out of paid work and make time investments in their children. This tradeoff suggests that the effects of positive productivity shocks that occur in early-life could be diminished or even reversed in regions that favor higher female labour force participation. This is an important insight for policy, and can help inform the targeting of social protection programs in regions with high labour market participation of women and children. Next, we invoke the dynamic complementarities channel, where the extent of work-schooling trade-off during contemporaneous shocks in school-going years depends on early-life shock exposure. We hypothesize that the opportunity costs are sharper for children who have experienced favorable productivity shocks during their early-life, since their increased health capital makes them more productive at school as well as work. Theoretically, this trade-off between schooling and work is likely to be prominent in regions with labour market conditions that favor female and child labour in paid work.[1]

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work. Theoretically, this trade-off between schooling and work is likely to be prominent in regions with labour market conditions that favour female and child labour in paid work.[2]

We test these predictions using rich data on learning outcomes for a sample of approximately three million children from rural India, from 2008 to 2016. Following prior research, we use the incidence of rainfall shocks as drivers of quasi-random shocks to household income (Corno et al., 2020; Jayachandran, 2006; Kaur, 2019; Mahajan, 2016; Shah & Steinberg, 2017). In India, less than typical rainfall manifests as a negative income shock, while more than typical rainfall acts as a positive shock. We use granular precipitation data from 1982 to 2016 to capture exogenous variation in district-level rainfall and classify districts based on whether they experienced below-normal, normal, or above-normal rainfall. We map this information to children's birth years to identify their exposure to shocks in the birth year and the four years following birth. These data allow us to study impacts separately for shocks experienced in early life (between 0–4 years) and in schooling years (between 5–16 years).

Consistent with the predictions of our theoretical framework, we find that positive rainfall shocks in early life reduce school attendance and the likelihood of being in the age-appropriate grade in non-loamy (high female and child LFP) regions, but that these effects are considerably diminished in loamy (low female and child LFP) regions. We then investigate the effects of the interaction between rainfall shocks in early life (0–5 years) and those in school-going years (5–16 years). Consistent with Shah and Steinberg (2017), we find that positive rainfall shocks during school-going years have detrimental impacts on learning outcomes and schooling. This reduction is particularly sharp for female children exposed to positive shocks in early life in low-loam regions. In direct contrast, in high-loam districts, female children who have faced positive shocks in early life experience marginal improvements under positive rainfall shocks in school-going years. We find no difference in the impacts on male children between the two types of districts. Our findings suggest that female children in districts with local institutions of female and child labour are likely to be particularly susceptible to learning losses under positive rainfall shocks.

Next, we address potential mechanisms. Given that we are interested in the mediating effects of local labour markets, we focus on changes in children's labour market participation in response to shock exposure.[3] To understand the mechanisms, we use four rounds of data from India's National Sample Survey and confirm that children's labour market responses to rainfall shocks are a key mechanism driving our results. Positive rainfall shock exposure in early life leads to higher participation in paid employment, unpaid work on a household enterprise, and full-time domestic work. This effect is prominent for children in non-loamy regions that favour child labour and female participation in paid work. Congruently, female children in these districts, who have faced positive shocks in early life, are likely to increase participation in paid employment and unpaid work on a household enterprise under a positive rainfall shock in school-going years, while those in loamy districts do not do so.

Our study makes several contributions to the literature. First, we add to the understanding of the gendered impacts of climatic shocks on human capital attainment (Afridi et al., 2022; Fruttero et al., 2023). In particular, our paper demonstrates how soil texture in a region guides the agricultural technologies, and, thereby, the local demand for female and child labour plays a major role in driving differences in learning outcomes under rainfall shocks. Most importantly, it shows that the local economic environment is a particularly significant influencing factor for female learning outcomes under climate shocks and potentially exacerbates the ex-

[2]For example, children could be complements to adult labour in agriculture, but substitutes for adult labour in caregiving (Dillon, 2013).

[3]We expect the labour market effects of positive and negative rainfall shocks in school-going years to operate in opposite directions. To confirm this, we provide analysis that separately estimates the effects of positive and negative shocks in school-going years in the Appendix. We provide an explanation of these results in Section 4

isting gender gaps in the face of a rainfall shock. Next, we study shocks that occur in early life and in school-going years and the interaction of the two, thereby speaking to the role of dynamic complementarities. We build on research such as Shah and Steinberg (2017), Shah and Steinberg (2021) and Bau et al. (2020) to show that the timing of rainfall shocks determines the way they interact with the gender and labour institutions of the setting to influence learning outcomes. Finally, using data on labour force participation, we identify a key mechanism that explains our results.

The rest of the paper is structured as follows: In Section 2 we develop the conceptual framework with testable theoretical predictions. Section 3 describes our data sources and the key variables. Section 4 lays out the empirical strategy and main results. Section 5 concludes.

2 Conceptual Framework

We draw on Becker and Tomes (1976, 1986) to present a framework to conceptualise a household's decision to invest in children's human capital. Consider a household that consists of a mother (or primary female caregiver) and a child. Each household is endowed with one unit of time in every period. The household derives utility from consumption and the child's future income, which is a function of the child's human capital attainment. Consider the first problem, where a child is born, and the household invests in developing early-life human capital through consumption and maternal time investments.

The household maximises

$$U = U(C, y_c)$$

where C represents consumption and y_c is the child's future income. Here, y_c depends on investments in the child's human capital H_c, $y_c = g(H_c)$, where $g(.)$ is increasing, and H_c is produced based on the following production function:

$$H_c = f(E, T_m, \alpha)$$

where E is material investments made by the household in the child's early life, T_m denotes the maternal time investments made in the child's early life, and α is an exogenously determined ability parameter. $f(.)$ is increasing and concave.

Rainfall shocks R occur with independent, exogenous probability. The shocks affect the household's non-labour income $Y(R)$ and market wages $w(R)$. Both $Y(R)$ and $w(R)$ are increasing in R, and wages are set exogenously. Thus, the household's budget constraint in the child's early life is:

$$C + E = Y(R) + (1 - T_m) * w(R)$$

where $(1 - T_m)$ is the time the mother spends in market work, not making time investments in child-rearing.

As an illustrative example, we assume log utility and a Cobb-Douglas human capital production function, so that the household optimisation problem becomes:

$$\max_{C,E,T_m} U = ln(C) + \theta * ln(y_c), y_c = H_c = \alpha E^a T_m^b$$

where $\theta > 0$ and $a, b \in (0, 1)$ and subject to

$$C + E = Y(R) + (1 - T_m) * w(R)$$

We consider the impacts of local labour market conditions by modelling two types of districts. A household is either located in a type L (Loamy) or H (Non-Loamy) district. Type L districts are characterised by lower reliance on female and child labour in agriculture. In type

H districts, agriculture is characterised by higher reliance on family members, with participation of women and children. Thus, in type H districts, work hours and participation rates for women and children respond more readily when households face rainfall shocks. In type H districts, mothers face a trade-off in choosing T_m respectively and can respond elastically to market wages. On the other hand, in type L districts, $T_m = 1$ inelastically.

Given the realisation of R, which determines both $Y(R)$ and $w(R)$, the household chooses $T_m \in [0, 1]$ to maximise lifetime utility, subject to the budget constraints and considering the human capital production function. It trades off current consumption with early-life human capital investments and higher future income for the child. This trade-off manifests differently in the two types of districts and leads to the first theoretical prediction.

Prediction 1: In type L districts, positive rainfall shocks in early life unambiguously increase human capital accumulation, H_c. This increase is because under labour market conditions with low demand for female labour, mothers devote the entire unit of time to childcare irrespective of market wages, and positive shocks increase material inputs E through $Y(R)$. In type H districts, the effect of positive shocks in early life is ambiguous. While positive shocks increase material inputs through $Y(R)$, higher $w(R)$ reduces the time allocated to childcare. Given that maternal time is an important input in the production of children's human capital, particularly in the early years of a child's life (Bernal, 2008; Bono et al., 2016; Del Boca et al., 2014), the overall effect of positive shocks in these districts may be neutral or even negative.

Next, we consider the household's problem when the child is of school-going age. Now, the unit of time the household is endowed with can be spent by the child on attending school or on market work. The household's utility maximisation problem remains the same, but the human capital production function and budget constraint differ. The child's future income y_c, depends on investments in human capital, $y_c = g(H_c)$, where $g(.)$ is increasing, and H_c is produced based on the following production function

$$H_c = f(\bar{h}, S, \alpha)$$

where $\bar{h}$ is early life human capital, S denotes the time the child spends in school, and α is an exogenously determined ability parameter. $f(.)$ is increasing and concave.

Once again, rainfall shocks R occur with independent, exogenous probability. The shocks affect the household's non-labour income, $Y(R)$, and market wages, $w(R)$. Both $Y(R)$ and $w(R)$ are increasing in R, and wages are set exogenously. Thus, the household's budget constraint in the child's school-going years is:

$$C = Y(R) + (1 - S) * \bar{h}^{\lambda} * w(R)$$

where $(1 - S)$ is the time the child spends in market work, while remaining out of school and $\lambda \geq 0$ captures the increasing returns to child labour from early-life human capital. Once again, we assume log utility and a Cobb-Douglas human capital production function, and the household's problem when children are of school-going age is:

$$\underset{C,S}{max} U = ln(C) + \delta * ln(y_c), y_c = H_c = \alpha \bar{h}^c S^d$$

where $\delta > 0$ and $c, d \in (0, 1)$ and subject to

$$C = Y(R) + (1 - S) * \bar{h}^{\lambda} * w(R)$$

As type L districts are characterised by low reliance on female and child labour, children face limited access to labour markets. On the other hand, in type H districts with high reliance on female and child labour, children are likely to adjust labour market hours more readily in response to wage shocks. Households take for given the realisation of R and early-life human capital stock $\bar{h}$ and choose the child's school time $S \in [0, 1]$. The household trades off consumption with investments in children's future income through school attendance. The trade-off between school and labour market work exists in both types of districts, albeit to varying extents leading to the second theoretical prediction.

Prediction 2: In both type H and type L districts, positive rainfall shocks during school-going years increase the opportunity cost of schooling by raising market wages. As a result, households reallocate children's time away from schooling and towards work. This reallocation is detrimental to ultimate human capital attainment. Prediction 2 aligns with the predictions and results in Shah and Steinberg (2017).

Since the framework allows for interactions between early-life investments and shocks in school-going years through their joint influence on $\bar{h}$, it captures dynamic complementarities. More concretely, this means that the elasticity $c \geq 0$ and the marginal return to schooling is higher when early-life human capital $\bar{h}$ is greater (Cunha & Heckman, 2007; Currie & Almond, 2011). However, as captured by $\lambda \geq 0$, children who have a high $\bar{h}$ may also be more productive in the labour market, and have higher potential earnings. This fact could create a reinforcing negative interaction, whereby children with higher early-life human capital might be more inclined to divert time away from school, particularly in settings where the labour market absorbs child labour. This provides the final theoretical prediction.

Prediction 3: In type L districts, where child labour is less prevalent, the interaction between early and positive rainfall shocks during school age is weak or could even slightly offset each other. Higher $\bar{h}$ is more likely to be preserved through continued school attendance even when market wages rise. In contrast, in type H districts, children with high $\bar{h}$ through higher R are more likely to trade off school for work as the combined effect of high ability and high market wages further increases the opportunity cost of schooling. In the rest of the paper, we describe our data and test these predictions empirically.

3 Data

3.1 Cognitive Outcomes and Schooling

We use objective data on schooling and learning outcomes for a sample of approximately three million children collected by the Annual Status of Education Report (ASER) for the years 2008–2012, 2014, and 2016. The ASER survey, conducted annually since 2005, measures schooling and learning outcomes for children aged 5–16 years. It is a representative household-level survey, covering all rural districts in India.[4] A unique feature of the ASER survey is that children are surveyed at home, meaning that data on their test scores is available irrespective of school enrolment status.

Our primary outcomes for learning ability draw on data that records children's ability to read in their native language and their maths ability. The surveyors code children's reading and maths abilities using a number from 1–5, where 1 indicates the lowest and 5 the highest level.[5] We convert each of these codes into z-scores by the child's age and compare each child's learning level to other children in their age cohort. The mean reading and maths z-scores in our sample are -0.01 and -0.02, respectively. The mean reading z-score is 0.012 for male children and -0.012 for female children. The corresponding statistics for the maths z-scores are 0.040

[4]For more details on ASER, see http://www.asercentre.org/

[5]1 indicates that the child cannot read anything, 2 indicates the child can identify letters, 3 indicates the child can read words, 4 indicates the child can read a grade 1 level text, and 5 indicates the child can read a grade 2 level text. In the case of maths, 1 indicates inability to do any arithmetic, 2 indicates ability to recognise numbers from 0-9, 3 indicates ability to recognise numbers from 11-99, 4 indicates ability to do simple subtraction and 5 indicates ability to do division.

and -0.045 for male and female children respectively.

In addition to learning outcomes, we also know each child's schooling status (currently enrolled, dropped out, or never enrolled), school grade (if enrolled), and whether the child attends any extra tuition.[6] Three per cent of the children in our sample have dropped out of school. The dropout rate is 3.1% for male children and 3.8% for female children. Moreover, 21% of the children in our sample are enrolled in extra tuition support. Enrollment in extra tuition support is slightly higher for male children, at 22.4%, and is 19.5% for female children.

In our regression specifications, we control for a range of school-, household-, and village-level characteristics available in the ASER data. We also compute a household wealth index using a principal component analysis of data on household asset ownership and include this index as a control.

3.2 Rainfall

We use rainfall data from the University of Delaware for the years 1982 to 2016.[7] These data are available in the form of monthly totals and gridded by latitude and longitude. We match each geopoint for which data are available with India's district boundaries, calculate the mean rainfall for all the coordinates that lie within each district's boundary, and assign this calculation as the rainfall for the district. We use the inter-temporal variation in rainfall *within* a district for our analysis. Moreover, define the rainfall shock variable by comparing the total annual rainfall in each district in a given year to the 20^{th} and 80^{th} for the last 10 years in the *same* district. In other words, we compare the rainfall in each district in the year the survey data were collected to the 20^{th} and 80^{th} for *the same district* computed using district-specific data for the last 10 years. The shock variable takes the value -1 (drought or negative shock) if the rainfall in the survey year is less than or equal to the 20^{th} percentile, value 1 (flood or positive shock) if the rainfall in the survey year is greater than or equal to the 80^{th} percentile, and value 0 (normal) if rainfall lies between the 20^{th} and 80^{th} percentiles. Our method of defining rainfall shocks aligns with the standard approach in the literature and follows Jayachandran (2006), Mahajan (2016), Shah and Steinberg (2017), Kaur (2019) and Corno et al. (2020).

We use data on rainfall shocks in the child's birth year and four years following birth to create a measure of rainfall exposure in early life. As our primary measure, we compute an index using a principal component analysis of the rainfall shocks in the first five years of a child's life. As an alternative measure, we also compute a simple average of the rainfall shock variable for these years and show that our results are robust to using this measure instead of the index. The resulting shock indicators for the ASER survey years are defined at the district–year level, and the indicators for early-life rainfall exposure are defined at the child level.

3.3 Soil Texture

We use data on soil texture from Carranza (2014). The original data are derived from *1991 Soils of India* and matched with district boundaries for 2001. These data provide the fraction of district areas under loamy, clayey, and sandy soil for 358 of India's 584 districts, as of 2001. We use the share of loamy soil in the district in terms of area to define the variable Loamy, which takes the value 1 for district d if the area under loamy soil in d is greater than the median loamy soil share in our sample, and 0 otherwise. We use this variable to introduce systematic

[6] Data on monthly tuition expenditure are available, but only for the years 2014 and 2016.

[7] The Willmott and Matsuura (2001) data are available here: https://psl.noaa.gov/data/gridded/data.UDel_AirT_Precip.html

variation in the extent of female and children's participation in paid work,[8] where districts for which Loamy takes the value 1 are type L districts from our conceptual framework. That is, these districts are characterised by low female and child participation in the labour market.[9] Correspondingly, districts for which Loamy takes the value 0 are type H districts from our conceptual framework and are characterised by high female and child participation in the labour market. We show in Appendix Table 6 that type H districts have systematically higher female and children's participation in the labour market than type L districts, but they do not differ in the levels of adult male participation.

3.4 National Sample Survey Data

We use data from the 61st, 64th, 66th and 68th Employment and Unemployment Surveys of India's National Sample Survey to examine how rainfall shocks affect adult and child labour force participation by gender and soil type.[10] Data are available from households across all of India's districts. We restrict analysis to rural households and have a combined sample of more than 775,454 individuals. We use data on adults' (ages 19–60 years) and children's (ages 5–18 years) 'Usual Principal Activity Status' to create indicators for whether each individual is engaged in paid employment, performs unpaid work for a family enterprise, or carries out domestic work full-time.[11]

4 Empirical Strategy and Results

Our primary question of interest involves understanding how the relative demand for women and children's labour in local labour markets mediates the impacts of rainfall shocks on children's educational attainment. We exploit quasi-random variation in the incidence of rainfall shocks *within* a district at two points in children's lives: first, shocks that occur in early life, that is, during the first five years of life, and second, shocks that occur contemporaneously in school-going years, when children are between 5 and 16 years old. We test for the differences in the impact of rainfall shocks by differences in the dominant soil variety,[12] which influences the extent of female and children's participation in the labour force and serves as our primary measure of variation in local labour markets.

Before estimating the impacts of rainfall shocks on children's learning outcomes, we establish baseline differences and gender gaps in outcomes between loamy and non-loamy districts. We present learning outcomes by loamy versus non-loamy districts separately for male and female children in Figure 2. The graph shows the average reading and maths z-scores and shares of children who have dropped out of school and who are in the age-appropriate grade. We find that in loamy (type L) districts, reading and maths scores are lower on average, and children are marginally more likely to have dropped out of school and are less likely to be in the age-appropriate grade. The gender gap in scores is also larger in loamy districts. The

[8] This follows prior work, such as Carranza (2014) who shows that the share of loamy soil is negatively related to female participation in the labour force. Thus, we expect 'loamy' districts to have lower female labour force participation than those that are not.

[9] In supplementary analysis, we use a continuous measure of the fraction of district area under loamy soil instead of the binary variable, and our main results remain unchanged. We retain the binary measure in the analysis for ease of interpretation.

[10] These data are available here: http://microdata.gov.in/nada43/index.php/catalog/EUE.

[11] We also use data on the following to include as controls in our regressions testing labour market mechanisms: individual's age and marital status; household size, religion, caste and indicators for whether it is an agricultural household and whether it owns any land.

[12] This is defined by the share of soil that is classified as loamy.

difference between the average reading scores for male and female children in these districts is 0.032. This number is more than two times 0.014, which is the difference in non-loamy districts. The same is true for maths scores, where the difference between the average score for male and female children is 0.099 in loamy districts, and 0.073 in non-loamy districts. In the case of the gender gap in school dropout shares, we find the opposite pattern compared to scores, and the gender difference is smaller in loamy districts. Female children are 0.2 pp more likely to have dropped out in loamy districts and 0.7 pp more likely to have dropped out in non-loamy districts than their male counterparts. The shares of children in the age-appropriate grade also present an interesting pattern, as in this case, the gender gap reverses in favour of female children. In both loamy and non-loamy districts, female children are more likely to be in the age-appropriate grade than male children. However, consistent with the reading and maths scores, we find that the gap between male and female children is higher in loamy districts (-1.8 pp) than in non-loamy districts (-1.4 pp).

Next, we use variation in the extent of female and children's labour force participation combined with the plausibly random occurrence of rainfall shocks to estimate a standard difference-in-differences model. To estimate the gender gap in education outcomes, we estimate both equations 1 and 2 separately for the sample of female and male children. Our results are identified based on the assumption that rainfall shocks in both a child's early years and school-going years occur plausibly randomly. We leverage rainfall shocks as quasi-random instruments for variation in gendered labour demand, which varies by the soil type in a region. These shocks are measured at the district–year level and then linked to individual outcomes. In the early-life specification, the treatment effect is identified at the cohort–district level –that is, differences in rainfall exposure across groups defined by birth-cohort and district. For contemporaneous (school-age) effects, the identifying variation comes from differences in rainfall shocks across district–year units.

The estimation equations are as follows:

$$\begin{aligned} \mathrm{Y}_{chvdt} = \alpha &+ \beta_1 \mathrm{Loamy}_d + \beta_2 \mathrm{EarlyLifeShock}_{chvdt} \\ &+ \beta_3 \mathrm{Loamy}_d * \mathrm{EarlyLifeShock}_{chvdt} \\ &+ \gamma_1 X_{1chvdt} + \gamma_2 X_{2hvdt} + \gamma_3 X_{3vdt} + \psi_t + \phi_d + \epsilon_{chvdt} \end{aligned} \tag{1}$$

$$\begin{aligned} Y_{chvdt} = \alpha &+ \beta_1 \mathrm{Loamy}_d + \beta_2 \mathrm{EarlyLifeShock}_{chvdt} + \beta_3 \mathrm{C.RainfallShock}_{dt} \\ &+ \beta_4 \mathrm{Loamy}_d * \mathrm{EarlyLifeShock}_{chvdt} \\ &+ \beta_5 \mathrm{Loamy}_d * \mathrm{C.RainfallShock}_{dt} \\ &+ \beta_6 \mathrm{C.RainfallShock}_{dt} * \mathrm{EarlyLifeShock}_{chvdt} \\ &+ \beta_7 \mathrm{Loamy}_d * \mathrm{C.RainfallShock}_{dt} * \mathrm{EarlyLifeShock}_{chvdt} \\ &+ \gamma_1 X_{1chvdt} + \gamma_2 X_{2hvdt} + \gamma_3 X_{3vdt} + \psi_t + \phi_d + \epsilon_{chvdt} \end{aligned} \tag{2}$$

In equation 1, we test for differences in the impact of early life rainfall by local labour market conditions. Y_{chvdt} is the outcome for child c in household h, village v, district d in year t. Our main outcomes of interest are age-specific z-scores of language and maths abilities, as well as indicators for whether the child has dropped out of school, is in an age-appropriate grade, and is enrolled in extra tuition support. $Loamy_d$ takes the value 1 if the share of loamy soil in district d is above the sample median and 0 otherwise, and it corresponds to districts with low relative FLFP. $EarlyLifeShock_{chvdt}$ is a measure of rainfall exposure for child c in their birth year and the four years following birth. Specifically, it is an index computed using principal component analysis on measures of rainfall shocks in the years concerned.[13] β_3 is

[13] In Appendix tables 11 and 12 we use a simple average of early life rainfall shocks instead of the principal component analysis. We find that the results are robust to this alternative measure of early life shock exposure

our main coefficient of interest and provides an estimate for the differential effect of early-life rainfall by the dominant soil type in the district.

X_{1chvdt} represents a battery of child-level controls. These include the child's age, an indicator representing whether their mother has gone to school, the grade in which they are enrolled, and the type of school being attended.[14] X_{2hvdt} represents a battery of household-level controls and includes a household wealth index computed based on measures of asset ownership, sibling cohort composition,[15] whether the household has a first-born female child, and the total number of children. X_{3vdt} represents the set of village controls and contains indicators for whether the village has access to a 'pucca' (paved) road, electricity supply, a bank, and a ration shop. We include survey year fixed effects, ψ_t, and district fixed effects, ϕ_d. Standard errors are clustered at the district level. Our estimation accounts for the effects of other policy interventions that might influence children's labour–schooling tradeoff, such as India's Midday Meal Scheme. Under this scheme, since 2002, all public and public fund-aided schools across India are required to provide children with a cooked midday meal in school. The time frame for our analysis is 2008 to 2016, by which time the scheme had been rolled out across all of India's districts for over six years. Additionally, our controls for school type, district, and survey year fixed effects would account for any effects arising from differential exposure to this scheme.

In equation 2, we are interested in the interaction between rainfall exposure in early life and contemporaneous rainfall shocks. We define contemporaneous rainfall shocks as those occurring during the child's school-going years, that is, when they are between 5 and 16 years old. To estimate these effects, we include a measure $C.RainfallShock_{dt}$ of rainfall shock exposure for each d in every survey year t. This measure takes the value -1 if district d experienced a 'drought,' that is, if rainfall in year t was lower than the 20th percentile value calculated using the last 10 years' rainfall for that district. Analogously, it takes the value +1 if the district experienced 'high rainfall', that is, the rainfall exceeded the 80th percentile value *for that district*. Finally, years of 'normal rainfall' where district d experiences rainfall levels between the 20th and 80th percentiles are assigned the value 0. Our approach is akin to other works that study the impacts of rainfall shocks, such as Jayachandran (2006), Kaur (2019), Mahajan (2016), and Shah and Steinberg (2017). We estimate the fully saturated model, including all pairwise coefficients. The equation includes the full set of child-, household-, and village-level controls and survey year and district fixed effects. The coefficient on the triple difference term β_7 is our main coefficient of interest in this case.

In Table 1, we present evidence for the differential effects of early life rainfall on learning and schooling by the extent of female and children's participation in the local labour market. We find that for both male and female children, higher rainfall exposure (i.e. positive shocks) in early life leads to improvements in reading and maths test scores *only* in loamy districts. Children are also no more likely to have dropped out of school, are more likely to be in the age-appropriate grade, and are less likely to be enrolled in extra tuition support in loamy districts if they have experienced higher rainfall in early life. In contrast, in non-loamy districts, higher rainfall exposure in early life does not affect reading and maths scores, increases the incidence of dropping out of school, reduces the likelihood of being in the age-appropriate grade, and increases the likelihood of attending extra tuition support.[16] Our analysis suggests that earlier findings, such as those from Shah and Steinberg (2017) that show that positive rainfall shocks in early life improve human capital outcomes, are driven by regions that have lower relative female and children's labour force participation.

[14] Categorized as public, private, Madarsa and other

[15] Categorized as only child, all female, all male, mixed gender

[16] We interpret enrollment in extra tuition as investments to provide children with added support when they lose time in school. These investments become possible under positive shocks due to their positive income effect.

The magnitudes of our estimates show that in loamy districts, greater rainfall exposure in early life improves learning outcomes and attenuates negative impacts on schooling for both female and male children. For every one standard deviation (SD) increase in early life rainfall exposure, female children in loamy districts experience a 0.014 SD increase in their reading score and a 0.023 SD increase in their maths scores. Their male counterparts experience an improvement in reading scores by 0.007 SD and maths scores by 0.019 SD, although the former is not a statistically significant effect. Female children in loamy districts are also 0.62 percentage points (pp) more likely to be in the age-appropriate grade (0.% over the mean) and 0.58 pp less likely to be enrolled in extra learning support (2.9% over the mean) for every 1 SD increase in early life rainfall. Male children are 0.5 pp more likely to be in the age-appropriate grade (0.6% over the mean) and 0.48 pp less likely to be in additional tuition support (2% over the mean) if they have experienced 1 SD higher rainfall shocks in early life.

In contrast, in non-loamy districts, higher rainfall exposure in early life has no impact on learning outcomes and worsens schooling for both female and male children. Each SD increase in early life rainfall increases the chances that a female child has dropped out of school by 0.2 pp (6.7% over the mean) and reduces the chances that she is in the age-appropriate grade by 0.7 pp (0.8% over the mean). Female children are also more likely to be enrolled in extra learning support by 0.7 pp (3.5% over the mean). Male children experience similar effects and are 0.3 pp more likely to have dropped out of school (9.6% over the mean), 0.6 pp less likely to be in the age appropriate grade (0.7% over the mean), and 0.9 pp more likely to be enrolled in additional learning support (4.2% over the mean) if they experience 1 SD higher rainfall shocks in early life. Our findings show that the impact of early-life positive shocks on learning outcomes depends on local labour market conditions, as follows from Prediction 1 from our theoretical framework.

Next, we estimate how dynamic complementarities depend on local labour markets. Specifically, we test for the interaction effects of rainfall shocks in early life and those that occur in a child's school-going years. Table 2 presents the results from the estimation of equation 2. We find that in both loamy and non-loamy districts, compared to negative rainfall shocks, positive shocks in children's school-going years lead to a worsening in their reading and maths scores and make children more likely to drop out of school, less likely to be in the age-appropriate grade, and less likely to be enrolled in extra learning support. This finding is in line with Prediction 2 of our theoretical framework and the results in Shah and Steinberg (2017), who show that higher market wages in positive rainfall shock years drive up the opportunity cost of schooling and are detrimental to children's learning outcomes. Our results suggest that while the negative effects on learning are similar or more severe for children in loamy districts, the effects on schooling – rates of dropping out of school and not being in the age-appropriate grade – are attenuated in loamy areas. The coefficient on the interaction between loamy and the variable capturing contemporaneous rainfall shocks shows that maths scores decrease by an additional 0.04 SD for both female and male children in loamy districts. However, under a contemporaneous shock, male children in loamy districts are less likely to have dropped out of school by 0.2 pp, and both female and male children are more likely to be in the age-appropriate grade by 0.5 pp and 0.4 pp, respectively.

Regarding the interaction of high rainfall exposure in early life and rainfall shocks that occur in school-going years, we find that experiencing higher early-life rainfall exacerbates the negative effects of a contemporaneous positive rainfall shock only in non-loamy districts. This finding supports Prediction 3 from our theoretical framework. Additionally, we find that this added detrimental effect is larger for female children than for male children. As indicated by the triple difference term, in loamy districts, the interaction of early life shocks and shocks in school-going years does not produce any additional effect, and, if anything, it attenuates the reduction in reading scores for female children. On the other hand, in non-loamy districts in positive rainfall shock years versus negative ones, female children who have faced 1 SD higher early-life rainfall exposure have reading scores that are 0.01 SD lower and are 0.3 pp more likely to drop out of school (8.8% over the mean). Their male counterparts are 0.17 pp more likely to have dropped out of school (5.5% over the mean). Thus, we find that positive rainfall shocks in school-going years are more costly for children who have faced high early-life rainfall exposure in non-loamy districts and for female children, in particular. To show that it is, indeed, the rainfall shocks that drive these patterns, we estimate equations 1 and 2 with randomly assigned rainfall shocks (both early life and contemporaneous) in Tables 18 and 19 in the Appendix. In this placebo analysis, we do not find any systematic effects, which indicates the robustness of our estimates.

Next, we explore the labour market mechanisms that might underpin these results. We investigate impacts on children's labour force participation based on their reported 'Principal Activity Status' in the Indian National Sample Survey Office's employment and unemployment survey. We restrict our sample to children between 5 and 18 years and study the effects of greater positive shock exposure in early life and school-going years on female and male rates of participation in full-time paid employment, unpaid work on a household enterprise, and full-time engagement in domestic work.

We report results from estimating equation 1 in Table 3. We find that in loamy districts, children who face higher exposure to rainfall in early life are less likely to be in full-time paid employment, doing unpaid work on a household enterprise, or, in the case of female children, carrying out domestic work for their household full-time. In contrast, in non-loamy districts, both male and female children are more likely to be in each of these activities if they have faced higher exposure to rainfall in early life. These results are consistent with the findings of our analysis of the ASER data, where higher exposure to rainfall in early life increases school dropouts only in non-loamy districts and not in loamy ones.

Our estimates show that for a 1 SD higher exposure to positive shocks in early life, female children in non-loamy districts are 0.7 pp more likely to be employed with pay (43% over the mean), 0.3 pp more likely to be carrying out unpaid work in a household enterprise (27% over the mean), and 1.7 pp more likely to be doing domestic work full-time (21% over the mean). Their male counterparts are 1.6 pp more likely to be in full-time paid employment (42% over the mean) and 0.7 pp more likely to be doing unpaid work for a household enterprise (29% over the mean). These effects are consistently attenuated in loamy districts, where, for female children, a 1 SD higher exposure to positive shocks in early life leads to a 0.4 pp lower likelihood of being in full-time employment or working on a household enterprise and a 0.8 pp lower likelihood of doing domestic work full-time. Male children in loamy districts are also 1.1 pp and 0.4 pp less likely to be in full-time employment and unpaid work, respectively, if they have been exposed to more positive rainfall in early life. These estimates signal a clear labour market channel for our results on learning outcomes, indicating that the diminished negative impacts of positive shock exposure in early life among children in loamy districts are because of their lower rates of participation in activities that would take away from time spent in school and making educational investments.

Finally, we investigate the labour-market effects of the interaction of positive shocks in early life and rainfall shocks in school-going years in Table 4.[17] We find that in positive rainfall shock years relative to negative ones, higher exposure to early-life shocks causes both female and male children in non-loamy districts to increase participation in full-time paid employment and unpaid work on a household enterprise. This finding is particularly true for female children who experience positive shocks in early life; they are 0.2 pp more likely to report both working full-time and doing unpaid work for their household (12.5% over the mean). We find

[17]We also carry out this analysis for adult labour market outcomes, but find limited results. Results are reported in Table 13 in the Appendix.

no interaction effect between early life and contemporaneous shocks for children in loamy districts. This finding aligns with our results on learning and schooling outcomes, where female children in non-loamy districts who have experienced high early life rainfall are most likely to drop out of school in positive contemporaneous rainfall shock years relative to negative ones.

In Appendix Tables 14 and 15, we report the interaction effects between positive shocks in early life separately for negative and positive shocks in school-going years. While this estimation reduces power and, therefore, provides noisy estimates, we show that in non-loamy districts, negative shocks lower female children's participation in out-of-school activities, while positive shocks produce the opposite effect. Similar to the results combining the shocks into a single variable, we do not find significant effects on male children. We also confirm that the effects of both negative and positive shocks are exacerbated by exposure to positive shocks in early life, particularly in non-loamy districts, with minimal effects in loamy districts. This result reinforces our finding that learning outcomes of children who experience positive shocks in early life, particularly female children, are more elastic to shocks occurring in school-going years in settings that favour children's participation in paid work. In non-loamy areas, we show that negative shocks reduce the likelihood that girls are employed full-time, while positive shocks lower their participation in unpaid work on household enterprises in favour of carrying out domestic duties full-time. As in the case of the combined results, exposure to positive shocks in early life leads to a further decline in paid employment during a negative shock but could lead to an increase in domestic work full-time. Under positive contemporaneous shocks, female children in non-loamy districts who have experienced positive shocks in early life increase both work on a household enterprise and full-time domestic work. We find very limited interaction effects between positive shocks in early life and either negative or positive shocks in school-going years in loamy districts.

5 Conclusion and Discussion

Given the growing vulnerability to climate shocks, it is essential to understand the factors shaping their impact on key human capital outcomes. In this paper, we explore how the local economic environment mediates gendered responses to climate shocks and the channels through which early-life and contemporaneous rainfall shocks affect children's learning. Leveraging quasi-random variation in rainfall shocks within districts over time, we assess how these shocks influence educational outcomes depending on local labour market conditions, particularly the prevalence of paid work among women and children. Using variation in the share of loamy soil, which determines agricultural demand and labour intensity, we identify the differential effects of rainfall shocks on learning by the locally dominant soil type. Our analysis draws on objective measures of learning outcomes, including test scores and school enrollment, for nearly three million children, irrespective of school attendance.

The study develops an analytical framework to examine how rainfall shocks affect children's learning outcomes across two types of districts, differentiated by local labour market dynamics. In districts with high female and child labour force participation, positive productivity shocks in early life create a trade-off: increased household income can boost material investments in children, but higher opportunity costs reduce maternal time investments. This consequence may weaken or reverse the benefits of early-life shocks. The framework allows for examining dynamic complementarities, suggesting that favourable early-life shocks may raise opportunity costs during school years, particularly in labour-intensive regions, as healthier children become more productive both at school and at work.

In line with our theoretical predictions, we find that positive early-life rainfall shocks reduce school attendance and grade progression in non-loamy districts – characterised by high female and child labour force participation – but these effects are attenuated in loamy districts with lower labour participation. Examining the interaction of early-life (0–5 years) and school-age (5–16 years) shocks, we find that positive shocks during school years adversely affect learning outcomes, especially for girls who also experienced positive early-life shocks in non-loamy regions. In contrast, girls in loamy districts show slight improvements under similar conditions. These results highlight that in non-loamy regions, girls are particularly vulnerable to learning losses from productivity shocks.

We identify labour market mechanisms underlying these effects, showing that children in non-loamy districts who experience positive rainfall shocks in early life are more likely to engage full-time in non-school activities, such as paid work, unpaid family labour, and domestic chores. Similarly, among children exposed to positive shocks during school-going years, only female children in non-loamy districts who also experienced early-life shocks show increased participation in such activities; their counterparts in loamy districts do not. These patterns suggest that the opportunity cost of schooling, as highlighted by Shah and Steinberg (2017), mediates the relationship between climate shocks and human capital outcomes. Our findings show that local labour market structures, particularly the structural factors that determine gendered division of labour in agricultural production, play a role in determining this opportunity cost. Consistent with Shah and Steinberg (2021) and Bau et al. (2020), we find that early-life gains from favourable shocks may hinder later educational attainment when local labour markets absorb child labour during a positive productivity shock. Extending this insight, we show that the local demand for child work can amplify these effects for girls, widening the gender disparities in learning outcomes.

Our findings suggest that local labour market conditions should be factored into the design of policies aimed at strengthening human capital resilience. This finding may be especially important for low- and middle-income countries like India, which are both vulnerable to future climate shocks and marked by significant heterogeneity in local labour markets. We highlight the need for future research to examine how other defining features of local markets, such as access to labour and natural resources, influence the transmission of climate shocks to human capital outcomes.

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6 Tables and Figures

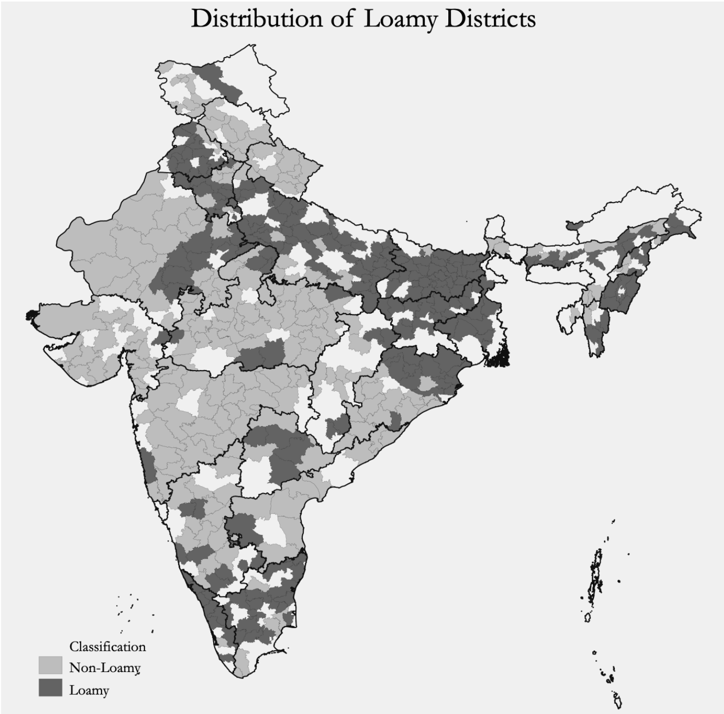

Figure 1: Distribution of loamy districts
(Note: Figure 1 shows the geographical distribution of loamy and non-loamy districts. Loamy districts have above-median area under loamy soil. Data is not available for regions in white)

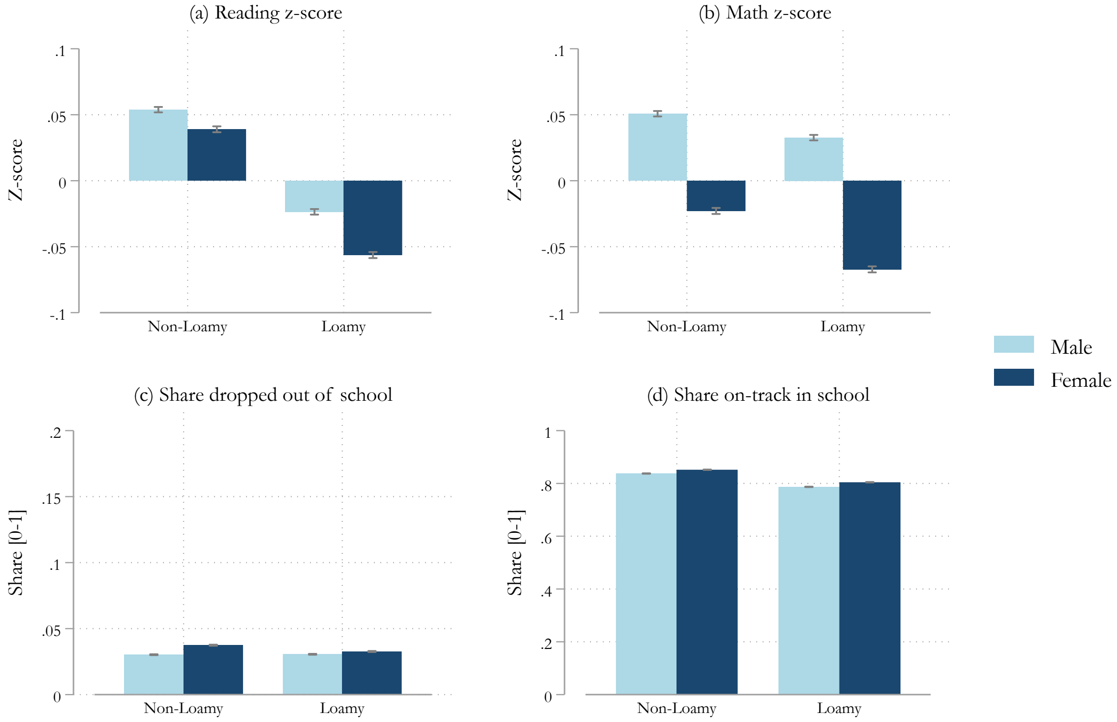

Figure 2: Baseline differences in educational attainment by soil type
(Note: Figure 2 shows differences in means for outcome variables by child's gender and district's soil type. Loamy districts have higher than median area under loamy soil, which drives relatively lower female and child labour force participation.)

Table 1: Effects of Early Life Positive Shock Exposure on Learning Outcomes

	Reading: Z-Score	Math: Z-Score	Drop Out	On Track	Attends Extra Tuition
Panel A: Female sample					
Early Life Shock	0.0018	0.0016	0.0023**	-0.0070***	0.0077***
	(0.36)	(0.29)	(2.42)	(-7.07)	(6.14)
Loamy × Early Life Shock	0.0136*	0.0237***	0.0013	0.0062***	-0.0058***
	(1.87)	(2.86)	(1.05)	(4.25)	(-3.09)
Constant	98.6509***	151.4059***	-0.9510**	-0.2834	10.3304***
	(20.05)	(24.48)	(-2.25)	(-0.48)	(8.07)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Early Life Shock	0.0052	0.0049	0.0038***	-0.0060***	0.0099***
	(1.19)	(0.98)	(5.03)	(-6.26)	(8.19)
Loamy × Early Life Shock	0.0079	0.0194**	-0.0011	0.0054***	-0.0048**
	(1.17)	(2.55)	(-0.95)	(3.83)	(-2.49)
Constant	106.3087***	140.5075***	-0.5484*	1.0027	7.7662***
	(24.69)	(25.89)	(-1.72)	(1.64)	(5.47)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 1 shows effects of early life rainfall shocks and soil type on educational outcomes for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing rainfall shocks in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca (paved) road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 2: Effects of Early Life and Contemporaneous Shock Exposure on Learning Outcomes

	Reading: Z-Score	Math: Z-Score	Drop Out	On Track	Attends Extra Tuition
Panel A: Female sample					
Rainfall Shock	-0.0266***	-0.0269***	0.0020**	-0.0025*	-0.0071***
	(-3.60)	(-2.62)	(2.29)	(-1.88)	(-3.00)
Loamy × Rainfall Shock	-0.0135	-0.0459***	-0.0014	0.0051***	0.0107***
	(-1.37)	(-3.73)	(-1.16)	(3.12)	(3.01)
Early Life Shock	0.0020	0.0031	0.0023**	-0.0072***	0.0072***
	(0.40)	(0.54)	(2.44)	(-7.26)	(5.72)
Loamy × Early Life Shock	0.0120*	0.0190**	0.0015	0.0066***	-0.0048**
	(1.67)	(2.35)	(1.20)	(4.46)	(-2.50)
Rainfall Shock × Early Life Shock	-0.0120***	-0.0084	0.0031***	-0.0002	-0.0014
	(-2.65)	(-1.59)	(2.90)	(-0.19)	(-0.92)
Loamy × Rainfall Shock × Early Life Shock	0.0116*	0.0043	0.0006	0.0009	0.0029
	(1.91)	(0.57)	(0.41)	(0.67)	(1.34)
Constant	104.2226***	159.9673***	-1.2030***	-0.3837	10.5575***
	(20.23)	(24.80)	(-2.82)	(-0.60)	(7.91)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Rainfall Shock	-0.0202***	-0.0206**	0.0024***	-0.0033***	-0.0074***
	(-2.61)	(-2.00)	(3.40)	(-2.61)	(-2.84)
Loamy × Rainfall Shock	-0.0114	-0.0389***	-0.0019**	0.0044***	0.0094**
	(-1.18)	(-3.33)	(-2.03)	(2.63)	(2.47)
Early Life Shock	0.0053	0.0060	0.0038***	-0.0062***	0.0095***
	(1.22)	(1.19)	(5.09)	(-6.43)	(7.79)
Loamy × Early Life Shock	0.0066	0.0155**	-0.0011	0.0057***	-0.0038*
	(0.99)	(2.06)	(-0.92)	(4.01)	(-1.92)
Rainfall Shock × Early Life Shock	-0.0038	-0.0013	0.0017**	-0.0002	0.0009
	(-0.81)	(-0.22)	(2.47)	(-0.27)	(0.54)
Loamy × Rainfall Shock × Early Life Shock	0.0068	-0.0021	0.0005	0.0009	0.0018
	(1.11)	(-0.28)	(0.46)	(0.67)	(0.78)
Constant	110.4820***	147.2868***	-0.7736**	1.0920*	8.0023***
	(24.16)	(25.78)	(-2.41)	(1.66)	(5.38)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 2 shows effects of early life rainfall shocks, contemporaneous rainfall shocks and soil type for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Rainfall Shock* is defined as -1 = Drought, 0 = Normal, 1 = Flood for each district-year. Reading and Math scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 3: Effects of Early Life Positive Shock Exposure on Principal Activity Status

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Early Life Shock	0.007***	0.003***	0.017***
	(4.38)	(3.90)	(9.22)
Loamy × Early Life Shock	-0.004**	-0.004***	-0.008**
	(-2.02)	(-2.98)	(-2.40)
Constant	-0.017***	-0.024***	-0.122***
	(-3.32)	(-5.72)	(-11.93)
Observations	79986	79986	79986
Mean of Dep. Var.	0.016	0.011	0.081
Panel B: Male sample			
Early Life Shock	0.016***	0.007***	0.000
	(8.75)	(6.94)	(0.85)
Loamy × Early Life Shock	-0.011***	-0.004**	-0.001
	(-4.01)	(-2.42)	(-1.35)
Constant	-0.067***	-0.070***	0.004
	(-10.07)	(-13.39)	(1.53)
Observations	92340	92340	92340
Mean of Dep. Var.	0.038	0.024	0.007

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 3 shows effects of early life rainfall shocks and soil type on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. Outcomes are indicators defined using the Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Table 4: Effects of Early Life and Contemporaneous Shock Exposure on Principal Activity Status

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Rainfall Shock	0.001	-0.003**	0.005
	(0.47)	(-2.10)	(1.40)
Loamy × Rainfall Shock	-0.000	0.002	0.004
	(-0.02)	(1.37)	(0.93)
Early Life Shock	0.006***	0.003***	0.018***
	(4.01)	(3.18)	(8.82)
Loamy × Early Life Shock	-0.004*	-0.003***	-0.009***
	(-1.84)	(-2.59)	(-2.71)
Rainfall Shock × Early Life Shock	0.002*	0.002**	-0.001
	(1.76)	(2.06)	(-0.68)
Loamy × Rainfall Shock × Early Life Shock	-0.001	-0.001	0.006**
	(-1.02)	(-1.16)	(2.10)
Constant	-0.018***	-0.023***	-0.126***
	(-3.34)	(-5.60)	(-12.23)
Observations	79986	79986	79986
Mean of Dep. Var.	0.016	0.011	0.081
Panel B: Male sample			
Rainfall Shock	-0.000	0.002	-0.000
	(-0.19)	(1.35)	(-0.14)
Loamy × Rainfall Shock	-0.002	-0.004**	0.004***
	(-0.55)	(-2.17)	(2.59)
Early Life Shock	0.016***	0.007***	0.000
	(8.07)	(6.43)	(0.80)
Loamy × Early Life Shock	-0.011***	-0.005***	-0.001
	(-3.93)	(-2.71)	(-1.56)
Rainfall Shock × Early Life Shock	0.003	0.002**	0.000
	(1.52)	(2.18)	(0.02)
Loamy × Rainfall Shock × Early Life Shock	0.001	0.001	0.001
	(0.32)	(0.56)	(1.30)
Constant	-0.066***	-0.070***	0.003
	(-10.11)	(-13.34)	(1.06)
Observations	92340	92340	92340
Mean of Dep. Var.	0.038	0.024	0.007

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 4 shows effects of early life rainfall shocks and soil type on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Rainfall Shock* is defined as -1 = Drought, 0 = Normal, 1 = Flood. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Appendix

6.1 Balance Tables

Table 5: Differences in ASER Variables: High and Low Loam Districts

	(1)		(2)		T-test
	Non-Loamy		**Loamy**		Difference
Variable	N	Mean/SE	N	Mean/SE	(1)-(2)
Female	1749353	0.466 (0.000)	1891591	0.467 (0.000)	-0.001
Age	1749353	10.393 (0.002)	1891591	10.269 (0.002)	0.123***
Reading Z-Score	1563583	0.047 (0.001)	1694488	-0.039 (0.001)	0.086***
Math Z-Score	1557950	0.016 (0.001)	1687734	-0.014 (0.001)	0.031***
Dropped Out	1749353	0.034 (0.000)	1891591	0.032 (0.000)	0.002***
Attends Extra Tuition	1253673	0.160 (0.000)	1397623	0.257 (0.000)	-0.097***
Public School	1749353	0.665 (0.000)	1891591	0.618 (0.000)	0.047***
Wealth Index	1685144	0.127 (0.001)	1815279	-0.085 (0.001)	0.212***
HH has First-born Female	1749353	0.487 (0.000)	1891591	0.485 (0.000)	0.003***
Mother Gone to School	1687935	0.510 (0.000)	1819454	0.492 (0.000)	0.018***
Normal Rainfall	1749353	0.409 (0.000)	1891591	0.322 (0.000)	0.087***
Negative Rainfall Shock	1296078	0.205 (0.000)	1391317	0.289 (0.000)	-0.084***
Positive Rainfall Shock	1296078	0.243 (0.000)	1391317	0.273 (0.000)	-0.030***
Early Life Shock Index	1296078	-0.014 (0.001)	1391317	0.013 (0.001)	-0.027***

Notes: The value displayed for t-tests are the differences in the means across loamy and non-loamy districts. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Variables are from the ASER data.

Table 6: Differences in NSS Variables: High and Low Loam Districts

Variable	(1) Non-Loamy N	(1) Non-Loamy Mean/SE	(2) Loamy N	(2) Loamy Mean/SE	T-test Difference (1)-(2)
Female	289129	0.489	336495	0.490	-0.001
		(0.001)		(0.001)	
Age	289093	28.500	336458	27.539	0.961***
		(0.036)		(0.033)	
Adult Paid Employment (M)	89701	0.760	99030	0.762	-0.003
		(0.001)		(0.001)	
Adult Paid Employment (F)	90176	0.217	101532	0.158	0.059***
		(0.001)		(0.001)	
Child Paid Employment (M)	58176	0.051	72727	0.044	0.007***
		(0.001)		(0.001)	
Child Paid Employment (F)	51076	0.024	63206	0.013	0.011***
		(0.001)		(0.000)	
Adult Unpaid Work on HH Enterprise (M)	89701	0.116	99030	0.105	0.011***
		(0.001)		(0.001)	
Adult Unpaid Work on HH Enterprise (F)	90176	0.137	101532	0.083	0.054***
		(0.001)		(0.001)	
Child Unpaid Work on HH Enterprise (M)	58176	0.031	72727	0.027	0.004***
		(0.001)		(0.001)	
Child Unpaid Work on HH Enterprise (F)	51076	0.015	63206	0.010	0.006***
		(0.001)		(0.000)	
Adult Full-time Domestic Work (M)	89701	0.006	99030	0.007	-0.001***
		(0.000)		(0.000)	
Adult Full-time Domestic Work (F)	90176	0.552	101532	0.669	-0.116***
		(0.002)		(0.001)	
Child Full-time Domestic Work (M)	58176	0.005	72727	0.007	-0.002***
		(0.000)		(0.000)	
Child Full-time Domestic Work (F)	51076	0.083	63206	0.086	-0.004**
		(0.001)		(0.001)	
HH Owns Land	289129	0.939	336495	0.958	-0.019***
		(0.000)		(0.000)	
Agricultural Household	289129	0.521	336495	0.490	0.031***
		(0.001)		(0.001)	
NREGA Operational	289129	0.825	336495	0.860	-0.035***
		(0.001)		(0.001)	

Notes: The value displayed for t-tests are the differences in the means across loamy and non-loamy districts. ***, **, and * indicate significance at the 1, 5, and 10 percent critical level. Variables are from the NSS data.

6.2 Results Using a Continuous Measure of Soil Loaminess

Table 7: Effect of Early Life Positive Shocks on Learning Outcomes: Share of Loamy Soil

	Reading: Z-Score	**Math: Z-Score**	**Drop Out**	**On Track**	**Attends Extra Tuition**
Panel A: Female sample					
Early Life Shock	-0.0029	-0.0094	0.0014	-0.0111***	0.0116***
	(-0.36)	(-0.97)	(0.91)	(-8.07)	(5.90)
Share of loamy	0.0173	0.0345**	0.0024	0.0109***	-0.0103***
soil × Early Life Shock	(1.54)	(2.57)	(1.12)	(5.25)	(-3.60)
Constant	98.6943***	151.4576***	-0.9501**	-0.2807	10.3268***
	(20.05)	(24.47)	(-2.25)	(-0.47)	(8.07)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Early Life Shock	0.0053	-0.0035	0.0057***	-0.0103***	0.0136***
	(0.72)	(-0.40)	(5.06)	(-7.63)	(7.16)
Share of loamy	0.0057	0.0274**	-0.0038**	0.0107***	-0.0093***
soil × Early Life Shock	(0.54)	(2.23)	(-2.23)	(5.26)	(-3.25)
Constant	106.3463***	140.5506***	-0.5442*	1.0025	7.7710***
	(24.68)	(25.88)	(-1.71)	(1.64)	(5.48)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 7 shows effects of early life rainfall shocks and soil loaminess on learning outcomes for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Share of loamy soil* is the fraction of area in the district under loamy soil. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 8: Effect of Early Life and Contemporaneous Shocks on Learning Outcomes: Share of Loamy Soil

	Reading: Z-Score	Math: Z-Score	Drop Out	On Track	Attends Extra Tuition
Panel A: Female sample					
Rainfall Shock	-0.0136	0.0229	0.0026	-0.0064***	-0.0079*
	(-1.07)	(1.25)	(1.49)	(-2.89)	(-1.88)
Share of loamy soil × Rainfall Shock	-0.0286*	-0.1058***	-0.0019	0.0095***	0.0095
	(-1.70)	(-4.67)	(-0.86)	(3.36)	(1.56)
Early Life Shock	-0.0014	-0.0041	0.0013	-0.0116***	0.0111***
	(-0.17)	(-0.43)	(0.85)	(-8.35)	(5.62)
Share of loamy soil × Early Life Shock	0.0141	0.0255*	0.0027	0.0116***	-0.0094***
	(1.28)	(1.93)	(1.30)	(5.49)	(-3.25)
Rainfall Shock × Early Life Shock	-0.0198***	-0.0137	0.0042**	0.0002	-0.0031
	(-2.78)	(-1.61)	(2.05)	(0.13)	(-1.15)
Share of loamy soil × Rainfall Shock × Early Life Shock	0.0202**	0.0101	-0.0010	0.0002	0.0046
	(2.18)	(0.87)	(-0.38)	(0.12)	(1.28)
Constant	104.4068***	160.5571***	-1.2168***	-0.4301	10.5166***
	(20.27)	(24.85)	(-2.84)	(-0.68)	(7.84)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Rainfall Shock	-0.0032	0.0244	0.0037***	-0.0058**	-0.0069
	(-0.23)	(1.33)	(2.89)	(-2.56)	(-1.48)
Share of loamy soil × Rainfall Shock	-0.0329*	-0.0941***	-0.0034**	0.0070**	0.0067
	(-1.92)	(-4.30)	(-2.05)	(2.34)	(1.01)
Early Life Shock	0.0068	0.0010	0.0057***	-0.0107***	0.0131***
	(0.92)	(0.11)	(5.12)	(-7.76)	(6.87)
Share of loamy soil × Early Life Shock	0.0028	0.0197	-0.0037**	0.0111***	-0.0082***
	(0.27)	(1.61)	(-2.22)	(5.39)	(-2.86)
Rainfall Shock × Early Life Shock	-0.0112	-0.0025	0.0021*	-0.0004	-0.0015
	(-1.48)	(-0.27)	(1.73)	(-0.29)	(-0.57)
Share of loamy soil × Rainfall Shock × Early Life Shock	0.0156	-0.0010	-0.0003	0.0010	0.0047
	(1.61)	(-0.08)	(-0.18)	(0.52)	(1.28)
Constant	110.7785***	147.8676***	-0.7621**	1.0616	7.9937***
	(24.25)	(25.82)	(-2.38)	(1.62)	(5.35)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 8 shows effects of early life rainfall shocks, contemporaneous rainfall shocks and soil loaminess on educational outcomes for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Share of loamy soil* is the area in the district under loamy soil. *Rainfall Shock* defined as -1 = Drought, 0 = Normal, 1 = Flood. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 9: Effect of Early Life Positive Shocks on Principal Activity Status: Share of Loamy Soil

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Early Life Shock	0.010***	0.006***	0.024***
	(4.68)	(4.57)	(7.49)
Share of loamy soil × Early Life Shock	-0.007***	-0.007***	-0.016***
	(-3.00)	(-3.84)	(-2.99)
Constant	-0.017***	-0.024***	-0.122***
	(-3.31)	(-5.71)	(-11.93)
Observations	79986	79986	79986
Mean of Dep. Var.	0.016	0.011	0.081
Panel B: Male sample			
Early Life Shock	0.024***	0.012***	0.001
	(8.29)	(6.45)	(1.41)
Share of loamy soil × Early Life Shock	-0.019***	-0.010***	-0.002
	(-4.57)	(-3.59)	(-1.45)
Constant	-0.067***	-0.070***	0.004
	(-10.11)	(-13.39)	(1.52)
Observations	92340	92340	92340
Mean of Dep. Var.	0.038	0.024	0.007

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 9 shows effects of early life rainfall shocks and soil loaminess on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Share of loamy soil* is the fraction of area in the district under loamy soil. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Table 10: Effect of Early Life and Contemporaneous Shocks on Principal Activity Status: Share of Loamy Soil

	Employed With Pay	Unpaid Work in HH Enterprise	Domestic Duties Only
Panel A: Female sample			
Rainfall Shock	0.002	-0.006*	0.002
	(0.73)	(-1.96)	(0.43)
Share of loamy soil × Rainfall Shock	-0.002	0.006*	0.007
	(-0.50)	(1.66)	(0.95)
Early Life Shock	0.009***	0.006***	0.025***
	(4.15)	(3.65)	(7.19)
Share of loamy soil × Early Life Shock	-0.006**	-0.007***	-0.018***
	(-2.58)	(-3.17)	(-3.26)
Rainfall Shock × Early Life Shock	0.004**	0.003	-0.006
	(2.07)	(1.45)	(-1.46)
Share of loamy soil × Rainfall Shock × Early Life Shock	-0.004*	-0.002	0.011**
	(-1.70)	(-0.96)	(2.08)
Constant	-0.018***	-0.023***	-0.126***
	(-3.35)	(-5.56)	(-12.24)
Observations	79986	79986	79986
Mean of Dep. Var.	0.016	0.011	0.081
Panel B: Male sample			
Rainfall Shock	0.004	0.006**	-0.003**
	(1.05)	(2.22)	(-2.06)
Share of loamy soil × Rainfall Shock	-0.007	-0.009**	0.008***
	(-1.60)	(-2.59)	(2.70)
Early Life Shock	0.024***	0.011***	0.001*
	(8.02)	(6.12)	(1.73)
Share of loamy soil × Early Life Shock	-0.020***	-0.010***	-0.002*
	(-4.63)	(-3.75)	(-1.85)
Rainfall Shock × Early Life Shock	0.000	0.003	-0.001*
	(0.17)	(1.39)	(-1.93)
Share of loamy soil × Rainfall Shock × Early Life Shock	0.003	0.000	0.003**
	(0.96)	(0.10)	(2.03)
Constant	-0.067***	-0.070***	0.003
	(-10.15)	(-13.36)	(1.07)
Observations	92340	92340	92340
Mean of Dep. Var.	0.038	0.024	0.007

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 10 shows effects of early life rainfall shocks, contemporary rainfall shocks and soil loaminess on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shock in the first 4 years of child's life, including birth year. *Share of loamy soil* is the fraction of area in the district under loamy soil. *Rainfall Shock* defined as -1 = Drought, 0 = Normal, 1 = Flood. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

6.3 Results using an alternative definition of early life shocks

Table 11: Effects of Early Life Positive Shock Exposure on Learning Outcomes

	Reading: Z-Score	**Math: Z-Score**	**Drop Out**	**On Track**	**Attends Extra Tuition**
Panel A: Female sample					
Early Life Shock	0.0044	0.0056	0.0069**	-0.0219***	0.0261***
(avg.)	(0.27)	(0.30)	(2.18)	(-6.79)	(6.38)
Loamy ×	0.0460*	0.0787***	0.0047	0.0208***	-0.0185***
Early Life Shock (avg.)	(1.94)	(2.92)	(1.12)	(4.34)	(-3.02)
Constant	98.6599***	151.5406***	-0.9693**	-0.2223	10.4360***
	(20.05)	(24.49)	(-2.29)	(-0.38)	(8.14)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Early Life Shock	0.0164	0.0154	0.0119***	-0.0187***	0.0327***
(avg.)	(1.15)	(0.95)	(4.92)	(-5.95)	(8.39)
Loamy ×	0.0265	0.0623**	-0.0040	0.0178***	-0.0151**
Early Life Shock (avg.)	(1.21)	(2.52)	(-1.04)	(3.88)	(-2.45)
Constant	106.3430***	140.5106***	-0.5689*	1.0605*	7.8539***
	(24.68)	(25.88)	(-1.79)	(1.73)	(5.54)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 11 shows effects of early life rainfall shocks and soil type on educational outcomes for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock (avg.)* is a simple average of the variables capturing shock in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 12: Effects of Early Life and Contemporaneous Shock Exposure on Learning Outcomes

	Reading: Z-Score	**Math: Z-Score**	**Drop Out**	**On Track**	**Attends Extra Tuition**
Panel A: Female sample					
Rainfall Shock	-0.0299***	-0.0294***	0.0028***	-0.0024**	-0.0074***
	(-3.95)	(-2.86)	(3.30)	(-2.03)	(-3.10)
Loamy × Rainfall Shock	-0.0100	-0.0444***	-0.0011	0.0052***	0.0116***
	(-1.00)	(-3.63)	(-1.03)	(3.29)	(3.30)
Early Life Shock (avg.)	0.0048	0.0099	0.0069**	-0.0226***	0.0245***
	(0.30)	(0.54)	(2.20)	(-6.97)	(5.95)
Loamy × Early Life Shock (avg.)	0.0406*	0.0630**	0.0052	0.0221***	-0.0149**
	(1.73)	(2.38)	(1.25)	(4.54)	(-2.38)
Rainfall Shock × Early Life Shock (avg.)	-0.0378**	-0.0284	0.0094***	0.0004	-0.0040
	(-2.56)	(-1.62)	(2.74)	(0.14)	(-0.80)
Loamy × Rainfall Shock × Early Life Shock (avg.)	0.0373*	0.0150	0.0024	0.0010	0.0103
	(1.89)	(0.62)	(0.52)	(0.24)	(1.47)
Constant	104.1878***	160.0570***	-1.2178***	-0.3315	10.6486***
	(20.22)	(24.80)	(-2.85)	(-0.52)	(7.98)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Rainfall Shock	-0.0212***	-0.0209**	0.0029***	-0.0033***	-0.0071***
	(-2.71)	(-2.06)	(3.94)	(-2.64)	(-2.77)
Loamy × Rainfall Shock	-0.0093	-0.0390***	-0.0018*	0.0043***	0.0101***
	(-0.93)	(-3.37)	(-1.92)	(2.60)	(2.70)
Early Life Shock (avg.)	0.0166	0.0187	0.0120***	-0.0193***	0.0314***
	(1.16)	(1.15)	(4.99)	(-6.11)	(7.96)
Loamy × Early Life Shock (avg.)	0.0223	0.0493**	-0.0039	0.0187***	-0.0115*
	(1.03)	(2.01)	(-1.02)	(4.02)	(-1.83)
Rainfall Shock × Early Life Shock (avg.)	-0.0122	-0.0043	0.0056**	0.0006	0.0026
	(-0.79)	(-0.22)	(2.54)	(0.20)	(0.52)
Loamy × Rainfall Shock × Early Life Shock (avg.)	0.0232	-0.0024	0.0013	-0.0003	0.0075
	(1.16)	(-0.10)	(0.41)	(-0.08)	(1.01)
Constant	110.4780***	147.2300***	-0.7952**	1.1389*	8.0770***
	(24.16)	(25.76)	(-2.48)	(1.73)	(5.44)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 12 shows effects of early life rainfall shocks, contemporaneous rainfall shocks and soil type for children between the ages of 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock (avg.)* is a simple average of the variables capturing shock in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Rainfall Shock* is defined as -1 = Drought, 0 = Normal, 1 = Flood for each district-year. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca road, a bank, a ration shop and electric supply. District and year fixed effects are included.

6.4 Results on Adult Labor Force Outcomes

Table 13: Effect of Contemporaneous Shocks on Adult Principal Activity Status: Loamy and Non-Loamy Districts

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Rainfall Shock	0.001	-0.009**	0.009
	(0.26)	(-2.18)	(1.40)
Loamy × Rainfall Shock	0.003	0.011**	-0.014*
	(0.57)	(2.13)	(-1.72)
Constant	0.511***	-0.083***	0.318***
	(36.79)	(-5.68)	(17.58)
Observations	176278	176278	176278
Mean of Dep. Var.	0.196	0.115	0.633
Panel B: Male sample			
Rainfall Shock	0.001	-0.002	0.000
	(0.32)	(-0.61)	(0.89)
Loamy × Rainfall Shock	0.004	-0.002	0.000
	(1.02)	(-0.45)	(0.03)
Constant	0.631***	0.105***	0.006***
	(58.21)	(14.66)	(4.46)
Observations	172568	172568	172568
Mean of Dep. Var.	0.786	0.119	0.005

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 13 shows effects of contemporary rainfall shocks and soil loaminess on labour market outcomes for adults (19-65yo). The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Rainfall Shock* is defined as -1 = Drought, 0 = Normal, 1 = Flood. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

6.5 Labour Market Results: Separating Positive and Negative Shocks

Table 14: Effects of Early Life Shocks and *Negative* Contemporaneous Shock Exposure on Children's Principal Activity Status

	Employed With Pay	Unpaid Work in HH Enterprise	Domestic Duties Only
Panel A: Female sample			
Negative Shock	-0.006*	0.003	0.001
	(-1.79)	(0.84)	(0.15)
Loamy × Negative Shock	0.003	-0.005	-0.006
	(0.88)	(-1.47)	(-0.59)
Early Life Shock	0.009***	0.002*	0.015***
	(3.87)	(1.90)	(6.25)
Loamy × Early Life Shock	-0.004	-0.003*	-0.001
	(-1.30)	(-1.82)	(-0.28)
Negative Shock × Early Life Shock	-0.007***	-0.000	0.009**
	(-2.85)	(-0.01)	(2.06)
Loamy × Negative Shock × Early Life Shock	0.002	0.001	-0.023***
	(0.52)	(0.26)	(-3.90)
Constant	-0.016***	-0.027***	-0.118***
	(-2.80)	(-5.03)	(-10.43)
Observations	50574	50574	50574
Mean of Dep. Var.	0.017	0.013	0.077
Panel B: Male sample			
Negative Shock	0.002	-0.003	0.001
	(0.31)	(-0.86)	(0.29)
Loamy × Negative Shock	0.001	0.001	-0.007**
	(0.12)	(0.30)	(-2.11)
Early Life Shock	0.016***	0.007***	0.000
	(7.39)	(6.15)	(0.49)
Loamy × Early Life Shock	-0.007**	-0.005**	-0.000
	(-2.32)	(-2.17)	(-0.41)
Negative Shock × Early Life Shock	-0.003	-0.002	0.001
	(-1.03)	(-1.29)	(0.78)
Loamy × Negative Shock × Early Life Shock	-0.009**	-0.002	-0.002
	(-2.20)	(-0.67)	(-1.29)
Constant	-0.066***	-0.070***	0.005
	(-8.79)	(-11.19)	(1.42)
Observations	58257	58257	58257
Mean of Dep. Var.	0.039	0.025	0.006

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 14 shows effects of positive early life rainfall shocks and negative contemporaneous shocks by soil type on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shocks in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Negative Shock* is defined as 1 = Drought, 0 = Normal. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Table 15: Effects of Early Life Shocks and *Positive* Contemporaneous Shock Exposure on Children's Principal Activity Status

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Positive Shock	-0.001	-0.003*	0.008*
	(-0.54)	(-1.95)	(1.70)
Loamy × Positive Shock	0.002	0.000	0.003
	(0.68)	(0.06)	(0.40)
Early Life Shock	0.008***	0.003**	0.015***
	(3.70)	(2.25)	(6.62)
Loamy × Early Life Shock	-0.003	-0.003**	-0.005
	(-1.23)	(-2.12)	(-1.10)
Positive Shock × Early Life Shock	-0.000	0.003**	0.003
	(-0.24)	(1.99)	(1.00)
Loamy × Positive Shock × Early Life Shock	-0.002	-0.002	-0.003
	(-0.84)	(-0.85)	(-0.71)
Constant	-0.019***	-0.023***	-0.129***
	(-3.21)	(-5.30)	(-12.04)
Observations	69530	69530	69530
Mean of Dep. Var.	0.017	0.012	0.082
Panel B: Male sample			
Positive Shock	0.001	0.003	0.001
	(0.37)	(1.30)	(0.64)
Loamy × Positive Shock	-0.002	-0.008**	0.002
	(-0.63)	(-2.37)	(0.94)
Early Life Shock	0.016***	0.007***	-0.000
	(7.62)	(6.06)	(-0.22)
Loamy × Early Life Shock	-0.007**	-0.004**	-0.001
	(-2.47)	(-2.15)	(-1.02)
Positive Shock × Early Life Shock	0.003	0.002	0.001
	(1.34)	(1.31)	(1.18)
Loamy × Positive Shock × Early Life Shock	-0.005*	0.000	0.000
	(-1.75)	(0.16)	(0.12)
Constant	-0.064***	-0.071***	0.001
	(-9.86)	(-12.76)	(0.42)
Observations	79921	79921	79921
Mean of Dep. Var.	0.037	0.024	0.007

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 15 shows effects of positive early life rainfall shocks and positive contemporaneous shocks by soil type on labour market outcomes for children between the ages of 5 and 18. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Early Life Shock* is an index created using principal component analysis of the variables capturing shocks in the first 4 years of child's life, including birth year. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Positive Shock* is defined as 1 = Flood, 0 = Normal. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Table 16: Effect of Negative Shocks on Adult Principal Activity Status: Loamy and Non-Loamy Districts

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Negative Shock	-0.005	0.004	-0.004
	(-0.41)	(0.47)	(-0.23)
Loamy × Negative Shock	-0.005	-0.014	0.024
	(-0.42)	(-1.25)	(1.31)
Constant	0.509***	-0.082***	0.312***
	(30.08)	(-5.22)	(15.09)
Observations	111527	111527	111527
Mean of Dep. Var.	0.201	0.118	0.622
Panel B: Male sample			
Negative Shock	0.009	-0.004	-0.000
	(1.33)	(-0.63)	(-0.20)
Loamy × Negative Shock	-0.013	0.011	-0.001
	(-1.48)	(1.28)	(-0.31)
Constant	0.625***	0.106***	0.006***
	(50.67)	(12.06)	(3.01)
Observations	109653	109653	109653
Mean of Dep. Var.	0.785	0.117	0.005

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 16 shows effects of negative rainfall shocks and soil loaminess on labour market outcomes for adults (19-65yo). The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Negative Shock* is defined as 1 = Drought and 0 = Normal. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

Table 17: Effect of Positive Shocks on Adult Principal Activity Status: Loamy and Non-Loamy Districts

	Employed With Pay	**Unpaid Work in HH Enterprise**	**Domestic Duties Only**
Panel A: Female sample			
Positive Shock	0.004	-0.012*	0.009
	(0.56)	(-1.87)	(1.04)
Loamy × Positive Shock	-0.003	0.009	-0.003
	(-0.32)	(1.01)	(-0.23)
Constant	0.519***	-0.082***	0.315***
	(35.97)	(-5.34)	(16.53)
Observations	154400	154400	154400
Mean of Dep. Var.	0.200	0.118	0.625
Panel B: Male sample			
Positive Shock	0.009**	-0.008**	0.000
	(2.08)	(-2.09)	(0.65)
Loamy × Positive Shock	-0.006	0.008	0.000
	(-1.03)	(1.54)	(0.22)
Constant	0.633***	0.106***	0.006***
	(55.28)	(13.97)	(3.97)
Observations	150825	150825	150825
Mean of Dep. Var.	0.785	0.120	0.005

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 17 shows effects of positive rainfall shocks and soil loaminess on labour market outcomes for adults (19-65yo). The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. *Positive Shock* is defined as 1 = Flood and 0 = Normal. Outcomes are indicators defined using Principal Activity Status codes in the NSS data. Individual level controls include age and marital status. Household controls include whether the household owns land, religion, caste, household size and whether the household is an agricultural household. District and survey sub-round fixed effects are included.

6.6 Placebo Checks: Randomly Assigned Rainfall Shocks

Table 18: Placebo Check: Randomly Assigned Early Life Shocks on Learning Outcomes

	Reading: Z-Score	**Math: Z-Score**	**Drop Out**	**On Track**	**Attends Extra Tuition**
Panel A: Female sample					
Random: Early Life Shock	0.0011 (1.00)	0.0010 (0.82)	-0.0001 (-0.53)	-0.0001 (-0.27)	0.0013** (2.37)
Loamy × Random: Early Life Shock	0.0004 (0.20)	-0.0013 (-0.73)	0.0004 (1.09)	-0.0000 (-0.03)	-0.0025*** (-3.02)
Constant	96.9272*** (19.81)	148.7063*** (24.12)	-1.5355*** (-4.01)	0.6381 (1.16)	9.1269*** (7.17)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Random: Early Life Shock	-0.0003 (-0.28)	0.0001 (0.05)	-0.0001 (-0.67)	0.0006 (1.56)	-0.0014*** (-2.86)
Loamy × Random: Early Life Shock	0.0003 (0.15)	0.0010 (0.66)	0.0002 (0.76)	-0.0007 (-1.31)	0.0011 (1.45)
Constant	104.4083*** (23.98)	137.5397*** (24.90)	-1.1889*** (-4.15)	1.7748*** (3.11)	5.9800*** (4.25)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 18 presents placebo checks. Results show the effect of *randomly assigned* early life rainfall shocks and soil type on children between the ages 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca (paved) road, a bank, a ration shop and electric supply. District and year fixed effects are included.

Table 19: Placebo Check: Randomly Assigned Early Life and Contemporaneous Rainfall Shocks on Learning Outcomes

	Reading: Z-Score	Math: Z-Score	Drop Out	On Track	Attends Extra Tuition
Panel A: Female sample					
Random: Rainfall Shock	-0.0006	0.0014	-0.0001	0.0001	-0.0002
	(-0.39)	(0.90)	(-0.24)	(0.18)	(-0.33)
Loamy × Random: Rainfall Shock	-0.0009	-0.0028	0.0002	0.0001	0.0005
	(-0.45)	(-1.29)	(0.38)	(0.15)	(0.49)
Random: Early Life Shock	0.0011	0.0010	-0.0001	-0.0001	0.0013**
	(1.00)	(0.82)	(-0.53)	(-0.26)	(2.37)
Loamy × Random: Early Life Shock	0.0003	-0.0013	0.0004	-0.0000	-0.0025***
	(0.19)	(-0.74)	(1.09)	(-0.03)	(-3.02)
Random: Rainfall Shock × Random: Early Life Shock	-0.0005	-0.0022	-0.0004	-0.0003	-0.0001
	(-0.31)	(-1.31)	(-1.35)	(-0.71)	(-0.08)
Loamy × Random: Rainfall Shock × Random: Early Life Shock	0.0032	0.0036	0.0005	-0.0002	-0.0003
	(1.45)	(1.58)	(1.40)	(-0.36)	(-0.27)
Constant	96.9251***	148.7048***	-1.5359***	0.6383	9.1268***
	(19.81)	(24.12)	(-4.01)	(1.16)	(7.17)
Observations	918521	915702	1125817	982891	767458
Mean of Dep. Var.	0.057	-0.003	0.034	0.868	0.201
Panel B: Male sample					
Random: Rainfall Shock	0.0006	0.0009	0.0001	-0.0002	-0.0004
	(0.40)	(0.61)	(0.22)	(-0.38)	(-0.62)
Loamy × Random: Rainfall Shock	0.0008	0.0009	-0.0002	-0.0004	0.0011
	(0.42)	(0.45)	(-0.51)	(-0.53)	(1.13)
Random: Early Life Shock	-0.0003	0.0000	-0.0001	0.0006	-0.0014***
	(-0.28)	(0.05)	(-0.67)	(1.56)	(-2.86)
Loamy × Random: Early Life Shock	0.0003	0.0010	0.0002	-0.0007	0.0011
	(0.15)	(0.66)	(0.76)	(-1.32)	(1.45)
Random: Rainfall Shock × Random: Early Life Shock	-0.0006	-0.0002	0.0002	-0.0007*	-0.0002
	(-0.38)	(-0.14)	(0.86)	(-1.84)	(-0.24)
Loamy × Random: Rainfall Shock × Random: Early Life Shock	-0.0001	-0.0019	-0.0003	-0.0002	0.0007
	(-0.03)	(-0.92)	(-0.87)	(-0.37)	(0.73)
Constant	104.4081***	137.5404***	-1.1890***	1.7755***	5.9797***
	(23.98)	(24.90)	(-4.15)	(3.11)	(4.25)
Observations	1029577	1026469	1274205	1114690	864386
Mean of Dep. Var.	0.062	0.071	0.031	0.851	0.233

Note: * 0.1 ** 0.05 *** 0.01. Standard errors are clustered at the district level. Table 19 presents placebo checks. Results show the effect of *randomly assigned* early life rainfall shocks, *randomly assigned* contemporaneous rainfall shocks and soil type on children between the ages 5 and 16. The sample is split by gender, and Panel A shows results for female children, Panel B shows results for male children. *Loamy* takes value 1 if the fraction of area in the district under loamy soil is greater than the sample median. Reading and Maths scores are z-scores computed by age. *Drop Out* in an indicator for whether the child has dropped out of school, *On-Track* is an indicator for whether the child is in the age-appropriate grade and *Attends Extra Tuition* is an indicator for whether the child is enrolled in tuition classes outside of school. Individual level controls include age, school grade, school type, and for all outcomes except drop out - an indicator for being enrolled in school. Household controls include indicator for whether the mother has gone to school, sibling cohort composition, whether the household has a first born female, number of children and a household wealth index. Village level controls include indicators for whether the village has a pucca (paved) road, a bank, a ration shop and electric supply. District and year fixed effects are included.