The impact of drought on human capital in rural India

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ONLINE APPENDIX

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1 Theoretical model of the impact of drought on human capital

To illustrate the mechanisms through which a drought shock can affect children's education, we follow the model developed in Skoufias (2001) and also used by Baez & Santos (2007). It is a simple single-period model of household decision making with full information and a unitary household. Parents maximize the consumption of the household (C) and the future earnings of the children (E). In this model, parents care only indirectly about their children's education because they will receive a fraction ϕ of the future earnings. Parents then maximize the utility function:

$$MaxU = U(C, E) \tag{A1}$$

where U'>0 and U"<0 for both C and E. Human capital of a child is a combination of education and health. It has two components: S, the stock of human capital and H, the flow of human capital i.e., the investment in human capital. Future earnings of the child are assumed to be a linear combination of the amount of human capital (S+H) and their ability (χ).

$$E = \alpha(S + H) + \beta\chi \tag{A2}$$

where α and β are the weights associated with human capital and genetics respectively. Human capital investment comprises of expenditure on goods and services required for schooling such as books, transport, uniform, food, vaccines and medicines (X), time spent by the child in school or medical care (t_C), and time spent by the parents on children's learning and care (t_P). The marginal effect of X, t_C and t_P on the child's human capital is assumed to be positive. Human capital investment also depends on other factors such as θ : observed characteristics of the child like gender, age and cohort; χ : unobserved characteristics of the child; and δ : parents' education, household wealth and community characteristics like quality of schools, health facilities and prices. Thus, human capital investment can be represented as follows.

$$H = H(X, t_C, t_P; \theta, \chi, \delta) \tag{A3}$$

Household expenditure will equal household income and assets (wealth) at the optimum. This is used to derive the budget constraint. We first define expenditure and income and then form the budget constraint. Expenditure has two components: consumption of the household (C) and consumption of goods and services related to human capital (X). C is assumed to be the numeraire and the expenditure on X is thus $p_x XN$ where p_x is the vector of prices of human capital related goods and N is the number of children in a household. The household's assets are denoted by A. There are four possible sources of income: non labor income of the household (Y_{nl}), labor income of the parents ($W_P(T - Nt_P)$), labor income of all children ($NW_C(T - t_C)$) and a fraction of the labor income of adult children ($\phi N_A E$). Here, parents' and children's wages are denoted by W_P and W_C respectively and T is the total time endowment. Labor income of a child is equal to his/her wage multiplied by the time dedicated to working. Thus, this model allows for the possibility of a child to be both enrolled in school and working, a feature commonly observed in rural India. Bringing together expenditure, assets and income, the budget constraint is constructed as follows:

$$C + p_x XN = A + Y_{nl} + NW_C(T - t_C) + W_P(T - Nt_P) + \phi N_A E \tag{A4}$$

Households maximize utility i.e., equation (A1) subject to the constraints (A2), (A3) and (A4). They choose the levels of consumption (C), time allocated to human capital (t_C, t_P), and consumption of human capital related goods and services (X). The first order conditions obtained on solving this utility maximization problem are:

$$MRS_{CE} = \frac{U_E}{U_C} = N\left(\frac{W_C}{\alpha H_{t_C}} - \phi\right) = MC_{t_C} \tag{A5}$$

$$MRS_{CE} = \frac{U_E}{U_C} = N\left(\frac{W_P}{\alpha H_{t_P}} - \phi\right) = MC_{t_P} \tag{A6}$$

$$MRS_{CE} = \frac{U_E}{U_C} = N\left(\frac{p_x}{\alpha H_x} - \phi\right) = MC_X \tag{A7}$$

Therefore, at the optimum, the marginal rate of substitution between household consumption and child's future earnings equals the marginal cost of investing in the human capital of the child. Essentially, there is a trade off between current household consumption and future child earnings (Udry, 2006). The household will set the marginal cost associated with the time of the child, time of the parent and the consumption of human capital related goods all equal as a solution to the maximization problem. The effect of drought on household investment in children's education and consequently on the children's educational outcomes, operates through two main channels:

Drought as a shock to income and wages: When agricultural income declines, the model predicts a decline in educational investment. The loss of crops, decline in productivity, and disruption of schooling and health facilities increases the marginal cost of goods and services needed for human capital formation. (MC_{t_C}, MC_{t_P} and MC_X increase) Thus the marginal rate of substitution between household consumption and child's future earnings increases, causing a decline in investments on human capital. Since primary education is free in India, a decline in educational investment comes in the form of decreased investment in study material, school transportation, uniform, parent's time dedicated to the child's learning, and child's time dedicated to learning. (X, t_P and t_C) Additionally, health and nutritional investments may also decline, negatively affecting a child's learning ability and cognitive skills. Children may also stop going to school to work in household owned farms or take up other part time work. Child labor is a very prevalent and persistent problem in India in-spite of the recent reforms to education. Since it is common to find children simultaneously enrolled in school and working in their free time, child labor could substitute leisure and not necessarily schooling. This decline in education due to a decline in income is the *'income effect'* of drought. It is based on the underlying idea that increases in household income lead to increases in educational investment. However, this does not necessarily imply that increases in *wages* lead to increases in educational investment (Udry, 2006). When an increase in household income comes primarily from wages, a *'substitution effect'* is also at play. Higher wages reflect a higher opportunity cost of schooling and are associated with lower schooling rates (Psacharopoulos, 1997). A drought shock causes a slowdown in the economy that results in inflation and lower wages. (W_P and W_C fall, lowering the correspponding MC's and MRS_{CE}) The opportunity cost associated with human capital investment falls, encouraging children to stay in schools, leading to improved learning outcomes compared to a situation of good rainfall. This is the pro-schooling substitution effect of a drought shock (Ferreira & Schady, 2009). As described by the model, the overall impact of a drought shock is thus determined by whether the income or the substitution effect dominates.

Drought as a direct shock to health: From the model, a direct shock to a child's health causes a direct decline in his/her human capital (S falls and H falls as the marginal cost of t_C and t_P increases). Drought may directly affect the health of children through an increase in the prevalence of weather related diseases (Bonjean *et al.*, 2012). Lack of proper health care systems in rural areas, reinforced by the income shortage faced by the households, means that children's health is likely to suffer disproportionately in drought years. This could result in lower school attendance and reduced learning capacity. While there has been extensive research on the effect of drought on health of children, the linkage from drought induced health shocks to education has not been explored. This channel is harder to study than the income and wages channel, as it may be confounded with the former. For instance, income shocks cause a decline in health or nutritional investment, which could then negatively affect a child's health and consequently his/her educational outcomes. In this paper, we are unable to isolate the health channel due to data limitations, and focus on the income and wages channel.

2 Rainfall variation in Maharashtra across districts and time

Table A1. *Percentage Deviation of District Rainfall from its Long-Term Mean*

District	2008	2009	2010	2011	2012	2013
Ahamadnagar	4	12	39	-21	-70	9
Akola	-32	-13	11	-27	-2	15
Amravati	-37	-29	20	-9	8	14
Aurangabad	-12	-6	19	-27	-83	0
Beed	-13	3	26	-8	-67	-2
Bhandara	-39	-38	8	-28	-10	16
Buldhana	-23	-5	28	-23	-32	21
Chandrapur	-20	-59	23	-25	-1	29
Dhule	-17	16	12	-12	-43	25
Gadchiroli	-21	-47	21	-23	4	30
Gondia	-31	-36	2	-24	-21	24
Hingoli	-63	-37	27	-23	-39	21
Jalgaon	-33	-4	13	-22	-66	24
Jalna	-22	-17	18	-32	-98	12
Kolhapur	-2	-1	-3	-2	-29	-42
Latur	-19	-44	19	-23	-33	10
Nagpur	-29	-18	10	-19	-14	23
Nanded	-46	-58	10	-39	-51	9
Nandurbar	12	-20	-9	-13	-23	40
Nasik	12	-20	-4	-28	-36	-19
Osmanabad	-7	-9	25	-55	-86	-11
Parabhani	-31	-18	20	-28	-40	15
Pune	-6	6	21	-7	-47	16
Raigadh	-3	-35	8	15	-13	2
Ratnagiri	-3	-9	22	26	0	21
Sangli	-14	18	18	-62	-90	-16
Satara	14	31	30	17	-27	0
Sindhudurg	-9	3	26	14	-15	9
Solapur	-3	10	28	-44	-74	-14
Thane	3	-31	11	8	-18	18
Wardha	-25	-45	19	-9	-22	17
Washim	-34	-38	15	-27	-15	36
Yavatmal	-42	-60	11	-30	-15	14

Total number of Districts from Maharashtra : 34
Positive values mean that the rainfall received exceeded the expected long term mean, while negative values show the percentage of rainfall deficit from the long term mean.

3 Impact of drought on school enrollment

To find whether the drought shock in 2012 in Maharashtra affects enrollment, we use the same difference in differences model as in the paper (equation (1) in the main paper). The dependent variable is now equal to 1 if a child is enrolled in school in a given year. It is equal to 0 if the child is not enrolled. We find that there is no effect of the drought shock on enrollment in 2012 and 2013. Enrollment falls in 2014 by an average of 2%, but recovers in 2016 where we find no significant differences. Results are presented in Table A2 below.

Table A2. *Impact of the 2012 Drought on School Enrollment in Maharashtra*

Dependent Variable: Probability of being enrolled in school	(1) DID	(2) DID
Drought 2012	-0.027***	0.005
	(0.009)	(0.009)
2007 × Drought 2012	0.001	
	(0.011)	
2008 × Drought 2012	0.016	
	(0.015)	
2009 × Drought 2012	-0.001	-0.002
	(0.014)	(0.013)
2010 × Drought 2012	0.008	0.004
	(0.015)	(0.015)
2012 × Drought 2012	0.013	0.017
	(0.012)	(0.013)
2013 × Drought 2012	0.005	0.012
	(0.012)	(0.012)
2014 × Drought 2012	-0.021**	-0.019*
	(0.010)	(0.010)
2016 × Drought 2012	-0.014	-0.012
	(0.010)	(0.009)
Rainfall deviation current year	0.000	0.000
	(0.000)	(0.000)
Rainfall deviation previous year	0.000	-0.000
	(0.000)	(0.000)
Child's age	0.024***	0.025***
	(0.001)	(0.001)
Child's gender (1 = girl)	-0.002	-0.001
	(0.001)	(0.002)
Total household members	-0.001***	-0.001***
	(0.000)	(0.000)
Mother attended school	0.028***	0.018***
	(0.004)	(0.003)
Father attended school		0.015***
		(0.003)
Household wealth index		0.006***
		(0.001)
Constant	0.659***	0.633***
	(0.012)	(0.013)
Observations	241,971	176,405
R-squared	0.087	0.098
District FE	Yes	Yes
Year FE	Yes	Yes

Note: Cluster-robust standard errors are in parentheses. Clustered at the district level. Statistically different from zero at the 1% (***), 5% (**), or 10% (*) level of significance. 'Drought 2012' is equal to 1 if rainfall received is less than 20% of long term mean rainfall in a district in 2012. Interactions of 'Drought 2012' with 2007, 2008, 2009, and 2010 capture pre-treatment (pre-drought) trends and interactions with 2012, 2013, 2014, 2016 capture the post-treatment (post-drought) difference-in-differences. 2011 is the base category. Rainfall deviations are measured as the percentage deviation of actual rainfall from long term mean rainfall in a district in a year. 'Child's age' is measured in years and 'Household wealth index' is a standardized variable. 'Child's gender', 'Mother attended school', and 'Father attended school' are indicator variables. 'DID' stands for difference-in-differences regression.

4 References

Baez JE and Santos IV (2007) Children's vulnerability to weather shocks: a natural disaster as a natural experiment. Social Science Research Network, New York.

Bonjean CA, Brunelin S and Simonet C (2012) Impact of climate related shocks on child's health in Burkina Faso. Working Papers halshs-00725253, HAL. Available at https://halshs.archives-ouvertes.fr/halshs-00725253/document.

Ferreira FH and Schady N (2009) Aggregate economic shocks, child schooling, and child health. *The World Bank Research Observer* **24**(2), 147-181.

Psacharopoulos G (1997) Child labor versus educational attainment some evidence from Latin America. *Journal of Population Economics* **10**(4), 377-386.

Skoufias E (2001) Progress and its impacts on the human capital and welfare of households in rural Mexico: a synthesis of the results of an evaluation by IFPRI. International Food Policy Research Institute, Washington, DC.

Udry C (2006) Child labor. In Banerjee AV, Benabou R and Mookherjee D (eds). *Understanding Poverty*. New York: Oxford University Press, pp. 243-258.