The effect of rainfall shocks on early childhood development in Uganda

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18 January, 2021

Abstract

Shocks faced in early life have been linked with persistent inequalities in long-term health and economic outcomes. This paper studies the link between seasonal rainfall shocks and early childhood development in rural Uganda. The results indicate that rainfall shocks during the Ugandan harvest season in the in-utero period and first year of life are positively associated with the cognitive and non-cognitive development of 3- to 5-year-old children. This contributes to the literature on the persistence of economic inequalities caused by adversities in early life.

Keywords: Early childhood development, Weather shocks, Seasonal effects
JEL: O13, O15, I24

1 Introduction

In low- and middle-income countries, agriculturally dependent households are vulnerable to fluctuations in rainfall which lead to losses in agricultural output and household welfare. Economic disruptions faced during the in-utero period or shortly after birth have been linked with persistent inequalities in adolescent and adult outcomes such as educational achievement, income, height and weight. Causal links between in-utero and post-birth rainfall shocks and longer-term outcomes have been documented by Maccini and Yang (2009) in rural Indonesia, Shah and Steinberg (2017) in India, Leight, Glewwe, and Park (2015) in China and Björkman-Nyqvist (2013) in Uganda. However, the effects of such shocks on *early childhood* outcomes remain relatively unexplored. Identifying the short-term effects can contribute to a better understanding of long-term effects and inform programs and policies aimed at mitigating the effect of adverse early-life circumstances.

This paper studies the link between early-life rainfall shocks and early childhood development (ECD) in Uganda. Research has shown that rainfall shocks are associated with household income in Uganda (Asiimwe and Mpuga 2007; Björkman-Nyqvist 2013) which reflects the fact that 53% of rural Ugandan households are subsistence farmers and that access to irrigation is rare (Uganda

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Bureau of Statistics 2018). To investigate whether these shocks are linked with ECD, I combine rainfall and survey data to estimate the relationship between rainfall shocks when a child is in-utero to two years of age and outcomes measured when the child is between 3 and 5 years of age. Figure 1 visualises the study design. The main contribution of this paper is providing evidence of a positive causal effect of in-utero and first year rainfall shocks during the Ugandan crop harvesting season on ECD. The results are robust to alternate specifications of control variables and standard error clustering.

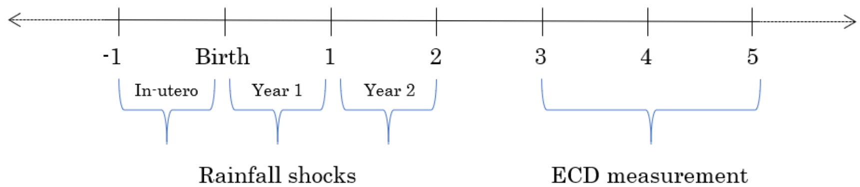

Figure 1: Study design

2 Data

2.1 Households and ECD

This study is based on surveys of a sample of 2007 households from nine Ugandan districts. BRAC Uganda conducted the surveys between November and December 2018. The sample consists of financially poor households with at least one child between 3 and 5 years of age. Table 1 displays some characteristics of the households in the sample.

The ECD level of one child (aged 3-5 years) per household was measured using the International Development and Early Learning Assessment (IDELA) instrument (Pisani, Borisova, and Dowd 2018). The IDELA is designed to measure the level of mastery that young children possess across four domains: motor skills, early literacy, early numeracy and social-emotional skills (see Appendix Table 1 for the skills captured within each domain). Task scores are aggregated and standardised within age groups to produce an index that captures a child's relative performance with respect to the child's age.[1]

[1]Age-standardised scores are calculated as: $\frac{Score - mean_{age}}{SD_{age}}$

Table 1: Descriptives

	Mean	SD	Min	Max	Median
Household and child characteristics					
Age	3.90	0.78	3	5	4
Sex	0.51	0.50	0	1	1
Household size	6.17	2.85	2	17	6
Owns business	0.44	0.50	0	1	0
Owns land	0.67	0.47	0	1	1
Owns livestock	0.47	0.50	0	1	0
Outstanding loans	0.41	0.49	0	1	0
Received transfers	0.42	0.49	0	1	0
Employment status					
Primary caregiver	0.63	0.48	0.00	1.00	1.00
Household head	0.85	0.35	0.00	1.00	1.00
Harvest rainfall shocks					
In-utero	-0.03	0.16	-0.41	0.41	-0.06
Year 1	-0.10	0.16	-0.46	0.41	-0.11
Year 2	-0.15	0.15	-0.58	0.40	-0.15
Plant rainfall shocks					
In-utero	0.05	0.12	-0.29	0.55	0.06
Year 1	0.08	0.14	-0.31	0.46	0.07
Year 2	0.06	0.15	-0.31	0.46	0.03
Observations	2007				

Age: 3, 4 or 5 - the age of the child in years. Sex: 0 - male, 1 - female. Household size is the number of people living in the same household. Owns business/land/livestock, outstanding loans and received transfers are indicators: 0 - no, 1 - yes. Employment status: 0 - unemployed and 1 - employed. Rainfall measures are percentage deviations from long-term means. Harvest season: Jun-Aug and Dec-Feb.

2.2 Rainfall shocks

Rainfall data comes from the National Oceanic and Atmospheric Administration's African Rainfall Climatology - 2 (ARC-2) dataset (Novella and Thiaw 2013) which contains daily estimates of precipitation for each cell of a 0.1° by 0.1° latitude grid. Rainfall measures for each household are calculated using data from the nearest cell; 71 unique cells are used in this analysis.

I use data from 1991 to 2018 to construct yearly and seasonal rainfall shocks faced by households in the year before a child's birth (*In-utero*), the first (*Year 1*) and the second (*Year 2*) year of a child's life.[2] Following previous research (Asiimwe and Mpuga 2007) and field inputs, I define the *Plant* season as the months of March–May and September–November and the *Harvest* season as June–August and December–February. Figure 2 shows the monthly long-term average rainfall and the *Harvest* and *Plant* seasons. Rainfall shocks are calculated relative to a child's birth month by computing the percentage difference between rainfall in a year or season and the long-term average for that period. The descriptive statistics for the seasonal rainfall shock variables in Table 1 indicate that harvest rainfall was low relative to the long term mean in *Year 1* and *Year 2* —the median household faced negative shocks of 11% and 15% in those periods.

[2] I selected 1991 as the starting date because the dataset contains some missing values before 1991.

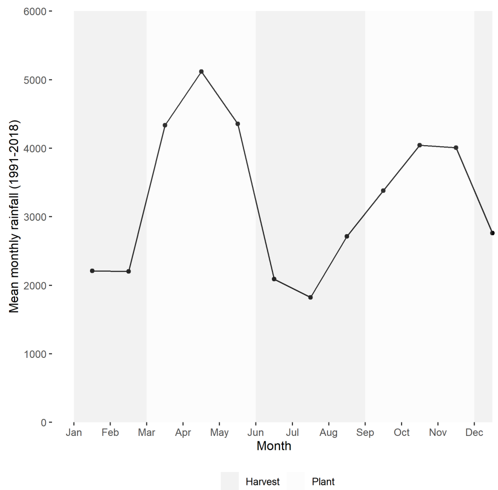

Figure 2: Rainfall seasons

3 Methods

I estimate the reduced form relationship between yearly/seasonal rainfall shocks and ECD levels using OLS:

$$ECD_i = \alpha + \beta_t \cdot Rainfall_{it} + controls_i + \mu_d + \epsilon$$

The outcome (ECD_i) is the age-standardised IDELA score. The β_t vector consists of the coefficients on the rainfall shock in a time period (year or season). As shocks are observed in three years and two seasons in each year, there are three coefficients in the yearly model and six in the seasonal model. These coefficients provide the estimated average causal effect of past rainfall shocks on current ECD levels. The employment status and education of household heads and primary caregivers, household size and asset ownership (land/business/livestock/loans/transfers), and the age and gender of the child are used as $controls$. μ_d is a district control that absorbs differences between the nine districts in our sample. Standard errors are clustered at the Ugandan sub-county level and p-values have been adjusted using the Romano-Wolf step down procedure (Clarke, Romano, and Wolf 2019) to account for the fact that we test 9 hypotheses with each model.

4 Results

Table 2 shows the results from estimating the model for annual and seasonal rainfall shocks. At the yearly level, there is no strong evidence of a link between early-life rainfall shocks and ECD scores (columns 1 and 2). At the seasonal level (columns 3 and 4), rainfall shocks in the *Harvest* season in the year before and after a child's birth are positively associated with the total IDELA score measured between ages 3 and 5. *Plant* season and *Year 2* rainfall shocks do not appear to be linked with ECD scores.

The estimates in column (4) suggest that a 10% negative shock in *Harvest* season rainfall during the *In-utero* year (36% of our sample) leads to a 0.0828 standard deviation reduction in the age-standardised IDELA score. Similarly, a 10% shock in *Year 1* leads to a 0.0955 standard deviation reduction in the score. The *Harvest* shock effects *In-utero* and in *Year 1* are not statistically distinguishable from each other. Tests of the seasonal coefficients within a year indicate that *Harvest* and *Plant* shock effects are statistically different from each other *In-utero* (p-value: 0.004) and in *Year 1* (p-value: 0.006). The results are robust to the inclusion of household controls (education, occupation and assets) and to other standard error specifications (not reported here). Appendix Table 4 shows suggestive evidence that the effects may be driven by motor, literacy and numeracy skill development.

5 Conclusion

This study contributes to the literature by identifying the causal effect of early life rainfall shocks on early childhood outcomes. The results suggest that there is a strong causal effect of rainfall shocks during the Ugandan harvest season when a child is in-utero or less than one year old on the ECD of children aged 3-5 years. There is no evidence that aggregate yearly or non-harvest season rainfall shocks have an effect on ECD. Investigating the links between income and seasonal rainfall shocks and attempting to identify the mechanisms that drive the observed relationship are potential avenues for future research.

Table 2: Yearly and Seasonal Effects of Rainfall on IDELA Scores

	Yearly No HH controls (1)	Yearly All controls (2)	Seasonal No HH controls (3)	Seasonal All controls (4)
In-utero	0.438	0.403		
	(0.343)	(0.330)		
Year 1	0.724	0.538		
	(0.388)	(0.382)		
Year 2	0.609*	0.525*		
	(0.289)	(0.259)		
Harvest In-utero (HU)			0.745***	0.828***
			(0.196)	(0.189)
Harvest Year 1 (HY1)			1.007***	0.955***
			(0.231)	(0.248)
Harvest Year 2 (HY2)			0.398	0.347
			(0.235)	(0.225)
Plant In-utero (PU)			-0.132	-0.225
			(0.286)	(0.285)
Plant Year 1 (PY1)			0.046	-0.050
			(0.282)	(0.270)
Plant Year 2 (PY2)			0.358	0.341
			(0.235)	(0.216)
Constant	-0.016	-0.222	0.340	0.148
	(0.117)	(0.160)	(0.183)	(0.191)
Observations	2,172	2,007	2,172	2,007
R-squared	0.100	0.141	0.112	0.155
Household controls	N	Y	N	Y
District and child controls	Y	Y	Y	Y
P-values from linear tests				
HU = PU			0.013	0.004
HY1 = PY1			0.008	0.006
HY2 = PY2			0.916	0.986
HU = HY1			0.284	0.602
HU = HY2			0.168	0.054
HY1 = HY2			0.021	0.029

The table reports regressions of yearly (columns 1, 2) and seasonal (columns 3, 4) rainfall shocks on ECD scores. The dependent variable is the age-standardised IDELA score. The rainfall variables in columns (1) - (4) are percentage differences from the long-term means for a year or a season in a particular year. Harvest season is Jun-Aug and Dec-Feb, Plant season is Mar-May and Sep-Nov. Asterisks denote significance levels: *** p < .01, ** p < .05, * p < .1. SEs are clustered at the district level and p-values are corrected for 9 multiple hypotheses using the Romano-Wolf step down procedure. The p-values listed at the bottom indicate whether the tested coefficients differ.

6 Acknowledgements

Field work and data collection were supported by the Research Council of Norway, Project number 274557. I am grateful to Kjetil Bjorvatn, Mulondo Charles, Denise Ferris, Selim Gulesci, Balakaita Joseph, Arne Nasgowitz, Nansubuga Robinah, Vincent Somville, Lore Vandewalle and many others at NHH Bergen and BRAC Uganda. Special thanks to Bertil Tungodden for providing extensive feedback and guidance in writing this paper.

References

Asiimwe, JB, and P Mpuga. 2007. "Implications of Rainfall Shocks for Household Income and Consumption in Uganda (Aerc Research Paper No. 168)." *African Economic Research Consortium, Nairobi, Kenya.*

Björkman-Nyqvist, Martina. 2013. "Income Shocks and Gender Gaps in Education: Evidence from Uganda." *Journal of Development Economics* 105: 237–53. https://doi.org/10.1016/j.jdeveco.2013.07.013.

Clarke, Damian, Joseph P Romano, and Michael Wolf. 2019. "The Romano-Wolf Multiple Hypothesis Correction in Stata." https://doi.org/10.1177/2F1536867X20976314.

Leight, Jessica, Paul Glewwe, and Albert Park. 2015. "The Impact of Early Childhood Shocks on the Evolution of Cognitive and Non-Cognitive Skills." *Gansu Survey of Children and Families Papers.*

Maccini, Sharon, and Dean Yang. 2009. "Under the Weather: Health, Schooling, and Economic Consequences of Early-Life Rainfall." *American Economic Review* 99 (3): 1006–26. https://doi.org/10.1257/aer.99.3.1006.

Novella, Nicholas S, and Wassila M Thiaw. 2013. "African Rainfall Climatology Version 2 for Famine Early Warning Systems." *Journal of Applied Meteorology and Climatology* 52 (3): 588–606. https://doi.org/10.1175/JAMC-D-11-0238.1.

Pisani, Lauren, Ivelina Borisova, and Amy Jo Dowd. 2018. "Developing and Validating the International Development and Early Learning Assessment (Idela)." *International Journal of Educational Research* 91: 1–15. https://doi.org/10.1016/j.ijer.2018.06.007.

Shah, Manisha, and Bryce Millett Steinberg. 2017. "Drought of Opportunities: Contemporaneous and Long-Term Impacts of Rainfall Shocks on Human Capital." *Journal of Political Economy* 125 (2): 527–61. https://doi.org/10.1086/690828.

Uganda Bureau of Statistics. 2018. "The National Labour Force Survey 2016/17 – Main Report."