Does the Timing of Productivity Shocks in Childhood Affect Educational Attainment?

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(This paper received *Kanematsu & Nishijima Awards*)

Motivation

- 265 million children (17%) work worldwide, with the highest rates in Sub-Saharan Africa (Ortiz-Ospina, Esteban and Roser, Max, 2024)
- Poor households trade off children's schooling and work (e.g., Ravallion and Wodon, 2000)
  - Intertemporal decision: immediate income vs. future educational returns
- Demand for child labor raises the opportunity cost of schooling, varying with children's characteristics (Shah and Steinberg, 2017; Atkin, 2016)
- In agricultural households, schooling decisions depend on productive assets that generate demand for child labor, especially where labor markets are limited

This paper

- **Research Question**. How do childhood productivity shocks affect educational attainment when child labor is linked to productive assets?
- **Natural Experiment**. Productivity shocks affecting pastoralists in Kenya and Ethiopia
  - Context: Livestock generate demand for child labor with limited labor and financial markets
  - Ambiguous prediction: child labor demand vs. income effects
  - Decompose effects by the marginal productivity of child labor: age and gender
- **Empirical Analysis**. Household survey and a 20-year history of productivity shocks
  - Estimate effects of age at productivity shock on educational attainment for 3,748 children
  - HH and birth-year FE using deviations in pasture conditions from historical mean

Summary of results

- Income effects dominate at early ages, while child labor becomes more salient with age
- Positive shocks during pre-school age boost education
  - Relax liquidity constraints for primary school entry
  - Children are too young to work
- Negative shocks during (mid-)primary school age *increase* educational attainment
  - Droughts reduce livestock holdings, lowering herding labor demand and increasing schooling, particularly for older children
  - Reduced migration / greater sedentarization reinforces this channel

Literature & contribution

- Human capital investment in contexts where child labor is prevalent (e.g., Bau et al., 2025)
  - Higher opportunity costs discourage schooling (Atkin, 2016; Shah and Steinberg, 2017; Aggarwal, 2018)
  - Trade-offs in children's time use between farm labor and schooling (Allen IV, 2024; Ito and Shonchoy, 2026)
  - **Contribution.** Provide insight into non-separable education–production decisions where labor markets are thin
    - ... highlighting the effects of *reduced* labor demand *within households*

- How early-life economic shocks, such as natural disasters, affect human capital formation (e.g., Maccini and Yang, 2009; Maluccio et al., 2009; Huang and Dong, 2025)
  - Early positive shocks persistently increase educational attainment (Alderman, Hoddinott, and Kinsey, 2006)
  - **Contribution.** Provide evidence that the destruction of productive assets in agricultural households alters demand for child labor, with heterogeneous effects

The context

Data: IBLI household survey and historical NDVI

- HH survey: Pastoralists in arid and semi-arid lands relying on extensive livestock grazing
  Map tbl. HH- summary stat.
  - Droughts account for up to 47% of livestock losses
  - Household panel: baseline (Kenya 2009; Ethiopia 2012), follow-ups through 2015
  - Main sample: school-aged children (ages 6–20) at endline (Kenya 2020; Ethiopia 2022)
  - Household GPS location

- NDVI (Normalized Difference Vegetation Index) since 2000 fig.: historical dist. NDVI
  - Satellite measure of vegetation greenness
  - Highly correlated with livestock mortality (Chantarat et al., 2013)

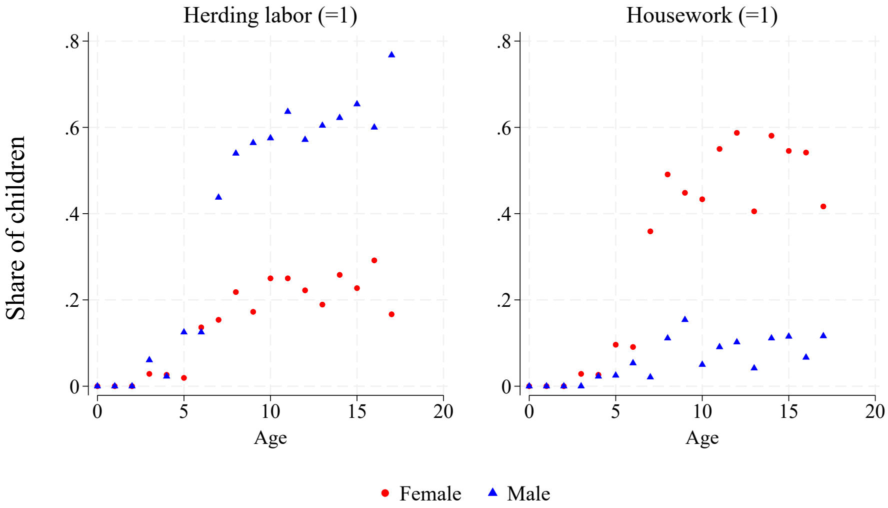
Context: Child labor and schooling

- Child labor is widespread (∼70%)
  - Gender roles differ: boys herd, girls do housework
  - Probability of working rises sharply at ages 7–10 [next slide]
- Livestock holdings strongly predict child labor (thus the opportunity cost of schooling)
  - e.g., herding, animal care, trekking — physically demanding work away from home
  - *Less* education (more likely to work) if (i) male and (ii) the household owns more livestock

fig: attainment | tbl.: sum stats – outcomes | tbl.: sum stats – controls

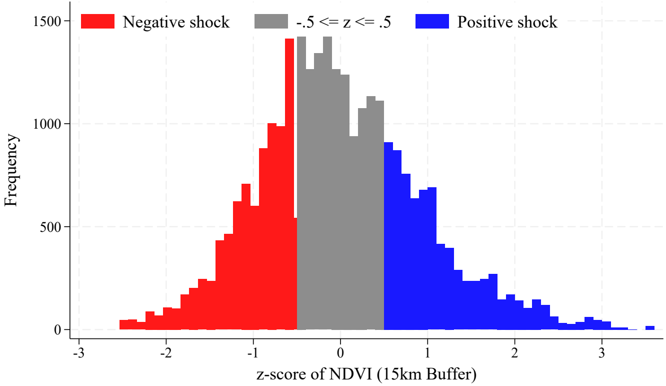
- School system
  - 8 years primary + 4 years secondary; entry at age 6 in Kenya, 7 in Ethiopia
  - In Borena zone, school catchment areas are 8–10 km (Kenea, 2019)

Child labor tasks by age and gender

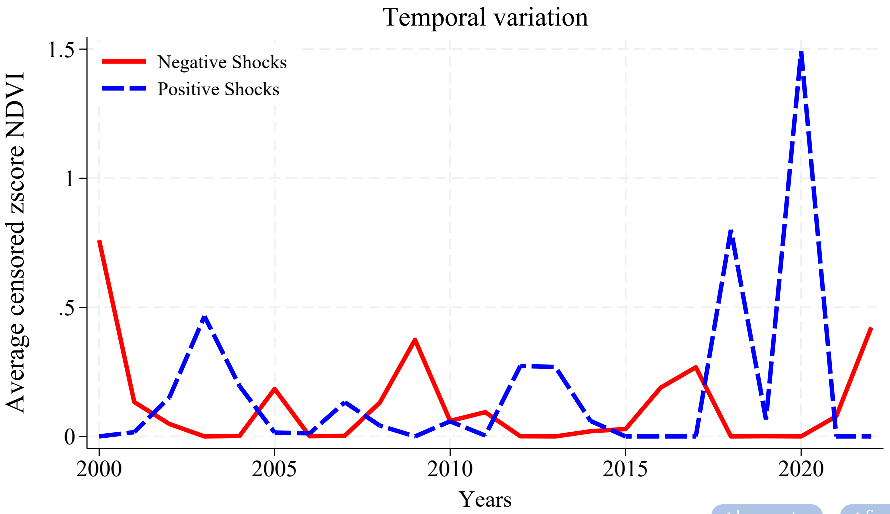


Definition of productivity shocks

- Yearly average NDVI, buffered around household locations (Liao et al., 2017) migration pattern
- Productivity shock := asymmetric censored NDVI z-score relative to the community's historical distribution fig: z-score over time mathematical definition discussion



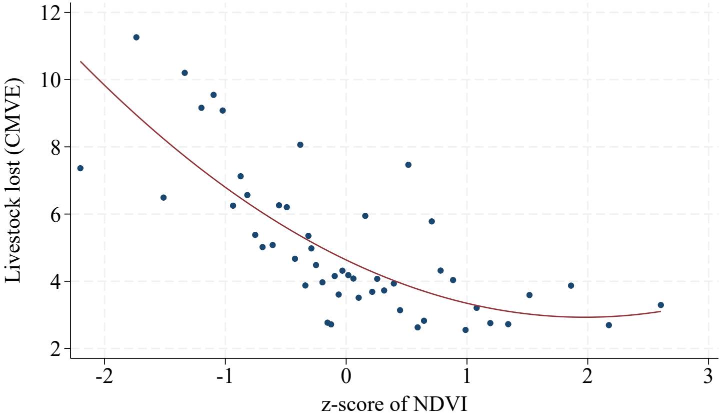
Temporal variations of productivity shocks over the study periods



by country
fig: spatial variation

Droughts exacerbate livestock loss

1SD negative productivity shock is associated with 3.5 [cattle market value equivalent] loss

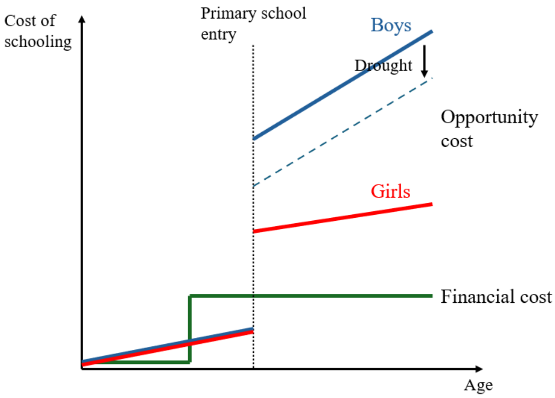


∼ 21–23 goats/sheep, 2.1–2.3 camels, or 3.4–3.7 cattle fig.: livestock holdings tbl.: livestock lost

Conceptual framework

Setup

- HHs w/ a child and livestock: schooling vs. labor
  - Limited outside labor market (∼10%)
  - Older boys involved in livestock management
  - No access to financial markets
- Heterogeneous financial and opportunity costs of schooling by age and gender
- Exogenous shocks to livestock production affect older boys most



Baseline specification

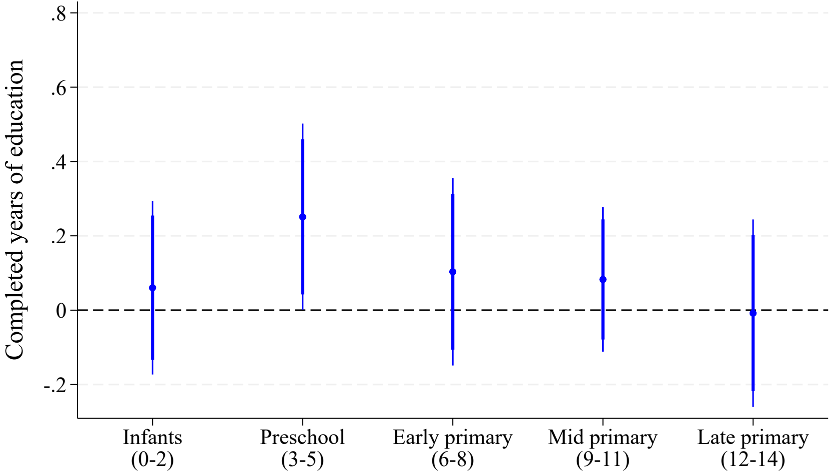
Attrition rate | tbl. differential attrition | tbl. selective attrition | tbl. joint test | tbl. fertility

For child i in household h, location j, born in year t

$$S_{ihjt} = \sum_b (\zeta_b^+ \theta_{h,b}^+ + \zeta_b^- \theta_{h,b}^-) + \lambda_h + \phi_t + \mathbf{X}'_{ih}\beta + \varepsilon_{ihjt}$$

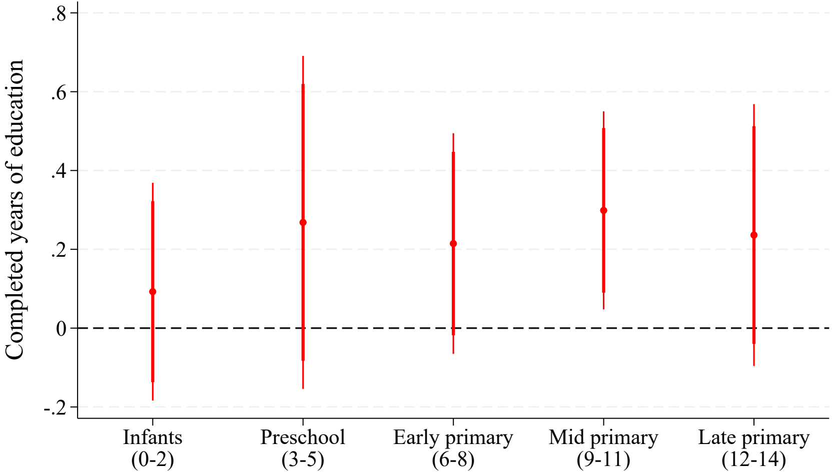
- S_{ihjt}: completed years of education at endline
- $\theta_{h,b}^{+/-}$: cumulative/max shocks (positive/negative, abs.) during {Infants, Preschool, Early primary, Mid primary, Late primary} fig.: dist. age at shock
- λ_h, ϕ_t: household and birth-year fixed effects
- X_{ih}: gender and birth-order dummies

Effects of cumulative **positive** productivity shocks at different ages



tbl. FE tbl. best tbl. missing tbl. buffer

Effects of worst **negative** productivity shocks at different ages

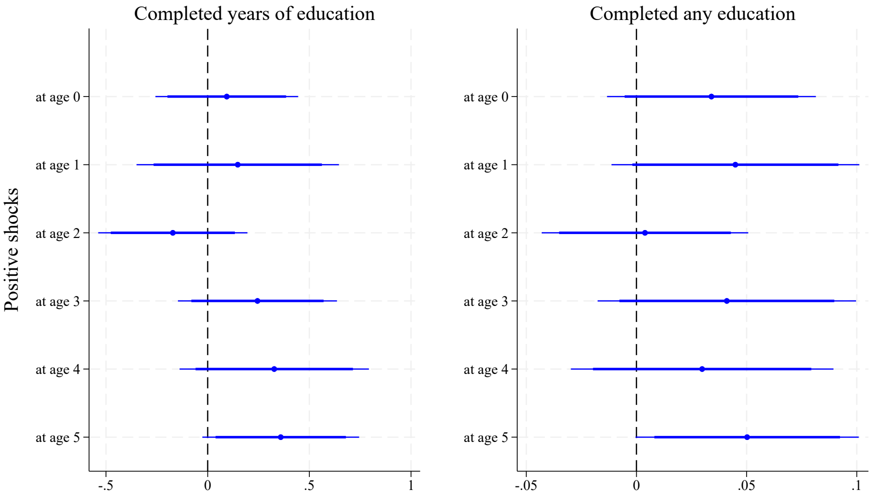


tbl. FE tbl. cumulative tbl. missing tbl. buffer

Mechanism

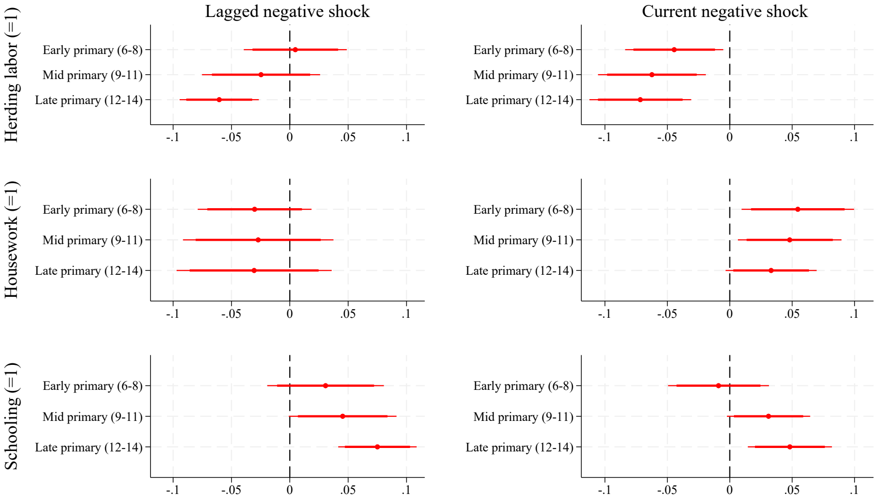
- Income effects in early life (e.g., Alderman, Hoddinott, and Kinsey, 2006) tbl: cash income
  - Liquidity relaxation at age 5 increases school entry [next slide]
  - Too young to work (work typically starts at ages 7–10)
  - Not consistent with nutrition channel (first 1000 days and school meals)
- Child labor demand discourages schooling during school age (Shah and Steinberg, 2017; Atkin, 2016)
  - Droughts destroy livestock, reducing child labor and increasing schooling immediately and persistently [next slide]
  - Reinforced by migration: past droughts reduce migration and increase sedentarization—likely via livestock loss—supporting schooling (Toth, 2015) tbl: migration conflict
  - Keeps children in school when they typically drop out for work fig: in-age-appropriate education
- Similar income effects by gender; child labor demand appears only for boys fig: reg by gender

Positive shocks concentrated on right before primary school starts



tbl. pre-school age

Negative shocks decrease herding and increases schooling



male | female | tbl. child time use | tbl. HH FE | tbl. HH Cluster

Policy implications and future work

- Policy implications
  - 268 million pastoralists in Africa's drylands, producing 70% of the continent's milk and meat
  - Relevant beyond this context: (i) link b/ child labor and production (ii) thin labor markets
  - Income-support policies that relax liquidity constraints w/o increasing child labor demand (Edmonds and Theoharides, 2020)
  - Compensation for natural disasters (e.g., insurance) (Barrett et al., 2025)

- Future work
  - How expectations about future climate change and labor markets affect human capital investment
  - Investing in productive assets (productivity, resilience) vs. human capital (non-agricultural opportunities, less climate-sensitive)
  - Information RCT + discrete choice experiment with vignettes for 2,000 pastoralist parents

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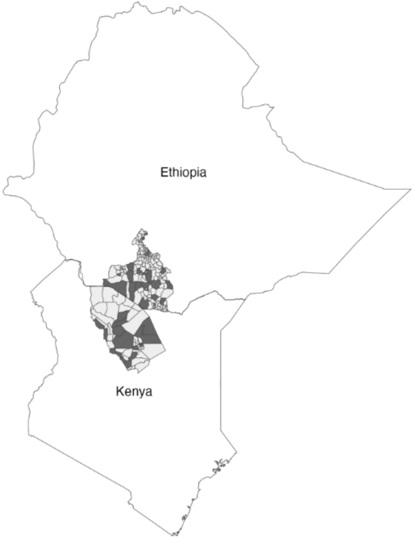
Study sites



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Household level summary statistics

	Mean/SD	Min	P25	Median	P75	Max	Obs
Total livestock holdings (CMVE)	22.64	0.00	4.50	11.08	26.60	416.95	1220
	[32.64]						
Camel holdings (CMVE)	9.08	0.00	0.00	0.00	9.60	299.20	1220
	[20.39]						
Cattle holdings (CMVE)	7.50	0.00	0.00	3.00	9.00	250.00	1220
	[14.76]						
Goat holdings (CMVE)	3.26	0.00	0.64	1.65	4.20	63.00	1220
	[4.58]						
Sheep holdings (CMVE)	2.79	0.00	0.00	0.60	2.85	77.25	1220
	[5.95]						
Livestock lost (CMVE)	10.48	0.00	2.00	5.15	12.50	200.60	1165
	[15.72]						
Cash earnings (USD)	556.97	0.00	106.01	255.98	553.67	10174.53	1152
	[930.48]						
Milk income (USD)	595.50	0.00	0.00	124.75	442.21	11629.81	1152
	[1313.93]						
Observations	1220						

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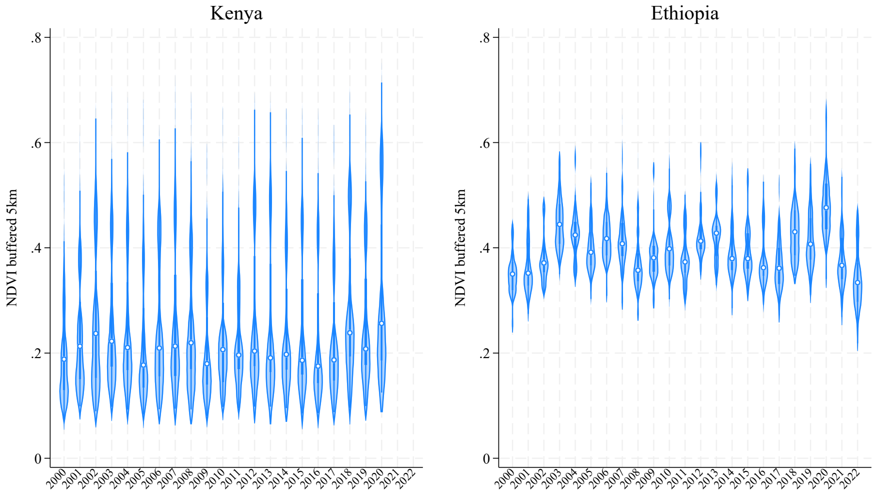
Historical NDVI distribution since 2000



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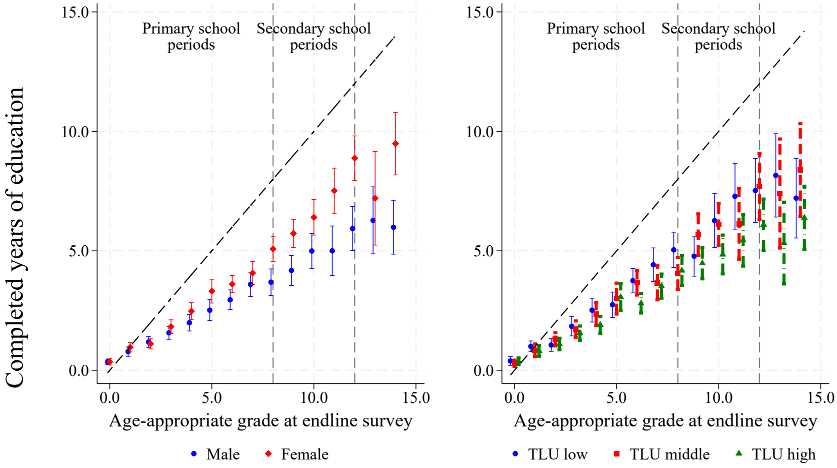
Outcome: Completed years of education

by age, gender, and livestock holdings



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Summary statistics of education variables

	(1) Full sample		(2) Female		(3) Male		(4) Pairwise t-test
	Mean	SD	Mean	SD	Mean	SD	Mean
Outcome variables							
Years of education	3.29	[3.64]	3.59	[3.56]	3.04	[3.70]	0.56***
Age appropriate education (=1)	0.25	[0.43]	0.28	[0.45]	0.22	[0.41]	0.06***
Educational attainment gap (yrs.)	2.15	[3.81]	1.60	[3.08]	2.60	[4.28]	-1.00***
Currently attending school (=1)	0.61	[0.49]	0.70	[0.46]	0.54	[0.50]	0.16***
Observations	3748		1699		2049		3748

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Summary statistics of control variables

	(1) Full sample		(2) Female		(3) Male		(4) Pairwise t-test
	Mean	SD	Mean	SD	Mean	SD	Mean
Control variables							
Age	12.16	[3.80]	11.82	[3.62]	12.43	[3.93]	-0.61***
Male (= 1)	0.55	[0.50]	0.00	[0.00]	1.00	[0.00]	-1.00
First born (=1)	0.33	[0.47]	0.31	[0.46]	0.35	[0.48]	-0.04*
Second born (=1)	0.28	[0.45]	0.28	[0.45]	0.28	[0.45]	0.00
Third born (=1)	0.19	[0.39]	0.20	[0.40]	0.19	[0.39]	0.01
Fourth or more born (=1)	0.20	[0.40]	0.21	[0.41]	0.18	[0.39]	0.03*
Other variables							
Exists siblings in the sample (=1)	0.95	[0.21]	0.94	[0.23]	0.96	[0.19]	-0.02*
# siblings in the sample (incl self).	3.76	[1.53]	3.78	[1.56]	3.73	[1.50]	0.05
Observations	3748		1699		2049		3748

Migration pattern

- Liao et al. (2017) investigated spatial rangeland utilization patterns in the Borana zone based on continuous GPS-tracking of cattle movement over seven months
  1. restrictive herding models: primarily involves linear movement between basecamp and the principal foraging areas
  2. semi-extensive herding models: involves the use of both base and satellite camps
  3. extensive herding models: founded on a distributed network of satellite camps
- The mean distance of the movement was $<$10km from the base camp with a longer left tail

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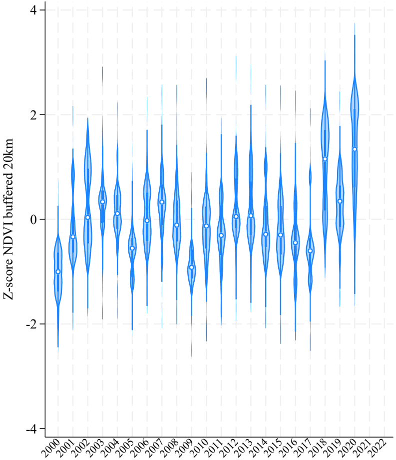
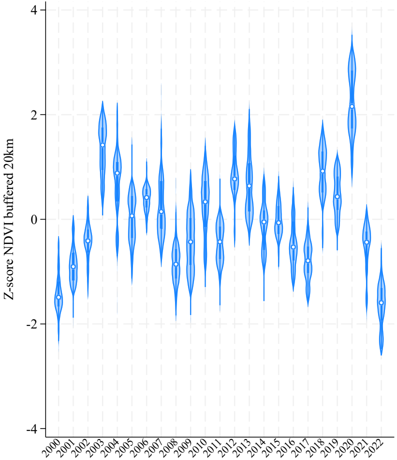
Average z-score over time





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Definition of productivity shocks

- Yearly average NDVI buffered around 20km for each household location (Liao et al., 2017)
- **"censored z-score NDVI"**: standard deviations, truncated $[-1, 1]$, relative to community historical distribution in absolute value

$$\begin{cases} \theta^{-}_{hjy} = |NDVIz^{-}_{hjy}| \text{ if } NDVIz_{hjy} < -1 \\ \text{[Comparison group]} \;\; = 0 \text{ if } NDVIz_{hjy} \in [-1, 1] \\ \theta^{+}_{hjy} = NDVIz^{+}_{hjy} \text{ if } NDVIz_{hjy} > 1 \end{cases} \tag{1}$$

- $NDVIz^{-/+}$: z-score value of NDVI relative to community j if it is negative (positive)
- *NDVInorm*: indicator variable taking 0 for NDVIz within $[-1, 1]$
- $>$1 ($<$-1) SD positive NDVI values impacts assuming no impact in [-1,1] interval

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Definition of shocks – discussion

- NDVI buffered around 5km robust to trekking strategies and seasonality (Liao et al., 2017)
- Preferable because ...
  - more severe shocks to have greater impacts while allowing asymmetry between good and bad
  - robust to endogenous livestock choice (rel. to community historical dist.)
  - clearly exogenous and comparable in sds magnitude across all households
- Not following Shah and Steinberg (2017), Kaur (2019), and Jayachandran (2006) because ...
  - "too short a time series" to claim extreme deviations from people's expectations in our setting
  - do not want to impose a constant number of shocks on each household

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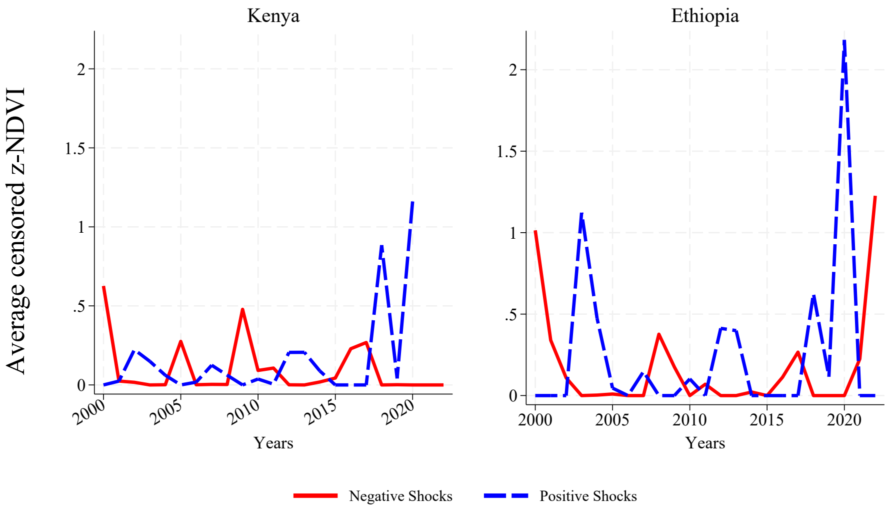
Temporal variation of shocks



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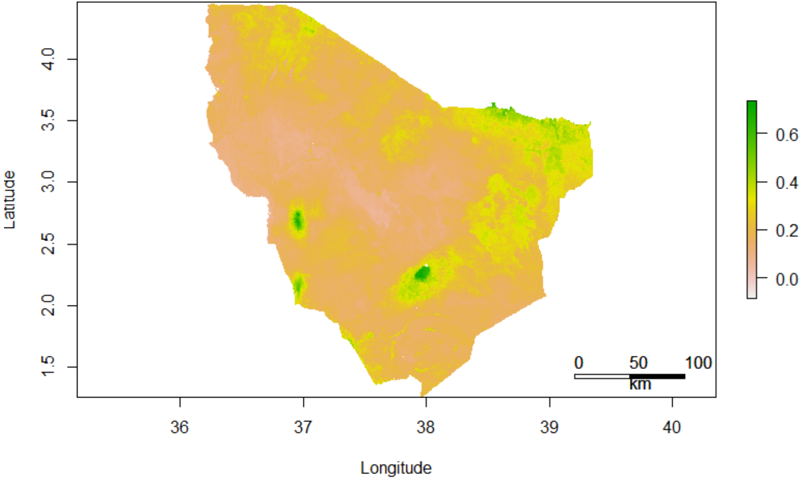
Spatial variation of NDVI in Marsabit district

2009 Kenya droughts



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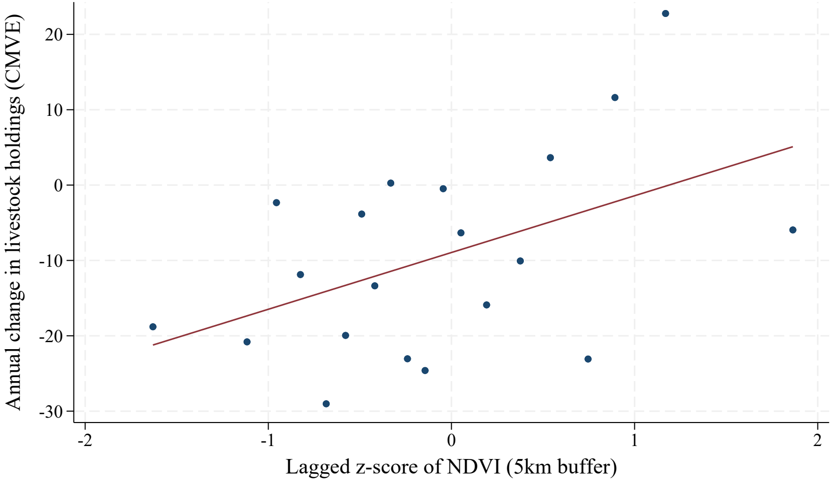
Annual change in livestock holdings and lagged z-score NDVI



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Effects of productivity shocks on livestock loss

	Livestock lost due to droughts (CMVE)		Livetock lost (CMVE)	
	(1)	(2)	(3)	(4)
Positive productivity shock	0.136	0.228	-0.898***	-1.129**
	(0.311)	(0.428)	(0.310)	(0.484)
Negative productivity shock	-0.851***	-1.897***	3.384***	3.786***
	(0.184)	(0.432)	(0.773)	(0.912)
Household fixed effects		✓		✓
Adjusted R-squared	0.002	-0.031	0.031	0.119
Observations	1365	1365	7836	7836

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Set up

- Non-separable agricultural households with children and livestock (Son, 2025)
- Consumption side
  - Standard concave utility function: consumption and education (static, for simplicity)
  - Households supply child labor: child time can be spent on education and labor
  - No outside labor market, and credit and insurance market are missing
- Production side
  - Households demand child labor (assuming adults supply inelastically)
  - Production function depends on child labor, varying by type and livestock size, with older boys having a higher marginal product of labor

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Attrition analysis

- At the household level
  - At the 10-year follow-up, we successfully re-interviewed 82% of baseline households (1,179 out of 1,439)
  - Households that were female-headed, had fewer adults, and did not own agricultural land were more likely to attrit from the sample (Barrett et al., 2025)
- At the child level (note: only includes those aged ≤ 9 in Kenya and ≤ 7 in Ethiopia)
  - Among children born in the relevant cohort at baseline, 77.3% were successfully followed up (i.e., 22.7% attrition)
  - Attrition is not differential based on the cumulative shocks
  - Older and female children were more likely to attrit, possibly due to marriage [next slide]
  - Number of children does not change by the exposure to the shocks

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Differential attrition

	Outcome: Attrition (=1)	
	(1)	(2)
Cumulative number of positive shocks (5km)	-0.002	
	(0.027)	
Cumulative number of negative shocks (5km)	0.001	
	(0.027)	
Cumulative number of positive shocks (15km)		0.002
		(0.027)
Cumulative number of negative shocks (15km)		-0.003
		(0.027)
Observations	1493	1493

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Selective attrition

	Independent variable: Attrition in the endline (=1)
	(1)
Age	1.81***
	(.315)
Male (=1)	-.105*
	(.0547)
First born (=1)	.095**
	(.0375)
Second born (=1)	.0531
	(.0404)
Third born (=1)	-.0119
	(.0518)
3rd	-.0119
	(.0518)
P-value of joint F-test	0.000
N	1774

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Joint test of selective attrition at child level

	Outcome: Attrit (=1)	
	(1)	(2)
Male (= 1)	-0.091***	-0.070*
	(0.020)	(0.038)
Age	0.039***	0.032***
	(0.004)	(0.010)
First born (=1)	0.005	0.073
	(0.033)	(0.122)
Second born (=1)	0.014	0.052
	(0.028)	(0.088)
Third born (=1)	-0.041	0.025
	(0.025)	(0.062)
F-statistics	25.269	6.792
p-value of joint significance	0.000	0.000
Household FE		✓
Observations	1774	1774

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Effects of shocks on fertility

	Outcome: Number of school-aged children at endline	
	(1)	(2)
Cumulative number of positive shocks (5km)	0.163	
	(0.130)	
Cumulative number of negative shocks (5km)	-0.160	
	(0.130)	
Cumulative number of positive shocks (15km)		0.218
		(0.137)
Cumulative number of negative shocks (15km)		-0.215
		(0.137)
Observations	1493	1493

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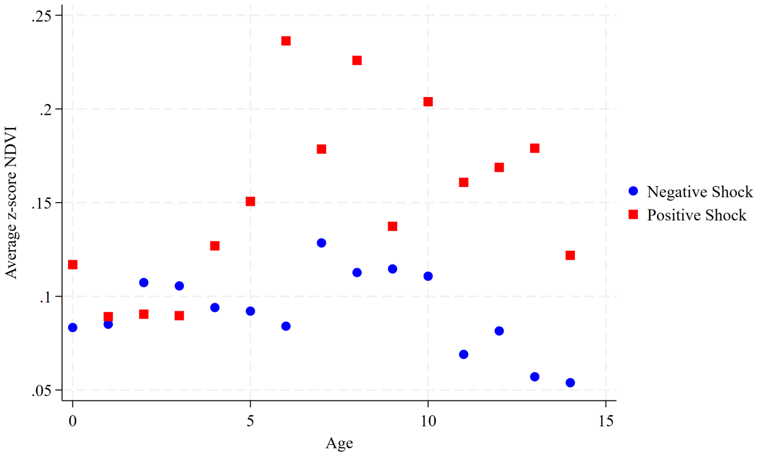
Variation of age at shocks



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Effects of cumulative **positive** productivity shocks at different ages

	Completed years of education at endline			
	(1)	(2)	(3)	(4)
Postive productivity shocks				
Infants (0-2)	0.060	0.069	0.056	-0.052
	(0.114)	(0.124)	(0.114)	(0.106)
Preschoolers (3-5)	0.251**	0.253**	0.265**	0.148**
	(0.123)	(0.122)	(0.120)	(0.064)
Early primary (6-8)	0.103	0.132	0.108	0.021
	(0.124)	(0.135)	(0.121)	(0.069)
Mid primary (9-11)	0.083	0.091	0.044	-0.028
	(0.095)	(0.106)	(0.068)	(0.055)
Late primary (12-14)	-0.008	0.003	0.042	-0.113
	(0.124)	(0.129)	(0.088)	(0.087)
Controls	✓		✓	✓
Birth-year fixed effects	✓	✓		✓
Household fixed effects	✓	✓	✓	
Community fixed effects				✓
F-statistic for positive shocks	1.159	1.161	2.177	2.259
P-value for F-test for positive shocks	0.351	0.350	0.082	0.073
Observations	3748	3748	3748	3748

Back

Effects of best **positive** productivity shocks at different ages

	Completed years of education at endline			
	(1)	(2)	(3)	(4)
Postive productivity shocks				
Infants (0-2 yrs. old)	0.065	0.078	0.044	-0.122
	(0.137)	(0.146)	(0.137)	(0.138)
Preschoolers (3-5 yrs. old)	0.223	0.213	0.239*	0.184*
	(0.135)	(0.127)	(0.136)	(0.095)
Early primary school (6-8 yrs. old)	0.164	0.179	0.149	0.097
	(0.163)	(0.169)	(0.152)	(0.087)
Mid-primary school (9-11 yrs. old)	0.135	0.120	0.051	0.008
	(0.094)	(0.095)	(0.071)	(0.076)
Late primary school (12-14 yrs. old)	0.079	0.082	0.091	-0.037
	(0.159)	(0.161)	(0.112)	(0.116)
Controls	✓		✓	✓
Birth-year fixed effects	✓	✓		✓
Household fixed effects	✓	✓	✓	
Community fixed effects				✓
F-statistic for positive shocks	0.773	0.782	0.974	1.792
P-value for F-test for positive shocks	0.576	0.570	0.449	0.144
Observations	3748	3748	3748	3748

▸ Back

Effects of cumulative **positive** productivity shocks: missing values

	Outcome: Completed years of education at endline									
	Full sample		Samples older than time of the shocks							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Postive productivity shocks										
Infants (0-2)	0.060	-0.052	0.026	-0.058	0.074	-0.042	0.077	0.017	-0.219	-0.118
	(0.114)	(0.106)	(0.105)	(0.096)	(0.128)	(0.116)	(0.204)	(0.155)	(0.338)	(0.171)
Preschoolers (3-5)	0.251**	0.148**	0.217**	0.148**	0.298***	0.172**	0.343**	0.192**	0.051	0.433***
	(0.123)	(0.064)	(0.094)	(0.062)	(0.094)	(0.068)	(0.168)	(0.090)	(0.500)	(0.144)
Early primary (6-8)	0.103	0.021			0.046	0.006	0.066	-0.067	0.153	0.052
	(0.124)	(0.069)			(0.104)	(0.065)	(0.193)	(0.092)	(0.384)	(0.125)
Mid primary (9-11)	0.083	-0.028					0.102	-0.034	-0.042	-0.190
	(0.095)	(0.055)					(0.155)	(0.082)	(0.488)	(0.154)
Late primary (12-14)	-0.008	-0.113							-0.166	-0.145
	(0.124)	(0.087)							(0.476)	(0.095)
Negative shocks	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Birth-year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Household fixed effects	✓		✓		✓		✓		✓	
F-statistic for positive shocks	1.159	2.259	2.847	3.982	3.627	4.139	1.924	2.776	0.215	3.196
P-value for F-test for positive shocks	0.351	0.073	0.073	0.029	0.024	0.014	0.131	0.044	0.953	0.019
Observations	3748	3748	3748	3748	3279	3279	2281	2281	1377	1377

▸ Back

Effects of cumulative **positive** productivity shocks: different buffer sizes

	Outcome: Completed years of education at endline			
	5km	10km	15km	20km
	(1)	(2)	(3)	(4)
Positive productivity shocks				
Infants (0-2)	0.060	-0.021	-0.139	-0.133
	(0.114)	(0.096)	(0.127)	(0.154)
Preschoolers (3-5)	0.251**	0.167	0.090	0.128
	(0.123)	(0.132)	(0.147)	(0.163)
Early primary (6-8)	0.103	0.137	0.091	0.100
	(0.124)	(0.117)	(0.133)	(0.159)
Mid primary (9-11)	0.083	0.153	0.057	0.092
	(0.095)	(0.112)	(0.131)	(0.141)
Late primary (12-14)	-0.008	0.018	-0.067	-0.083
	(0.124)	(0.128)	(0.126)	(0.126)
Controls	✓	✓	✓	✓
Birth-year fixed effects	✓	✓	✓	✓
Household fixed effects	✓	✓	✓	✓
F-statistic for negative shocks	0.675	0.571	0.622	0.690
P-value for F-test for negative shocks	0.646	0.722	0.684	0.635
Observations	3748	3748	3748	3748

Back

Effects of worst **negative** productivity shocks at different ages

	Completed years of education at endline			
	(1)	(2)	(3)	(4)
Negative productivity shocks				
Infants (0-2)	0.093	0.105	-0.003	0.092
	(0.135)	(0.147)	(0.147)	(0.112)
Preschoolers (3-5)	0.268	0.283	0.280	0.220
	(0.207)	(0.222)	(0.220)	(0.138)
Early primary (6-8)	0.215	0.235	0.221	0.175
	(0.137)	(0.152)	(0.142)	(0.119)
Mid primary (9-11)	0.299**	0.301**	0.227*	0.190
	(0.123)	(0.122)	(0.117)	(0.119)
Late primary (12-14)	0.236	0.260	0.277*	0.086
	(0.163)	(0.168)	(0.142)	(0.154)
Controls	✓		✓	✓
Birth-year fixed effects	✓	✓		✓
Household fixed effects	✓	✓	✓	
Community fixed effects				✓
F-statistic for negative shocks	2.028	2.199	1.586	1.839
P-value for F-test for negative shocks	0.102	0.080	0.193	0.134
Observations	3748	3748	3748	3748

Back

Effects of cumulative **negative** productivity shocks at different ages

	Completed years of education at endline			
	(1)	(2)	(3)	(4)
Negative productivity shocks				
Infants (0-2)	0.138	0.163	0.081	0.073
	(0.132)	(0.141)	(0.131)	(0.079)
Preschoolers (3-5)	0.260	0.294	0.291	0.165
	(0.199)	(0.214)	(0.194)	(0.111)
Early primary (6-8)	0.206	0.236	0.218	0.129
	(0.178)	(0.194)	(0.172)	(0.124)
Mid primary (9-11)	0.210	0.221	0.190	0.075
	(0.161)	(0.175)	(0.149)	(0.122)
Late primary (12-14)	0.145	0.164	0.217^{*}	-0.030
	(0.141)	(0.144)	(0.125)	(0.135)
Controls	✓		✓	✓
Birth-year fixed effects	✓	✓		✓
Household fixed effects	✓	✓	✓	
Community fixed effects				✓
F-statistic for negative shocks	0.622	0.778	1.257	0.627
P-value for F-test for negative shocks	0.684	0.573	0.307	0.680
Observations	3748	3748	3748	3748

Back

Effects of worst **negative** productivity shocks: missing values

	Outcome: Completed years of education at endline									
	Full sample		Samples older than time of the shocks							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Negative productivity shocks										
Infants (0-2)	0.093	0.092	0.020	0.062	-0.027	0.064	-0.048	0.142	0.324	0.098
	(0.135)	(0.112)	(0.148)	(0.109)	(0.169)	(0.122)	(0.334)	(0.205)	(0.444)	(0.301)
Preschoolers (3-5)	0.268	0.220	0.171	0.211	0.100	0.173	0.098	0.174	0.421	0.373
	(0.207)	(0.138)	(0.188)	(0.134)	(0.207)	(0.148)	(0.317)	(0.216)	(0.639)	(0.299)
Early primary (6-8)	0.215	0.175			0.061	0.156	0.054	0.152	0.429	0.181
	(0.137)	(0.119)			(0.155)	(0.117)	(0.280)	(0.213)	(0.496)	(0.246)
Mid primary (9-11)	0.299**	0.190					0.069	0.137	0.488	0.273
	(0.123)	(0.119)					(0.241)	(0.153)	(0.692)	(0.280)
Late primary (12-14)	0.236	0.086							0.253	0.319
	(0.163)	(0.154)							(0.537)	(0.242)
Negative shocks										
Controls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Birth-year fixed effects	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Household fixed effects	✓		✓		✓		✓		✓	
F-statistic for positive shocks										
P-value for F-test for positive shocks										
Observations	3748	3748	3748	3748	3279	3279	2281	2281	1377	1377

Back

Effects of cumulative **negative** productivity shocks: different buffer sizes

	Outcome: Completed years of education at endline			
	5km	10km	15km	20km
	(1)	(2)	(3)	(4)
Negative productivity shocks				
Infants (0-2)	0.079	0.173	0.093	0.008
	(0.172)	(0.157)	(0.135)	(0.140)
Preschoolers (3-5)	0.311	0.265	0.268	0.298**
	(0.205)	(0.201)	(0.207)	(0.136)
Early primary (6-8)	0.169	0.162	0.215	0.162
	(0.174)	(0.161)	(0.137)	(0.130)
Mid primary (9-11)	0.125	0.195	0.299**	0.311*
	(0.134)	(0.153)	(0.123)	(0.156)
Late primary (12-14)	0.181	0.197	0.236	0.244
	(0.178)	(0.163)	(0.163)	(0.156)
Controls	✓	✓	✓	✓
Birth-year fixed effects	✓	✓	✓	✓
Household fixed effects	✓	✓	✓	✓
F-statistic for negative shocks	0.745	0.780	2.028	2.197
P-value for F-test for negative shocks	0.596	0.571	0.102	0.080
Observations	3748	3748	3748	3748

▸ Back

Effects of productivity shocks on cash income

	Cash earnings (USD)	Milk income (USD)
	(1)	(2)
Panel A: Positive productivity shocks		
Positive shock	6.147	45.979
	(52.572)	(60.031)
Lag positive shock	11.019	60.500
	(37.252)	(52.634)
Observations	7562	7555

Panel B: Negative productivity shocks		
	Cash earnings (USD)	Milk income (USD)
	(1)	(2)
Negative shock	-61.052	160.163
	(39.032)	(190.428)
Lag negative shock	73.269*	-121.827
	(36.215)	(100.760)
Observations	7562	7555

Back

Effects of productivity shocks on migration

	Household fully-settled (=1)	
	(1)	(2)
Negative productivity shock	-0.087**	-0.085**
	(0.034)	(0.035)
Positive productivity shock	0.024	0.038
	(0.024)	(0.026)
Lagged negative productivity shock		0.090*
		(0.046)
Lagged positive productivity shock		-0.067
		(0.047)
Household fixed effects	✓	✓
Adjusted R-squared	0.453	0.452
Observations	7001	6873

Back

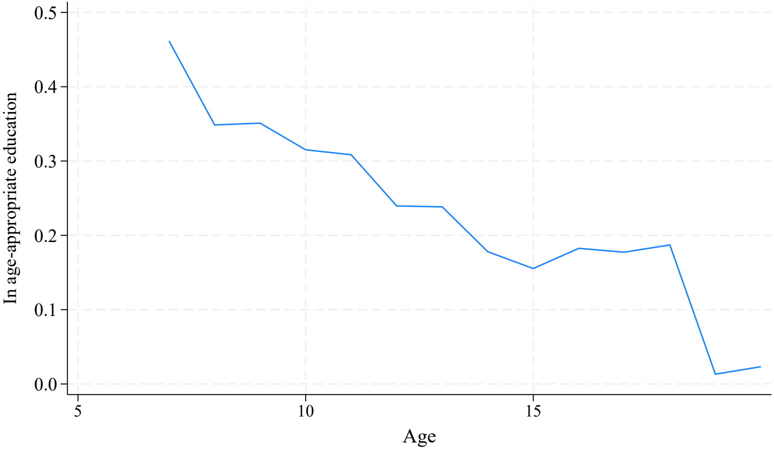
Conflict

- Concern: Negative shocks increase contemporaneous migration and raiding, raising income and thus education
- This is unlikely:
  - Raiding-related livestock loss is rare: 0.034 events/year ($\sim$ 1% of total losses) (Jensen et al., 2025)
  - Jensen et al. (2025) find increased risk of *being* raided, not raiding
- Unfortunately no data on raiding activity, but stolen livestock must be sold quickly—otherwise it increases child labor and reduces schooling, which is against the interpretation

Back

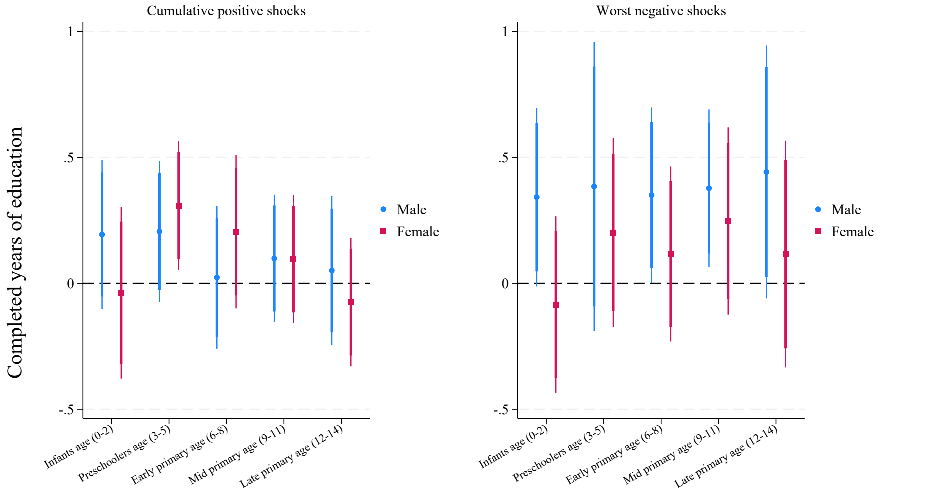
In age-appropriate education over age

Cross-sectional evidence



Back

Heterogeneity by gender



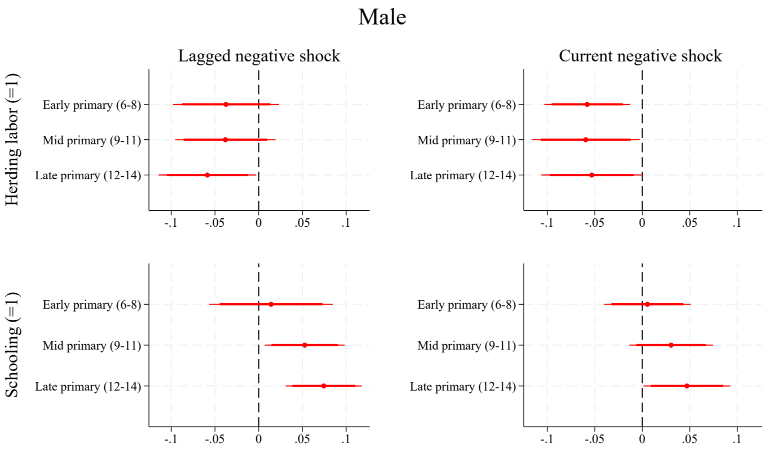
Back

Positive shocks concentrated on right before primary school starts

	Completed years of education	Completed any schooling
	(1)	(2)
at age 0	0.094	0.034
	(0.172)	(0.023)
at age 1	0.148	0.045
	(0.244)	(0.028)
at age 2	-0.171	0.004
	(0.180)	(0.023)
at age 3	0.245	0.041
	(0.192)	(0.029)
at age 4	0.327	0.030
	(0.228)	(0.029)
at age 5	0.359*	0.050*
	(0.189)	(0.025)
Observations	3748	3748

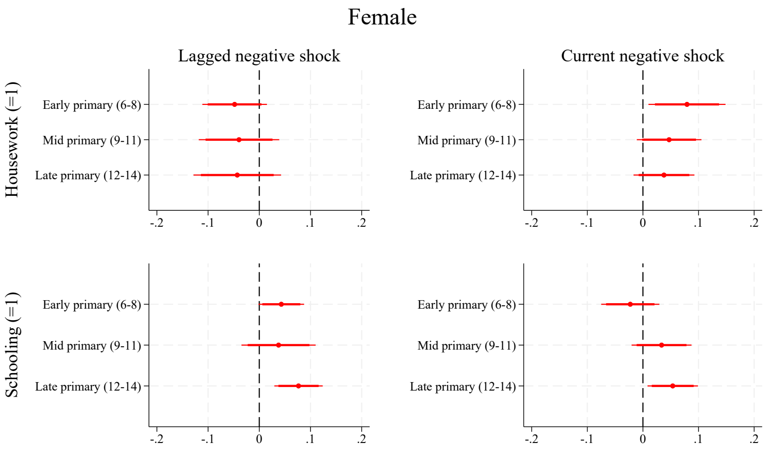
Back

Negative shocks decrease herding and increases schooling for older male



Back

Negative shocks decrease increases schooling for older female



Back

Effects of productivity shocks on child time use at different stages

	Herding labor (=1)	Housework (=1)	Any schooling (=1)
	(1)	(2)	(3)
Reference category: age 6-8			
Lagged negative shock	0.005	-0.030	0.031
	(0.022)	(0.024)	(0.024)
Binned age=9-11 × Lagged negative shock	-0.029	0.003	0.015
	(0.028)	(0.025)	(0.029)
Binned age=12-14 × Lagged negative shock	-0.065***	-0.000	0.044
	(0.023)	(0.030)	(0.028)
Current negative shock	-0.045**	0.055**	-0.009
	(0.019)	(0.022)	(0.020)
Binned age=9-11 × Current negative shock	-0.018	-0.007	0.040*
	(0.017)	(0.018)	(0.023)
Binned age=12-14 × Current negative shock	-0.027*	-0.021	0.057**
	(0.015)	(0.017)	(0.021)
Controls	✓	✓	✓
Community fixed effects	✓	✓	✓
Round fixed effects	✓	✓	✓
Lagged coef. for age 9-11	-0.025	-0.027	0.045
p-value for age 9-11	0.328	0.398	0.054
Lagged coef. for age 12-14	-0.060	-0.031	0.075
p-value for age 12-14	0.001	0.355	0.000
Current coef. for age 9-11	-0.062	0.048	0.031
p-value for age 9-11	0.006	0.025	0.067
Current coef. for age 12-14	-0.072	0.033	0.048
p-value for age 12-14	0.001	0.074	0.007
Observations	18587	18587	18587

Back

Effects of productivity shocks on child time use: HH FE

	Herding labor (=1)	Housework (=1)	Any schooling (=1)
	(1)	(2)	(3)
Reference category: age 6-8			
Lagged negative shock	0.014	-0.038	0.025
	(0.025)	(0.028)	(0.023)
Binned age=9-11 × Lagged negative shock	-0.028	0.013	0.003
	(0.027)	(0.027)	(0.027)
Binned age=12-14 × Lagged negative shock	-0.071***	0.007	0.049
	(0.024)	(0.031)	(0.029)
Current negative shock	-0.035	0.058**	-0.017
	(0.022)	(0.024)	(0.021)
Binned age=9-11 × Current negative shock	-0.027*	-0.006	0.042*
	(0.016)	(0.018)	(0.023)
Binned age=12-14 × Current negative shock	-0.025	-0.022	0.059**
	(0.017)	(0.018)	(0.022)
Controls	✓	✓	✓
Household fixed effects	✓	✓	✓
Round fixed effects	✓	✓	✓
Lagged coef. for age 9-11	-0.014	-0.025	0.027
p-value for age 9-11	0.584	0.474	0.144
Lagged coef. for age 12-14	-0.057	-0.031	0.073
p-value for age 12-14	0.005	0.391	0.000
Current coef. for age 9-11	-0.062	0.052	0.025
p-value for age 9-11	0.013	0.025	0.114
Current coef. for age 12-14	-0.060	0.037	0.042
p-value for age 12-14	0.012	0.057	0.018
Observations	18587	18587	18587

Back

Effects of productivity shocks on child time use: Cluster SE at HH

	Herding labor (=1)	Housework (=1)	Any schooling (=1)
	(1)	(2)	(3)
Reference category: age 6-8			
Lagged negative shock	0.005	-0.030*	0.031*
	(0.016)	(0.017)	(0.017)
Binned age=9-11 × Lagged negative shock	-0.029	0.003	0.015
	(0.021)	(0.022)	(0.021)
Binned age=12-14 × Lagged negative shock	-0.065***	-0.000	0.044**
	(0.021)	(0.022)	(0.020)
Current negative shock	-0.045***	0.055***	-0.009
	(0.014)	(0.015)	(0.015)
Binned age=9-11 × Current negative shock	-0.018	-0.007	0.040**
	(0.017)	(0.018)	(0.019)
Binned age=12-14 × Current negative shock	-0.027	-0.021	0.057***
	(0.019)	(0.017)	(0.019)
Controls	✓	✓	✓
Community fixed effects	✓	✓	✓
Round fixed effects	✓	✓	✓
Lagged coef. for age 9-11	-0.025	-0.027	0.045
p-value for age 9-11	0.168	0.138	0.006
Lagged coef. for age 12-14	-0.060	-0.031	0.075
p-value for age 12-14	0.001	0.088	0.000
Current coef. for age 9-11	-0.062	0.048	0.031
p-value for age 9-11	0.000	0.001	0.023
Current coef. for age 12-14	-0.072	0.033	0.048
p-value for age 12-14	0.000	0.022	0.000
Observations	18587	18587	18587

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