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RESEARCH SYMPOSIUM

MEASURING & REDUCING SOCIETAL IMPACTS

International Lessons on Climate Adaptation

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Upscaling Adaptation to Climate Change Through Female Entrepreneurship

Upscaling adaptation to climate change through female entrepreneurship

The role of gender in firm-level climate change adaptation behavior:

Insights from small businesses in Senegal and Kenya

Kate Gannon, Shaikh Eskander, Elena Castellano,

Mamadou Diop, Dorice Agol, Antonio Avila

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

Grantham Research Institute on Climate Change and the Environment

Introduction

- SMEs play crucial roles for local economic development, including by contributing to economic growth and poverty reduction (Ayandibu and Houghton, 2017)
- The enterprise landscape in developing countries is dominated by small and medium enterprises (SMEs)
  - In Senegal, for example, they represent 90% of all enterprises and employ 60% of the active population (GOV, 2014)
- SMEs are more vulnerable to climate risks and have a lower ability to deal with weather extremes (Yoshida and Deyle, 2005; Runyan, 2006; Wedawatta et al, 2010).
  - Even fairly moderate changes in climate parameters can produce significant, but under-recognised, consequences for SMEs across a range of urban and rural sectors (Gannon et al., 2018; Siderius et al., 2018).
- Private sector actors will innovate in response to changing climatic impacts and pressures
  - by adopting measures to reduce costs, manage their internal exposure to risks, minimise disruption to their operations and maximise opportunities where they arise (e.g., Mendelsohn, 2012).
- As such, an emerging body of literature has explored the processes through which businesses institute strategies to manage climate risk within their own operations (Pauw and Pegels 2013)

Introduction

- Gender can play a significant role here: women often make relatively higher contributions to family and social welfare than men -
  - Gender gaps in financial inclusion can influence sustainable development (Adegbite and Machete, 2019)
  - Gender gaps in access to agricultural inputs can lead to gender gaps in agricultural productivity (FAO, 2011)
  - Closing the gender gap in access to agricultural inputs could increase farm yields by 20-30% (Quisumbing et al, 2014)
  - Gender gaps in education can affect GDP (Abu-Ghaida and Lmasen, 2004).
- Their traditional roles positioned women to have unique situated knowledges (Haraway 1991, Harding 1991) and expertise that they bring to adaptation (UN WomenWatch, 2009; Wedeman and Petruney, 2018; Enarson 2013; Antwi, 2020).
  - These can be useful as entrepreneurs when making adaptation decisions

Gender and adaptation by SMEs

- Women may occupy a strategic role in adaptation wherein they may be more likely to undertake sustainable, equitable or effective adaptation actions than men
- Despite being an interesting topic, literature on this specific aspect is almost non-existent.
  - A search of the Scopus database in October 2020 using the key words "*Adapt* AND Woman OR gender* OR female AND Climate change AND Entrepreneur* OR business OR enterprise*" returned only 61 relevant articles
  - Of these 12 were focused on gendered adaptation behavior, to which 5 others were added through a snowball search of their references.
  - Of these 17, only 2 papers directly addressed gender dimensions of adaptation behavior at firm-level, where the rest focused on household or individual dimensions.
- None conducted a quantitative investigation

Our contribution

- This paper contributes to this gap in the literature by exploring how female gender representation at firm level impacts the propensity of a firm to undertake (un)sustainable adaptation behaviour.
- Given the key role of exposure in shaping adaptation behaviour (Crick et al., 2018), we consider how this propensity varies in the context of increasing exposure to extreme events.
- In particular, we empirically investigate
    1. how female representations in ownership and management of SMEs in Kenya and Senegal affect their adoption of sustainable and unsustainable adaptation strategies,
    2. mitigating/exaggerating effects of financial barriers and assistance, and
    3. implications of those strategies for preparation for the future.

Data: SME survey (2016)

- We use the dataset collected by Crick *et al.* (2018).
- The survey, conducted in 2016, comprises 325 SMEs in three different regions of Senegal (Louga, Saint Louis and Kaolack) and in the county of Laikipia in Kenya.
- For our analysis, we restrict the sample to SMEs that are relatively homogenous in terms of their size, exposure to climate events and ownership structures.
    - In particular, we exclude SMEs that were exposed to more than 8 extreme events (this only removes one outlier), have more than 10 employees or more than 5 owners.
- The final estimating sample consists of 205 SMEs: 125 in Kenya and 80 in Senegal.

Adaptation strategies

- Following Crick *et al.* (2018), we categorize adaptation strategies into sustainable and unsustainable strategies.
- ***Sustainable strategies*** may not have any adverse effect on SME's future profits
  - uptakes of loans and insurances,
  - switching to different commodities or crops,
  - trading or farming additional commodities or crops, and
  - switching to different varieties of same commodities or crops
- ***Unsustainable strategies*** might adversely affect their future returns
  - reducing the number of employees,
  - selling of productive assets,
  - selling assets at lower price, and
  - mortgaging assets.

Future planning

- Future planning actions that might increase business ***resilience*** include
  - increased water and energy efficiency to improve operations,
  - upgradation or retrofitting infrastructure, equipment or company assets to reduce impact of the risk,
  - coordinating with other firms, and
  - uptake of loans to increase climate resilience.
- Future planning actions that might increase business ***expansion*** include
  - adoption of new crop varieties or new breeds or new commodities,
  - diversifying operations or switch to a different commodity, and
  - uptake of insurance to cover assets or activities at risk.
- Future planning actions that might increase business ***contraction*** include
  - discontinuation of business partnerships and
  - relocation of facilities or assets to reduce the risk of exposure.

Explanatory variables

- Surveyed firms report the ***number of extreme events*** that they have experienced in last five years.
  - Examples of such events include drought, flood, extreme rainfall, storms, extreme heat, extreme cold, extreme windstorms and dust.
- We construct the ***gender variable*** in terms of representation of females in ownership and management of the SME.
  - The variable takes the value of 1 if there is at least one female owner, or if the main manager of the firm is a woman.
- The ***vector of controls*** includes different indicators of adaptive capacity
  - such as financial barriers, assistance, training, membership, and market distance.

Econometric specifications

- SMEs decide how many sustainable and unsustainable adaptation strategies to adopt.
- Here, our outcome variables are count variables and therefore are non-negative.
- Therefore, we fit the following Poisson regression model

$$E(y|x) = \exp\left(\alpha + \beta_1 N_i + \beta_2 N_i^2 + \beta_3 F_i + \beta_4 N_i \times F_i + \beta_5 N_i^2 \times F_i + \boldsymbol{z}\delta + u_i\right), \quad (1)$$

  - x : all the explanatory variables,
  - $z \subset x$: internal firm characteristics and external business environment.
  - N_i : the number of climate events experienced by the SME i,
  - F_i : gender representation.
- We are interested in the estimated coefficients of the interaction terms,
  - i.e., $\hat{\beta}_4$ and $\hat{\beta}_5$, that show the additional effects the SMEs experiences due to female representation when choosing their adaptation strategies when exposed to climate events.

Econ.. (2)

- We next investigate the potential mitigating or exaggerating effects of assistance and training.
- We include additional interactions to eq. (1):

$$E(y|x)$$
$$= \exp\big(\alpha + \beta_1 N_i + \beta_2 N_i^2 + \beta_3 F_i + \beta_4 N_i \times F_i + \beta_5 N_i^2 \times F_i + \gamma_1 N_i \times M_i + \gamma_2 N_i^2 \times M_i + \gamma_3 F_i \times M_i$$
$$+ \gamma_4 N_i \times F_i \times M_i + \gamma_5 N_i^2 \times F_i \times M_i + \boldsymbol{z}\delta + u_i\big), \qquad (2)$$

- where γ_4 and γ_5 denote the mitigating/exaggerating effects of assistance or training (M_i).
- All other variables and estimation strategy are as described for equation (1).

Econ.. (3)

- Finally, we investigate the implications of the adoptions of sustainable and unsustainable adaptation strategies for future planning.
- We adopt a 2SLS method where the first stage has been estimated by eq. (1).
- In the second stage, we estimate

$$P_i = \omega_0 + \omega_1 \hat{S}_i + \omega_2 \hat{R}_i + \boldsymbol{w}\theta + \epsilon_i, \tag{3}$$

  - $\hat{S}_i$ and $\hat{R}_i$: predicted number of sustainable and unsustainable adaptation strategies
  - P_i: outcome variables: resilience, expansion and contraction.
- We adopt a linear probability model with cluster-robust standard errors to retrieve the marginal effects of $\hat{S}_i$ and $\hat{R}_i$ on P_i, i.e., $\widehat{\omega}_1$ and $\widehat{\omega}_2$.

Results (1)

- SMEs with female representation are less propense to implement unsustainable adaptation when they are not exposed to extreme events
- However, they do not keep the same propensity as their exposure to extreme events increases
- When faced with an increased number of disasters, female-led/owned SMEs adopt more unsustainable adaptation practices (at a decreasing rate)

Table 2. Main Results: Effects of Gender

	Main specification: Poisson Regressions		Alternative specification: Negative Binomial Regressions	
Variables	Sustainable	Unsustainable	Sustainable	Unsustainable
No. of events	2.311**	-0.012	2.259**	-0.009
	(1.045)	(0.459)	(1.052)	(0.458)
(No. of events)^2	-0.500*	0.034	-0.485*	0.033
	(0.261)	(0.061)	(0.264)	(0.062)
Females	0.714	-1.481**	0.622	-1.504**
	(0.855)	(0.656)	(0.891)	(0.673)
Females × No. of events	**-1.018**	**1.363*** **	-0.912	1.375***
	(1.057)	**(0.377)**	(1.093)	(0.382)
Females × (No. of events)^2	**0.289**	**-0.254*** **	0.265	-0.257***
	(0.262)	**(0.058)**	(0.269)	(0.056)
No. of Obs.	204	204	204	204
R-squared			0.159	0.213
District FE	YES	YES	YES	YES
Control variables	YES	YES	YES	YES

Results (2)

- *Assistance* and *Training* are significant mitigating effects, with their potentials of
  - increasing sustainable adaptation strategies by female-led SMEs
  - decreasing unsustainable adaptation strategies by female-led SMEs

Table 3. Mitigating Effects

Variables	Sustainable	Unsustainable
Assistance		
× Females × No. of events	4.180***	-1.031
	(0.885)	(0.652)
× Females × (No. of events)^2	-0.890***	0.400**
	(0.210)	(0.198)
Training		
× Females × No. of events	5.003**	-0.405
	(2.502)	(0.631)
× Females × (No. of events)^2	-1.094	0.169*
	(0.672)	(0.098)

Results (3)

- The choice of climate resilient planning is especially affected by current adaption strategies
- In turn, these have implications for women entrepreneurs and for mitigating strategies

Table 4. Future Planning

Variables	Climate Resilience	Business Expansion	Business Contraction
No. of sustainable adaptation practices (est.)	0.081*** (0.017)	0.023 (0.043)	0.014 (0.008)
No. of unsustainable adaptation practices (est.)	0.055** (0.017)	0.052 (0.085)	0.028 (0.020)
Observations	204	204	204
R-squared	0.249	0.155	0.189
District FE	YES	YES	YES
Control variables	YES	YES	YES

Summary and Policy Implications

- General business support, adaptation assistance (particularly to women), and specific trainings encourage sustainable adaptation responses
- Engaging in adaptation today also increases the likelihood that a firm is preparing for future climate change
- The finding lends support to the strategy of many development agencies who use adaptation to current climate variability as a way of building resilience to future climate change
    - In a gender-inclusive way

Thank you

Q&A

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Climate, Mothers' Time-Use, and Child Nutrition: Evidence from Rural Uganda

Climate, Mothers' Time-Use, and Child Nutrition: Evidence from Rural Uganda

Chris M. Boyd
University of Minnesota

Climate Adaptation Research Symposium 2021
September 8, 2021

Motivation

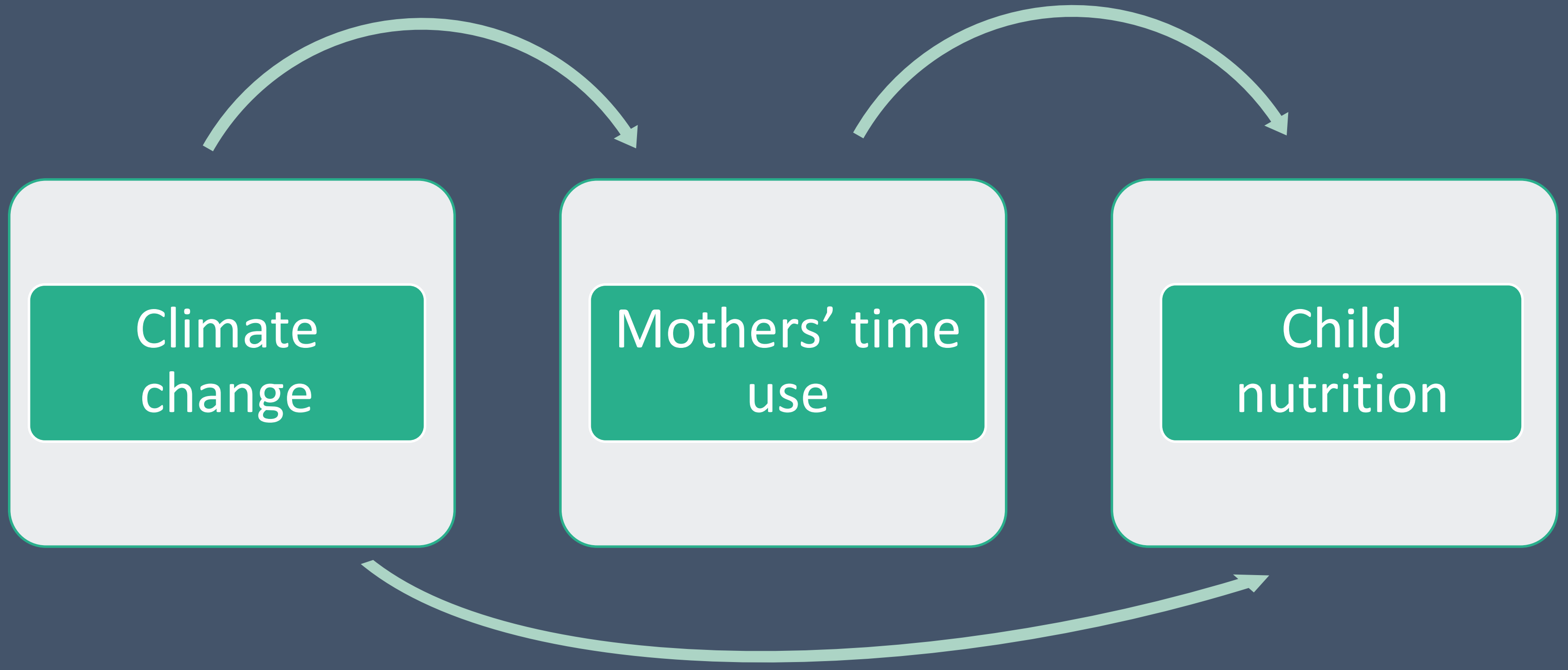
- Differential impacts of climate change on men and women (Sachs 1996, Udry 1996, Bryan et al. 2017)
- Impact of climate change on rural families focused on farm production but not on labor (Lee et al. 2021)

- Increasing literature on the impacts of climate change on child nutrition, in the short and long run

Motivation

- Only a few papers explored the mechanisms of this relationship (Omiat & Shively 2020, Tiwari et al. 2017)
- Besides the disease and the food-production mechanisms, other mechanisms not studied, e.g., role of mother’s time use (Bryan et al. 2017)
- Role of women as intermediaries between agriculture and nutrition lacks study

Research question



Theoretical Framework

- I extend Omiat & Shively 2020, Tiwari et al. 2017, and define:

$$C_t = C_t(P_t(R_{t,} R_{t-1}, L_t^{fp}, L_{t-1}^{fp}), F_t, L_t^{hw})$$

$$D_t = D_t(R_t, L_t^{hw}, L_t^{ohw}(R_t))$$

Theoretical Framework

$$\max_{L_t^{fp}, L_t^{lfp}, L_t^{hw}, L_t^{ohw}, L_t^{m}} H_t = f\left(H_{t-1}, C_t\left(P_t\left(R_{t,} R_{t-1}, L_t^{fp}, L_{t-1}^{fp}\right), F_t, L_t^{hw}\right), D_t(R_t, L_t^{hw}, L_t^{ohw}(R_t))\right)$$

subject to:

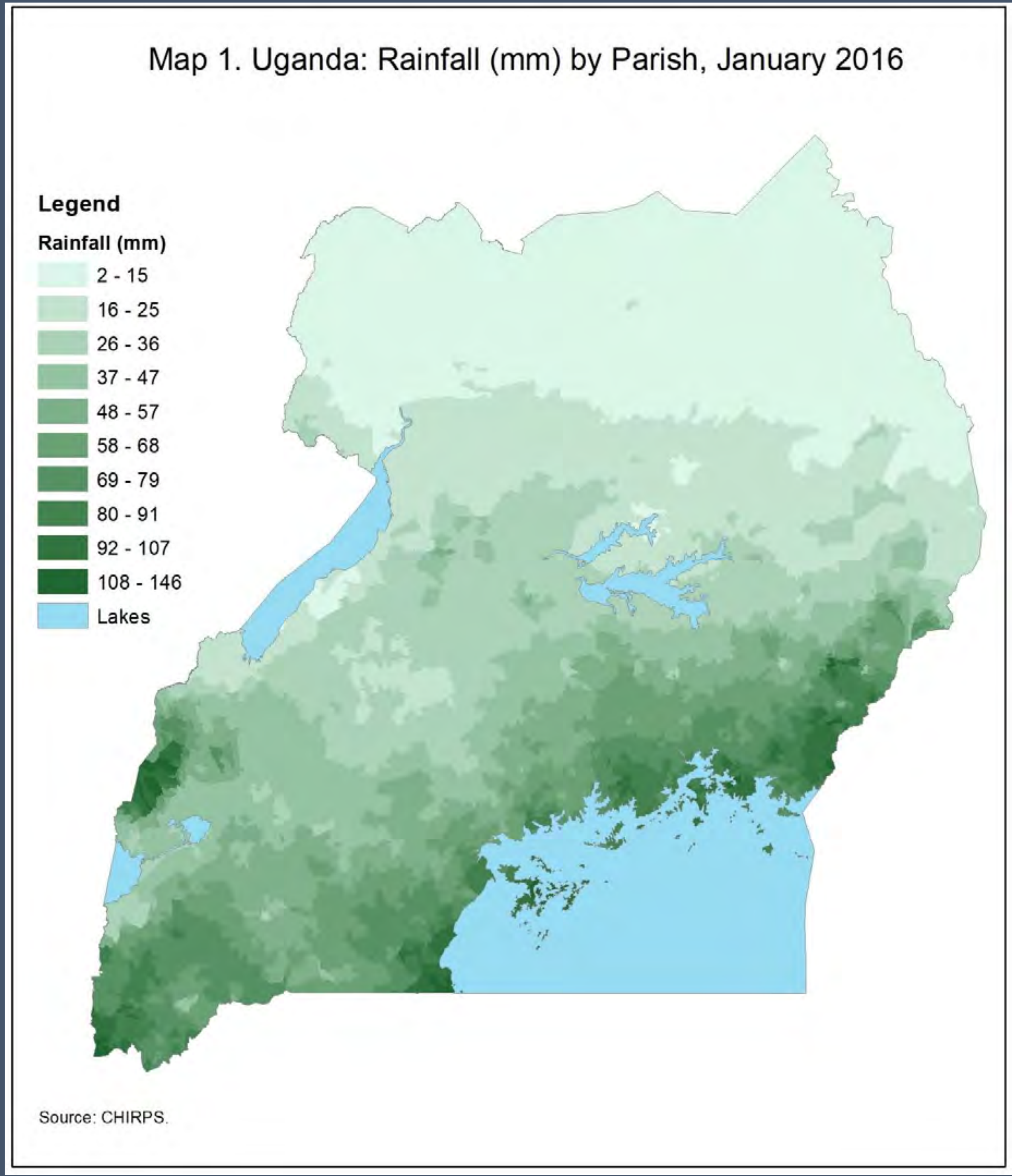
$$p_t P_t + w_t\left(L_t^{lfp} + L_t^{m} - L_t^{fp} - L_t^{hw} - L_t^{ohw} - L_t^{l}\right) + \overline{W_t} \leq S_t$$

$$L_t^{T} = L_t^{fp} + L_t^{lfp} + L_t^{hw} + L_t^{ohw} + L_t^{m} + L_t^{l}$$

Data

- Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)
  - High resolution data (0.05° x 0.05°, approximately 5km)

- CHIRPS monthly **rainfall** aggregated at the parish level



Data

- Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS – ISA) / UNPS
- Two panel waves: 2013-2014 and 2015-2016

pooled: **1,645 obs. kids under 5**

2013-2014 & 2015-2016

382 kids + 488 kids

488 kids + 287 kids

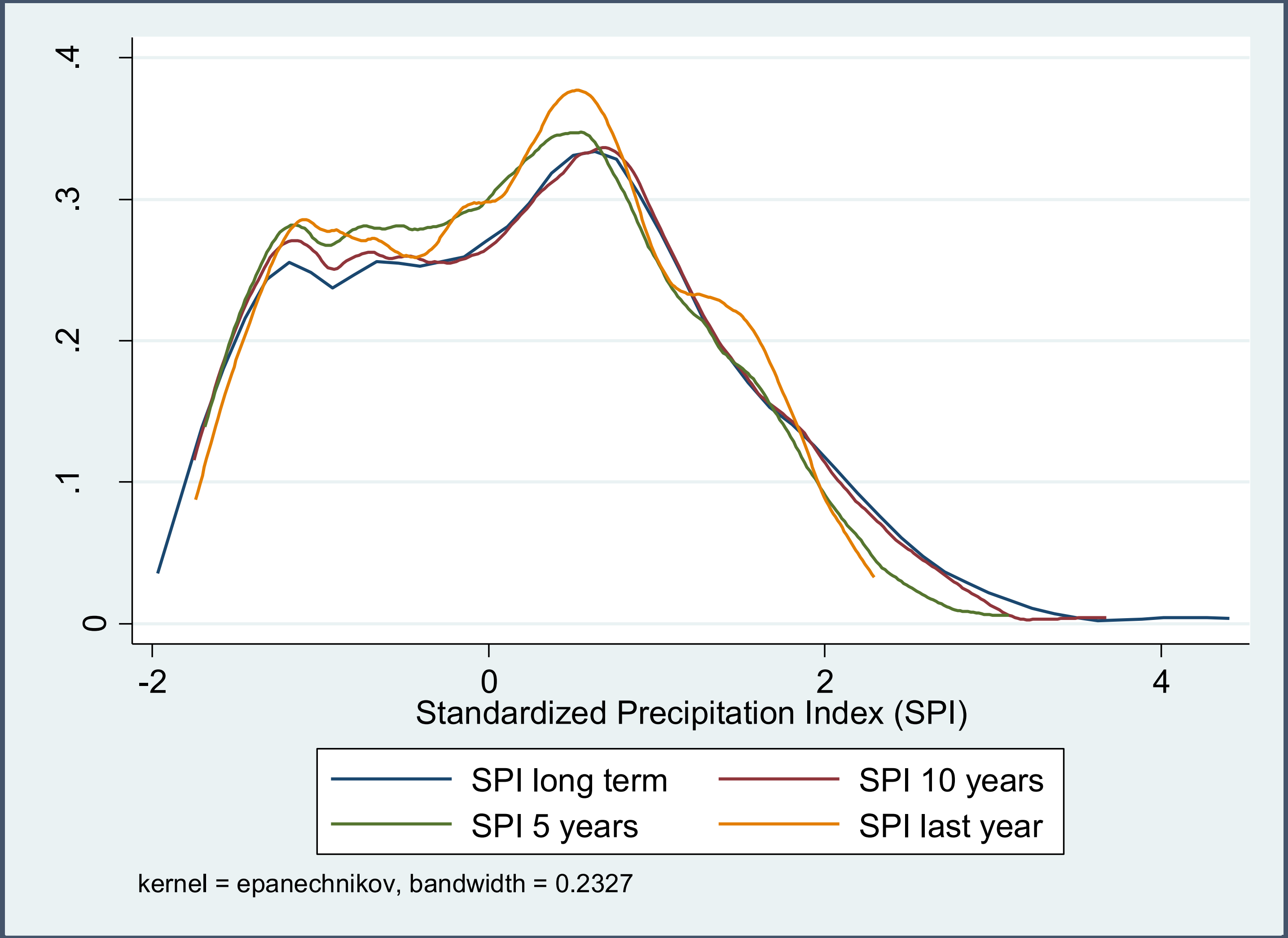
(in 754 unique agricultural households & are in both waves)

Methodology

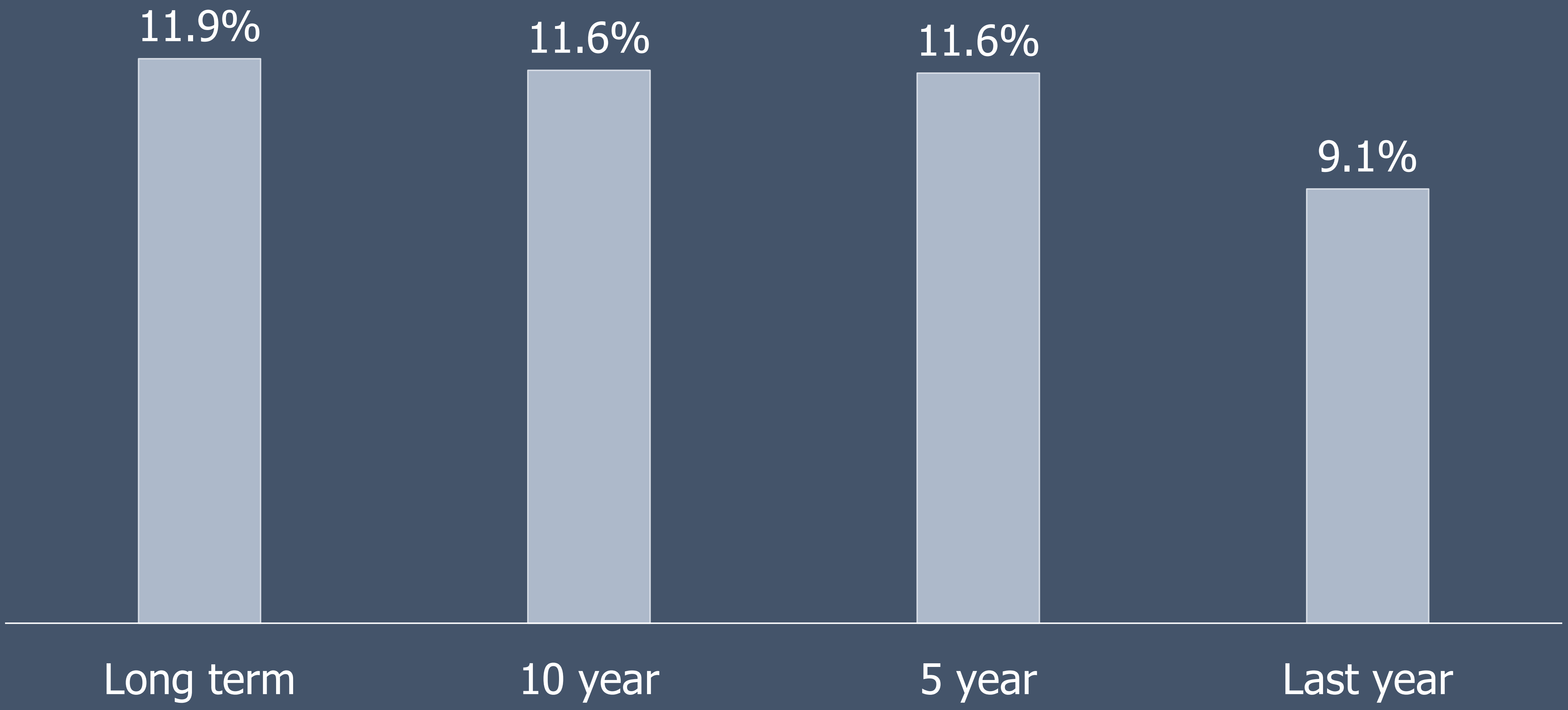
- Two-way fixed effects
  - What is the impact of climate change on child nutrition?
  - What is the impact of climate change on mother's time use?

- Mediation analysis (Acharya et al. 2016):
  - Is mother's time-use a mediating factor between weather variation and child nutrition?

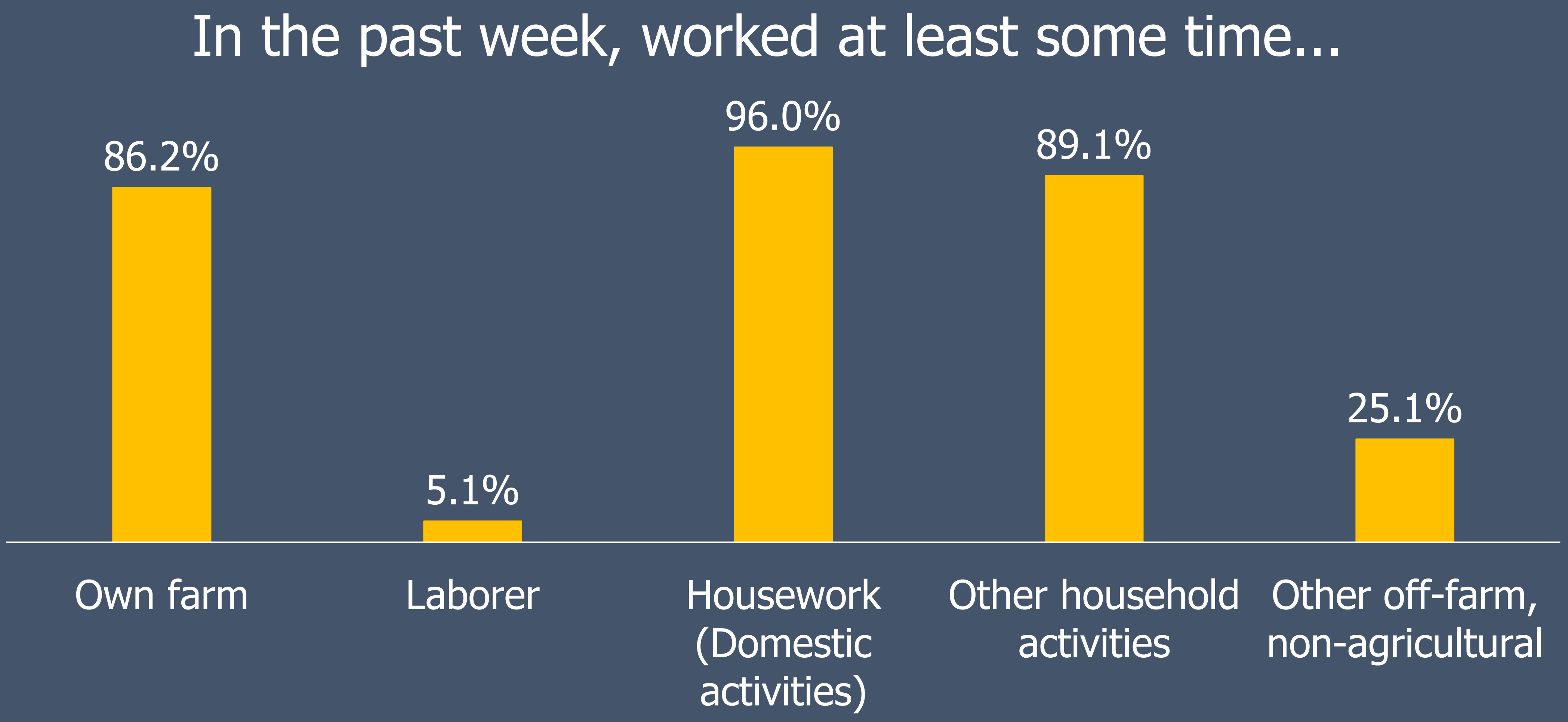
Descriptive stats – Rainfall variation

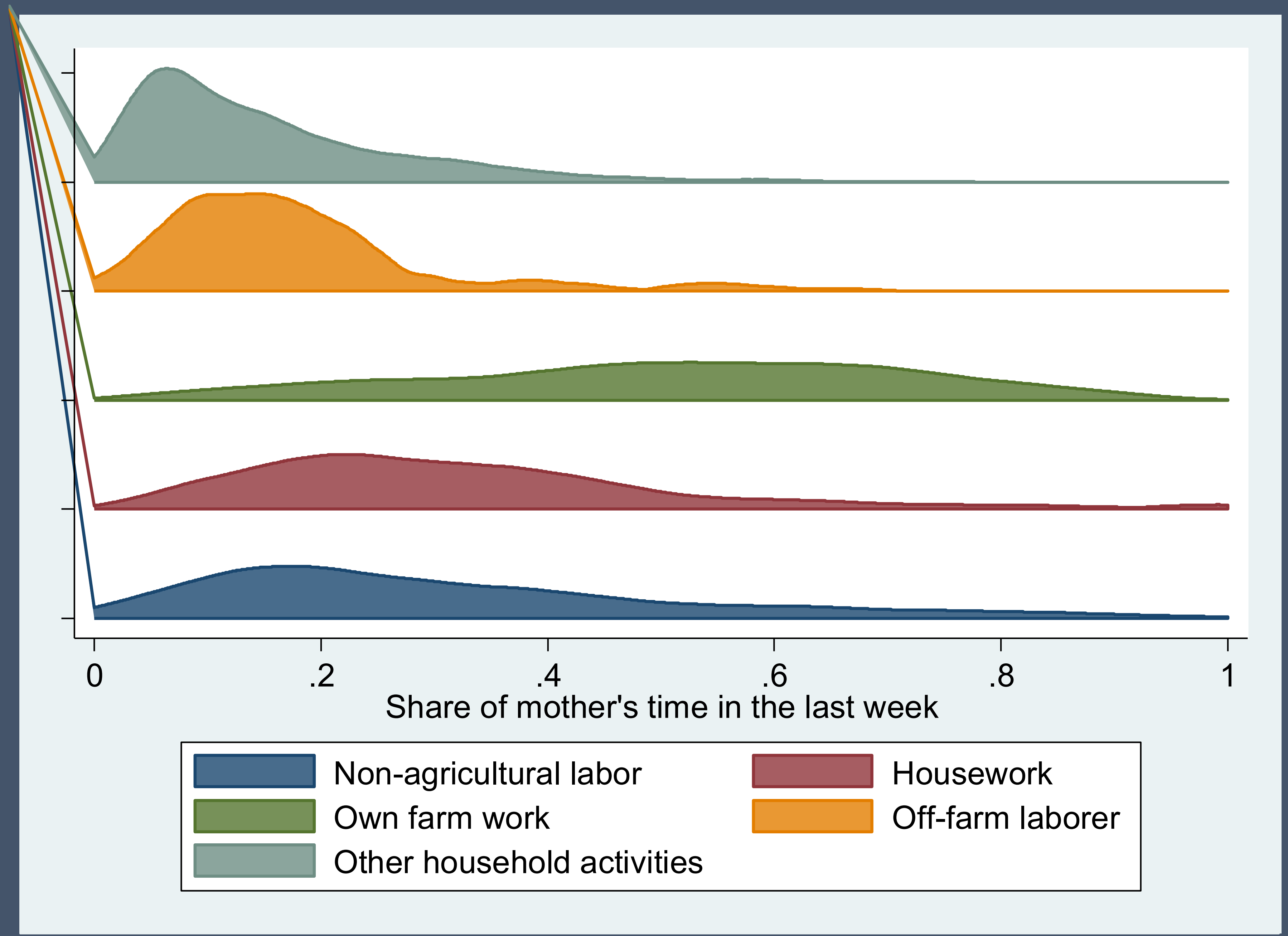


Drought as SPI<-1.3, with respect to,...

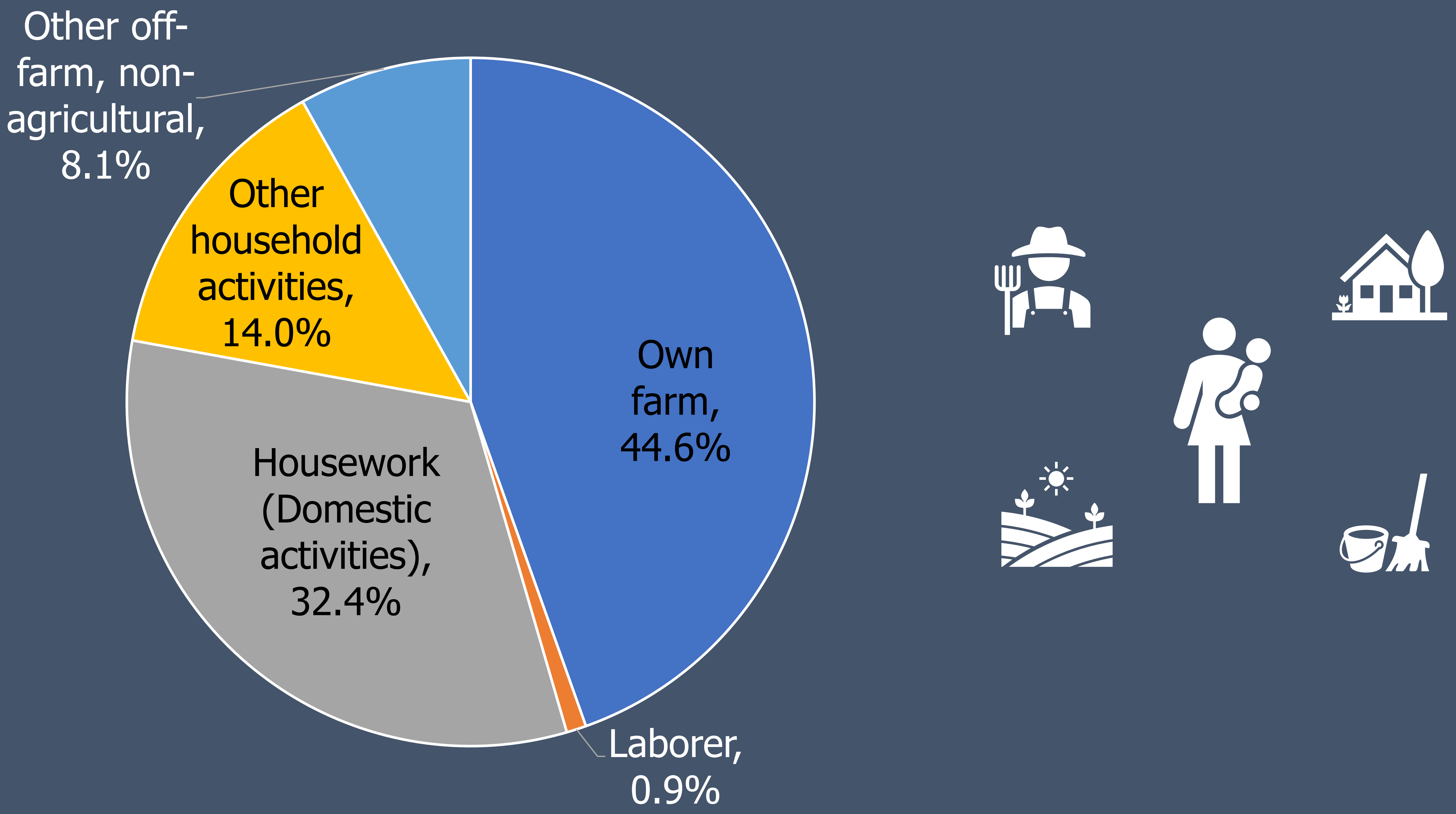


Descriptive stats – Mother's time-use

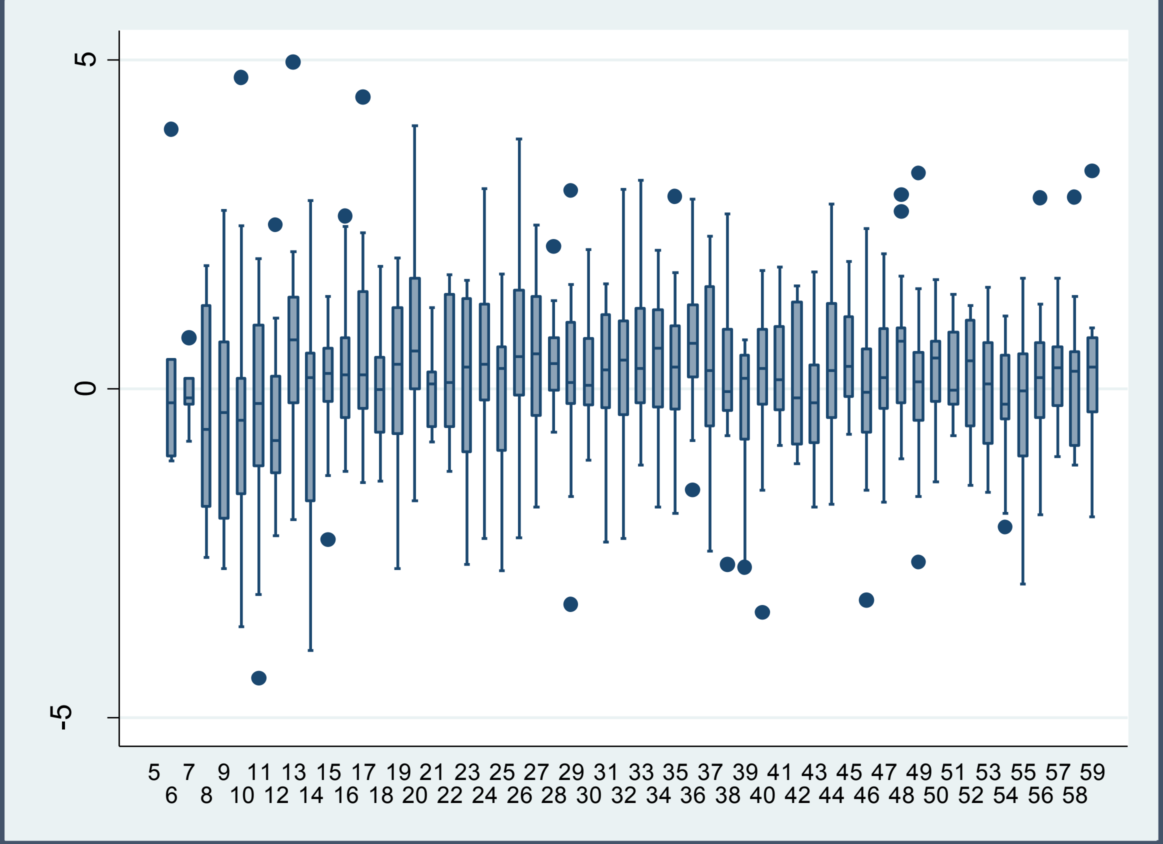


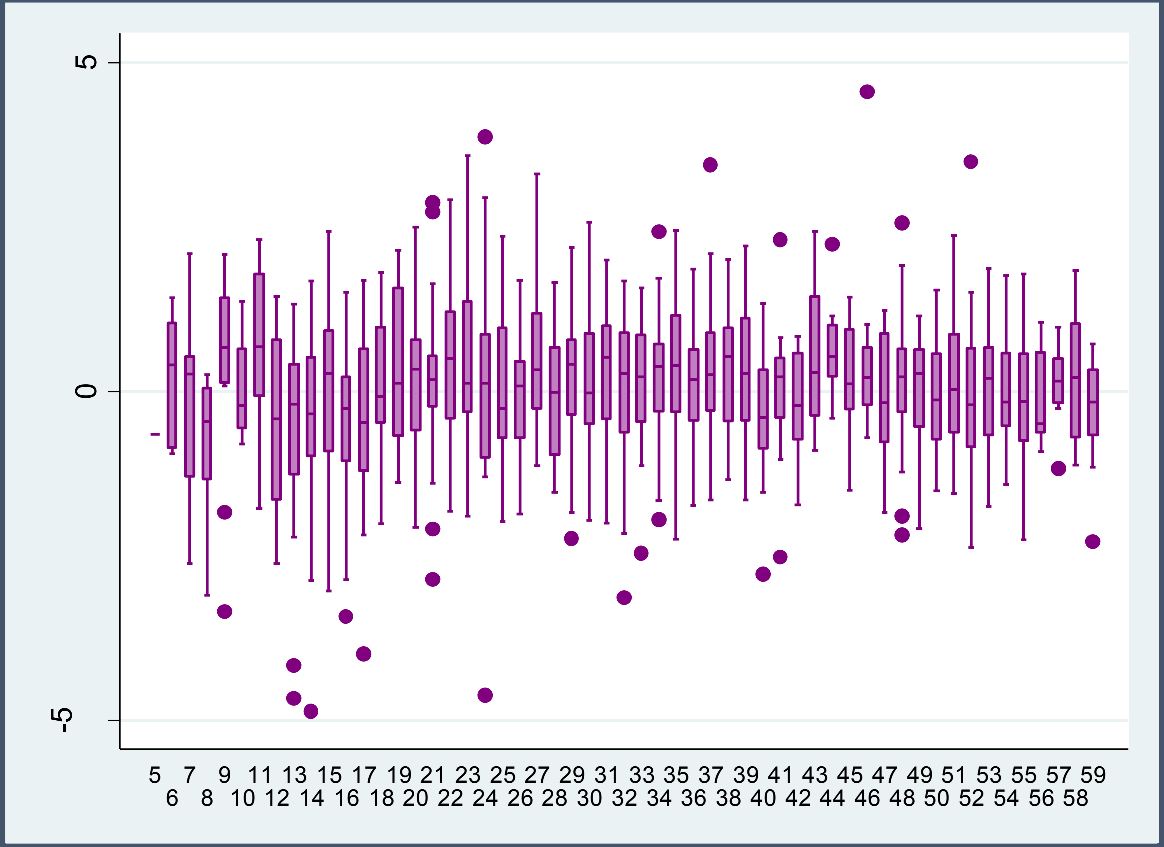


0
.2
.4
.6
.8
1
Share of mother's time in the last week
Non-agricultural labor
Housework
Own farm work
Off-farm laborer
Other household activities


Other off-farm, non-agricultural, 8.1%
Other household activities, 14.0%
Own farm, 44.6%
Housework (Domestic activities), 32.4%
Laborer, 0.9%

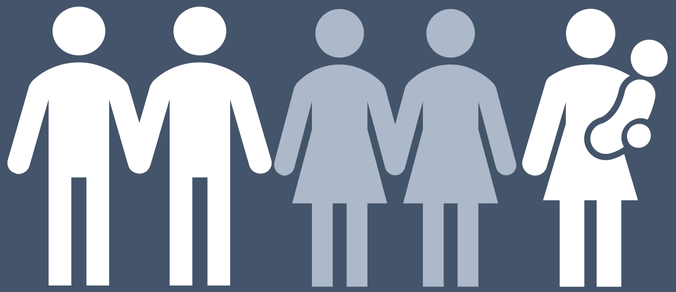
Descriptive statistics – Child nutrition





Descriptive stats - Controls

Agricultural household with at least one child under 5 years old



- Family size > 6
- Mothers ~ 1
- Children under 5 ~ 1
- Elders: 0.2
- Childless women: 2.2

- Multi-generational: 30%
- Mother in polygamous union: ~ 20%

Descriptive statistics

- 8.4 months without enough food to feed the household
- 94% of households grow food crops (maize, beans, peas, potato, cassava)

Impact of rainfall variability on mothers' time-use

	Time share spent by mother...									
	Working at the farm		As a laborer		On domestic activities		On other household activities		On other non-agricultural activities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Drought occurrence										
Drought w.r.t. long run (=1)	-0.004	0.004	0.021**	0.022*	0.009	-0.005	0.030	0.022	-0.056*	-0.042
	(0.071)	(0.050)	(0.010)	(0.011)	(0.065)	(0.049)	(0.027)	(0.027)	(0.032)	(0.032)
R-squared	0.103	0.541	0.064	0.208	0.083	0.434	0.139	0.256	0.052	0.338
Drought w.r.t. 5-year (=1)	0.027	0.019	0.006	0.004	0.017	0.029	0.017	0.005	-0.067**	-0.056*
	(0.067)	(0.048)	(0.017)	(0.020)	(0.059)	(0.047)	(0.026)	(0.026)	(0.031)	(0.030)
R-squared	0.103	0.541	0.055	0.200	0.083	0.435	0.137	0.255	0.054	0.341
Drought w.r.t. last-year (=1)	-0.020	-0.041	0.006	0.006	0.071	0.034	0.004	0.008	-0.061	-0.008
	(0.089)	(0.053)	(0.008)	(0.008)	(0.085)	(0.060)	(0.034)	(0.036)	(0.040)	(0.036)
R-squared	0.103	0.542	0.055	0.201	0.085	0.435	0.136	0.255	0.051	0.336
Observations	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
N. Households	754	754	754	754	754	754	754	754	754	754
Child, Mother, & HH Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Impact of rainfall variability on mothers' time-use

	Time share spent by mother...									
	Working at the farm		As a laborer		On domestic activities		On other household activities		On other non-agricultural activities	
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Impact of rainfall variability on mothers' time-use

	Time share spent by mother…									
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Impact of rainfall variability on mothers' time-use

	Time share spent by mother…									
	Working at the farm		As a laborer		On domestic activities		On other household activities		On other non-agricultural activities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel B. Rainfall index										
SPI (SD from long run rainfall mean)	-0.012	-0.013	0.002	0.004	0.031	0.044*	-0.024**	-0.024**	0.003	-0.011
	(0.027)	(0.020)	(0.004)	(0.004)	(0.025)	(0.023)	(0.012)	(0.011)	(0.019)	(0.015)
R-squared	0.103	0.541	0.055	0.202	0.087	0.441	0.145	0.262	0.047	0.337
SPI (SD from 5-year mean)	-0.012	-0.007	0.002	0.003	0.030	0.040*	-0.023*	-0.023*	0.004	-0.013
	(0.029)	(0.022)	(0.005)	(0.005)	(0.027)	(0.024)	(0.013)	(0.013)	(0.021)	(0.017)
R-squared	0.103	0.541	0.055	0.201	0.085	0.439	0.143	0.260	0.047	0.337
SPI (SD from last year mean)	-0.008	0.011	0.002	0.003	0.053*	0.049**	-0.035**	-0.037**	-0.012	-0.026
	(0.033)	(0.024)	(0.007)	(0.006)	(0.029)	(0.024)	(0.015)	(0.015)	(0.025)	(0.020)
R-squared	0.103	0.541	0.055	0.201	0.090	0.439	0.148	0.265	0.047	0.339
Observations	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
N. Households	754	754	754	754	754	754	754	754	754	754
Child, Mother, & HH Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Impact of rainfall variability on mothers' time-use

	Time share spent by mother…									
	Working at the farm		As a laborer		On domestic activities		On other household activities		On other non-agricultural activities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel B. Rainfall index										
SPI (SD from long run rainfall mean)	-0.012	-0.013	0.002	0.004	0.031	0.044*	-0.024**	-0.024**	0.003	-0.011
	(0.027)	(0.020)	(0.004)	(0.004)	(0.025)	(0.023)	(0.012)	(0.011)	(0.019)	(0.015)
R-squared	0.103	0.541	0.055	0.202	0.087	0.441	0.145	0.262	0.047	0.337
SPI (SD from 5-year mean)	-0.012	-0.007	0.002	0.003	0.030	0.040*	-0.023*	-0.023*	0.004	-0.013
	(0.029)	(0.022)	(0.005)	(0.005)	(0.027)	(0.024)	(0.013)	(0.013)	(0.021)	(0.017)
R-squared	0.103	0.541	0.055	0.201	0.085	0.439	0.143	0.260	0.047	0.337
SPI (SD from last year mean)	-0.008	0.011	0.002	0.003	0.053*	0.049**	-0.035**	-0.037**	-0.012	-0.026
	(0.033)	(0.024)	(0.007)	(0.006)	(0.029)	(0.024)	(0.015)	(0.015)	(0.025)	(0.020)
R-squared	0.103	0.541	0.055	0.201	0.090	0.439	0.148	0.265	0.047	0.339
Observations	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
N. Households	754	754	754	754	754	754	754	754	754	754
Child, Mother, & HH Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Results – Rainfall on time-use

- Rainfall variation does not significantly impact mother’s time-use in own-farm agriculture
- A meteorological drought **increases** time share as a laborer (2%) and **decreases** the time share in market activities (6%)
- Drier weather decreases time share in domestic activities (4%) and increases the time share in other household activities (3%)

Impact of rainfall variability on child nutrition

	WAZ	WAZ	Under-weight (=1)	Under-weight (=1)	WHZ	WHZ	Wasting (=1)	Wasting (=1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Drought occurrence								
Drought w.r.t.	-0.258	-0.202	0.034	0.048	-0.840*	-0.554*	0.060	0.035
long run (=1)	(0.218)	(0.168)	(0.058)	(0.066)	(0.458)	(0.289)	(0.053)	(0.044)
R-squared	0.044	0.123	0.074	0.131	0.041	0.100	0.034	0.125
Drought w.r.t. 5-year (=1)	-0.261	-0.205	0.034	0.056	-0.808*	-0.551**	0.058	0.036
	(0.201)	(0.156)	(0.053)	(0.059)	(0.424)	(0.270)	(0.049)	(0.041)
R-squared	0.044	0.123	0.074	0.131	0.041	0.101	0.034	0.125
Drought w.r.t.	-0.160	-0.068	0.114	0.092	-0.148	-0.146	-0.012	-0.012
last-year (=1)	(0.191)	(0.203)	(0.072)	(0.071)	(0.277)	(0.289)	(0.051)	(0.051)
R-squared	0.043	0.122	0.076	0.132	0.030	0.096	0.032	0.124
Observations	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
N. Households	754	754	754	754	754	754	754	754
Child, Mother, & HH Controls	No	Yes	No	Yes	No	Yes	No	Yes

Impact of rainfall variability on child nutrition

	WAZ	WAZ	Under-weight (=1)	Under-weight (=1)	WHZ	WHZ	Wasting (=1)	Wasting (=1)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel B. Rainfall index								
SPI (SD from long	0.109	0.181*	-0.068*	-0.062*	-0.049	-0.080	0.018	0.028
run rainfall mean)	(0.101)	(0.103)	(0.036)	(0.037)	(0.155)	(0.145)	(0.031)	(0.029)
R-squared	0.044	0.127	0.080	0.135	0.029	0.096	0.033	0.126
SPI (SD from 5-year mean)	0.089	0.152	-0.067*	-0.058	-0.052	-0.080	0.020	0.030
	(0.106)	(0.108)	(0.040)	(0.041)	(0.174)	(0.160)	(0.035)	(0.031)
R-squared	0.043	0.125	0.079	0.134	0.029	0.096	0.033	0.126
SPI (SD from last year mean)	0.076	0.125	-0.089**	-0.068	-0.120	-0.151	0.019	0.020
	(0.108)	(0.114)	(0.043)	(0.044)	(0.184)	(0.172)	(0.038)	(0.032)
R-squared	0.043	0.124	0.081	0.134	0.030	0.097	0.033	0.125
Observations	1,645	1,645	1,645	1,645	1,645	1,645	1,645	1,645
N. Households	754	754	754	754	754	754	754	754
Child, Mother, & HH Controls	No	Yes	No	Yes	No	Yes	No	Yes

Results – Rainfall on child health

- Meteorological droughts are only negatively related to WHZ
- Drier weather is positively related with being underweight (WAZ<-2)

Mediation Analysis: Impact of rainfall variability on the probability of being underweight

	Underweight (=1)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline estimate	Sequential g-estimate, or Average Controlled Direct Effect (ACDE), demediating the effect of mother's time share…				
		Working at the farm	As a laborer	On domestic activities	On other household activities	On other non-agricultural activities
SPI (SD from long run rainfall mean)	-0.073**	-0.073**	-0.073**	-0.073**	-0.073**	-0.073**
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Constant	-0.195	-0.170	-0.848***	-0.172	-0.391*	-0.111
	(0.205)	(0.205)	(0.205)	(0.205)	(0.205)	(0.205)
R-squared	0.081	0.081	0.081	0.081	0.081	0.081
SPI (SD from last year rainfall mean)	-0.092**	-0.092**	-0.092**	-0.092**	-0.092**	-0.092**
	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
Constant	-0.194	-0.175	-0.836***	-0.173	-0.385*	-0.096
	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)
R-squared	0.081	0.081	0.081	0.081	0.081	0.081
Observations	1,645	1,645	1,645	1,645	1,645	1,645
Number of households	754	754	754	754	754	754
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Mediation Analysis: Impact of rainfall variability on the probability of being underweight

	Underweight (=1)					
	(1)	(2)	(3)	(4)	(5)	(6)
		Sequential g-estimate, or Average Controlled Direct Effect (ACDE), demediating the effect of mother's time share...				
	Baseline estimate	Working at the farm	As a laborer	On domestic activities	On other household activities	On other non-agricultural activities
SPI (SD from long run rainfall mean)	-0.073**	-0.073**	-0.073**	-0.073**	-0.073**	-0.073**
	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)	(0.037)
Constant	-0.195	-0.170	-0.848***	-0.172	-0.391*	-0.111
	(0.205)	(0.205)	(0.205)	(0.205)	(0.205)	(0.205)
R-squared	0.081	0.081	0.081	0.081	0.081	0.081
SPI (SD from last year rainfall mean)	-0.092**	-0.092**	-0.092**	-0.092**	-0.092**	-0.092**
	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)	(0.043)
Constant	-0.194	-0.175	-0.836***	-0.173	-0.385*	-0.096
	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)	(0.204)
R-squared	0.081	0.081	0.081	0.081	0.081	0.081
Observations	1,645	1,645	1,645	1,645	1,645	1,645
Number of households	754	754	754	754	754	754
Household Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Results – Time-use as a mediator

- Mediation analysis:
  - Accounting for mother’s time-use variables do not change the direct relationship between rainfall variability and child nutrition
  - Mother’s time-use does not seem to be an important mediator

Conclusion

In the short-run, drier weather:

- ∅ farm work mothers' time share
- ↓ housework
- ↑ other household activities
- ↑ laborer
- ↓ other off-farm non-agricultural work

- Negative relationship of rainfall variation/drought and child health in the short run

Conclusion

- Mother's time use does not appear to be a mediator

- Changes in mother's time-use respond to climate change, but as an **adaptation mechanism** to provide food/water to children.

Questions
or
comments?

Paul Stainier

Ph.D. Student, UCLA Institute of the Environment and Sustainability

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The Effects of Hot Weather on Rural Indian Diet Quality: A Focus on Iron

The Effects of Hot Weather on Rural Indian Diet Quality: a Focus on Iron

Paul Stainier | UCLA
Dr. Manisha Shah | UCLA

Nutrition and climate change in India

- India: 190 million undernourished people (FAO, 2021)
- 59% of Indian children anemic (NFHS, 2016)
- Iron deficiency decreases:
  - Energy levels
  - Learning in children
  - Productivity in adults

Nutrition and climate change in India

- 60% of Indians rely on agriculture for livelihood (Garg et al., 2020)
- Hot and dry weather lowers:
  - Crop yields (Taraz, 2018)
  - Incomes (Carpena, 2019)
  - Diet quality (Carpena, 2019)

What we do and do not know

- Droughts lower diet quality (Carpena, 2019)
- Most prior work has focused on calories, protein (e.g. Carpena, 2019)
- Little evidence on other micronutrients and minerals
    - **Our contribution: iron**

Research Questions

- Does hot weather decrease iron consumption in rural India?

Research Questions

- Does hot weather decrease iron consumption in rural India? Yes, by more than calories

Research Questions

- Does hot weather decrease iron consumption in rural India? Yes, by more than calories
- Do these losses occur in households with already low levels of iron consumption?

Research Questions

- Does hot weather decrease iron consumption in rural India? Yes, by more than calories
- Do these losses occur in households with already low levels of iron consumption? Yes

Data Sources: Nutrition and Yields

- National Sample Survey
  - Repeated cross-section of households in India
  - Sample: ~300k rural households
    - Last month’s food consumption
  - 2003-2012 (last year of available data)
  - Iron content of NSS foods (Gopalan et al. 1989)
- International Crops Research Institute for the Semi-Arid Tropics:
  - Yearly crop yield data by district, 1981-2012

Data Sources: Weather from ERA5

- Daily temperature and precipitation
- Separate the weather into growing (June - December) and non-growing (March-May) season
- Count the number of days in 10 degree bins
  - Tmax<70F to Tmax>100F
- India is very hot:
  - 45% of districts have no days with Tmax <60F
  - 9% of districts have no days with Tmax < 70F

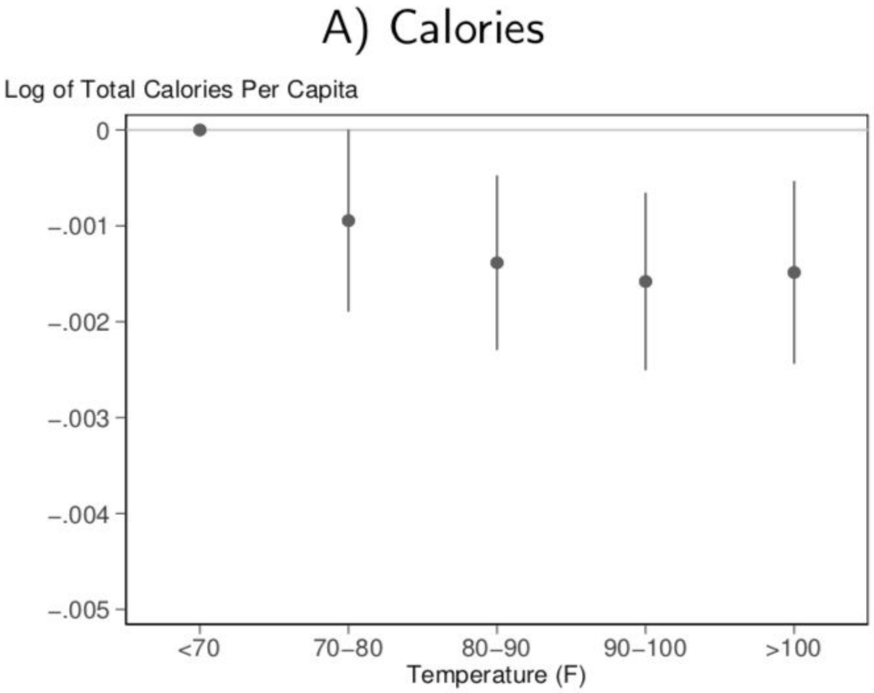
Empirical Strategy

- Dependent variables:
  - Yields (district-level)
  - Diet quality outcomes (household-level)
- Independent variables:
  - Number of days in temperature bins, rainfall controls (district-level)
  - Yields: this growing season temperature
  - Nutrition: last growing season temperature

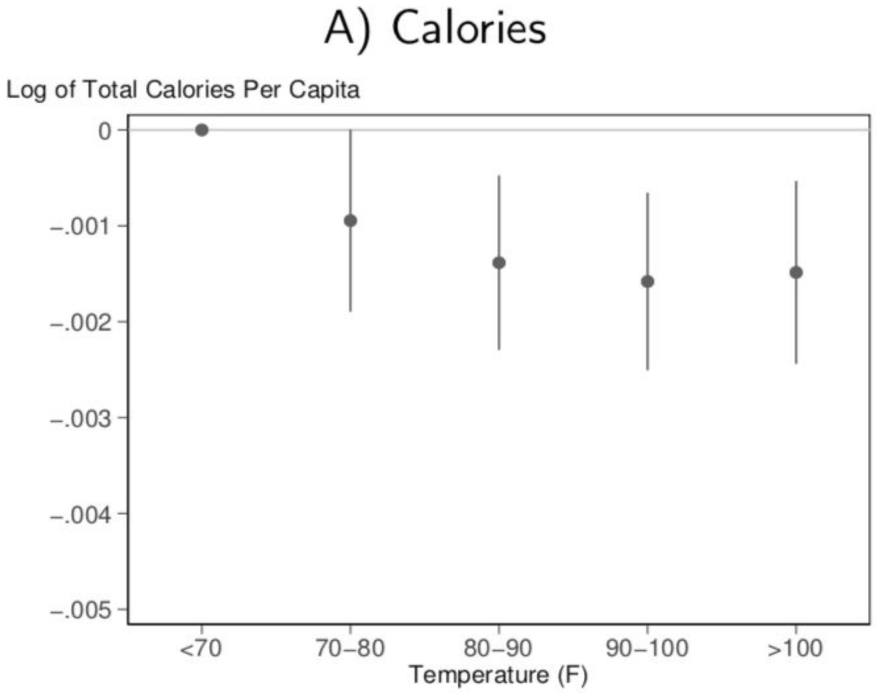
Empirical Strategy

- Threats to causality: arbitrary relationships between temperatures and diet quality
  - e.g. Maybe hotter districts are also better fed on average
- We use district-month and year-month fixed effects

Calories and Iron Intake

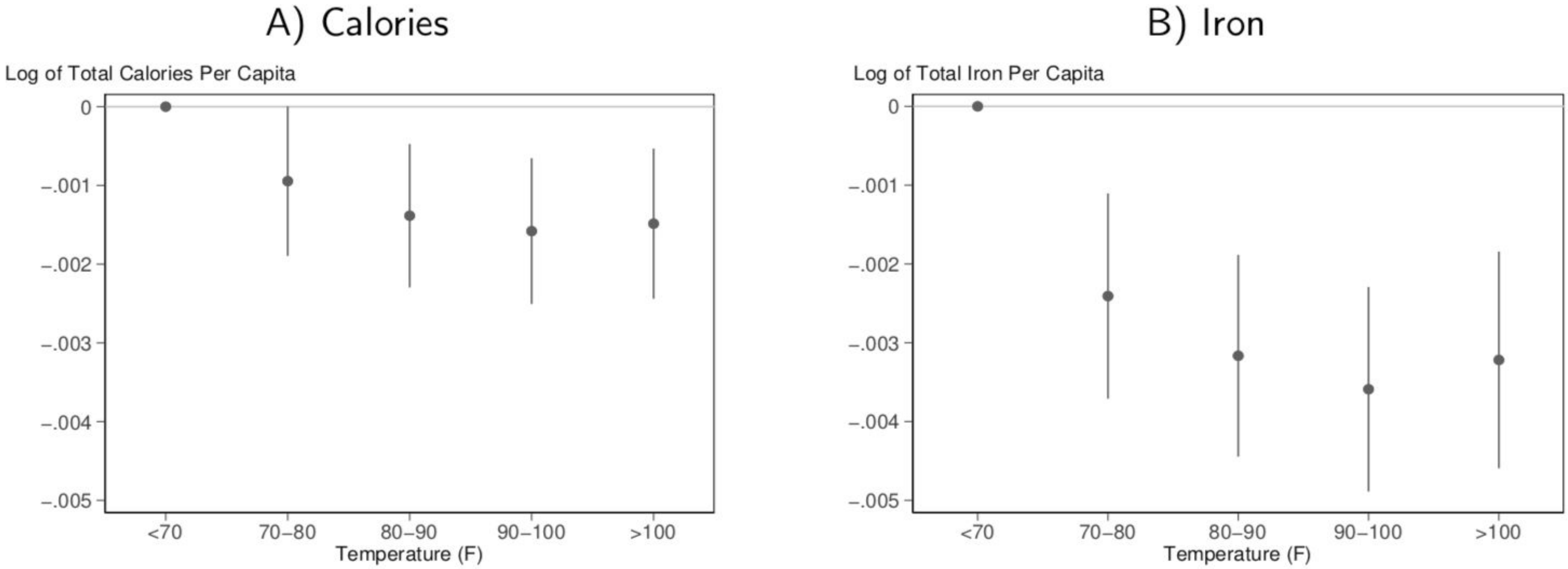


Calories and Iron Intake



- 9 days/growing season > 100F
  - District range of 0 to 76
- 13 days/growing season < 70F
  - District range of 0 to 214

Calories and Iron Intake



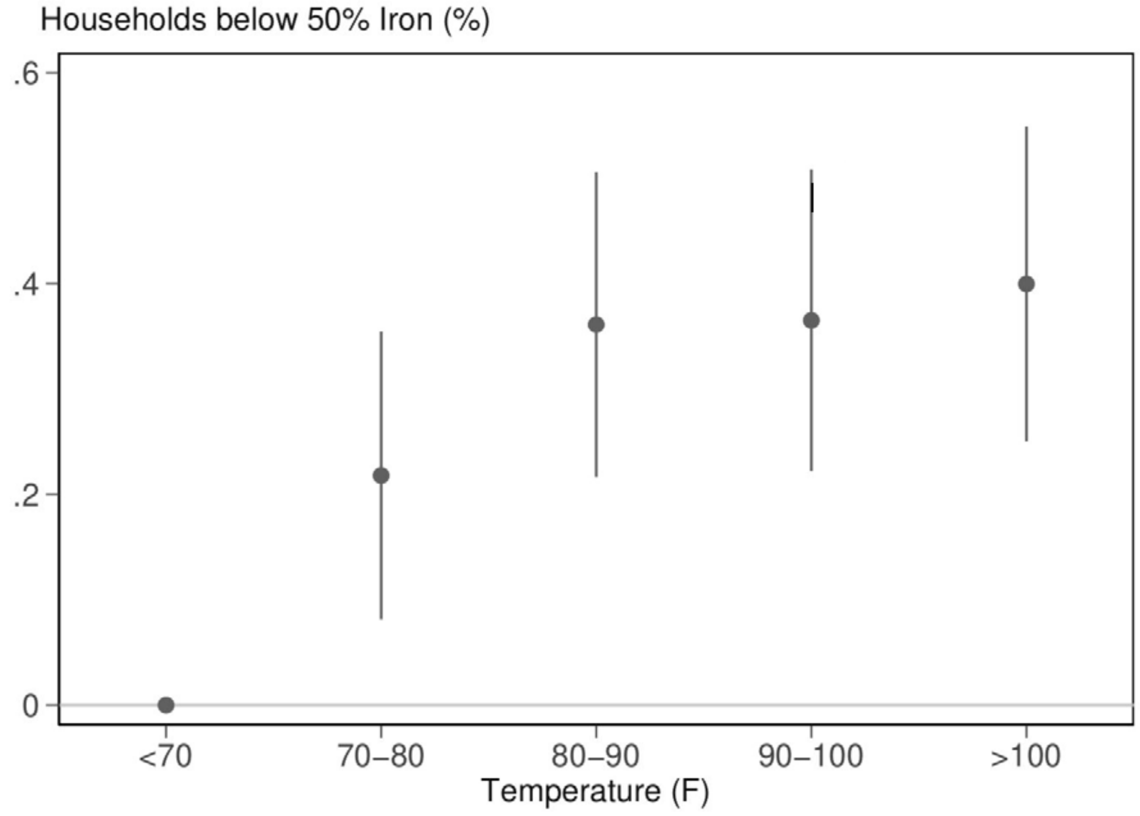
Hot weather decreases iron intake more than calories

Households below 50% Recommended Iron

Baseline: 17%
of households

Households below 50% Recommended Iron

Baseline: 17% of households

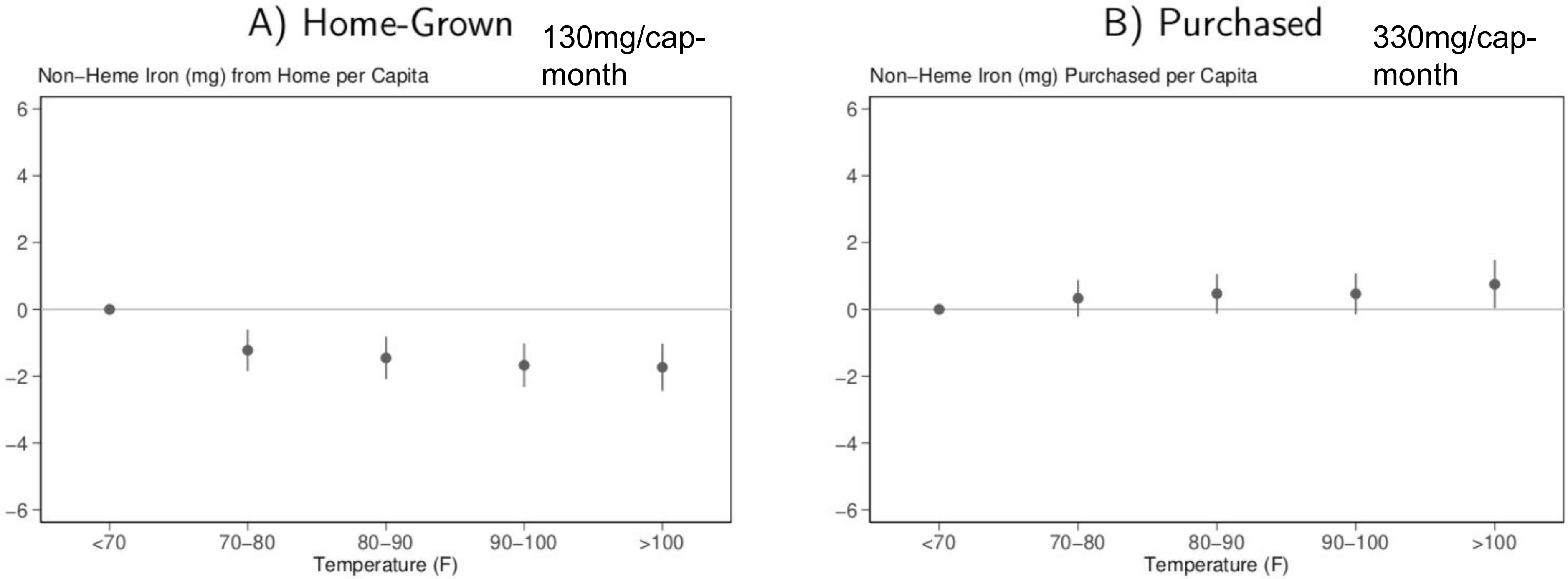


4 Distinct sources of iron

	Home-Grown	Purchased
non-Heme 	27.2%	70.7%
Heme 	0.1%	2.0%

Heme iron (meat) more easily absorbed

Non-heme Iron per Capita

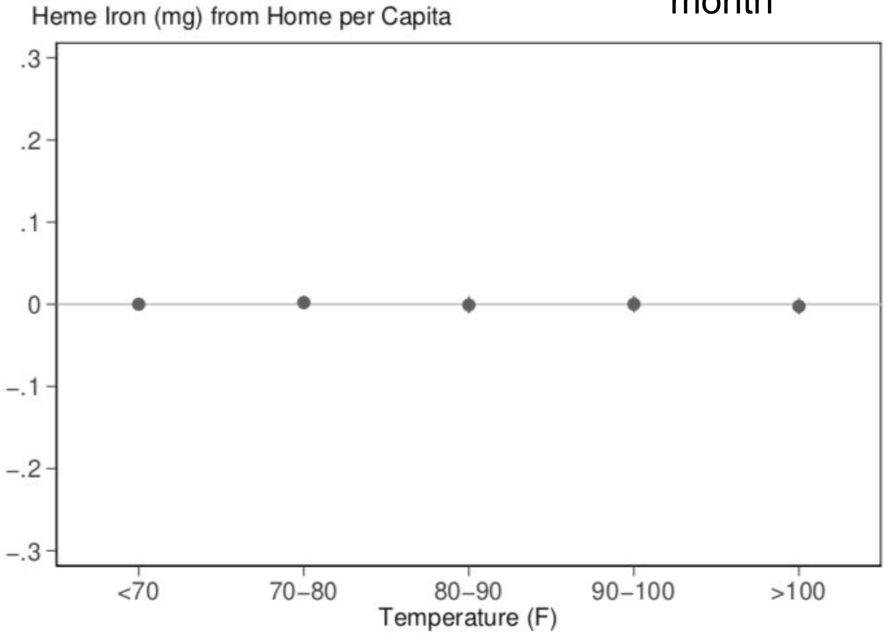


After a hot growing season, households lose home-grown crops, and partially make up for it with purchases.

Heme Iron per Capita

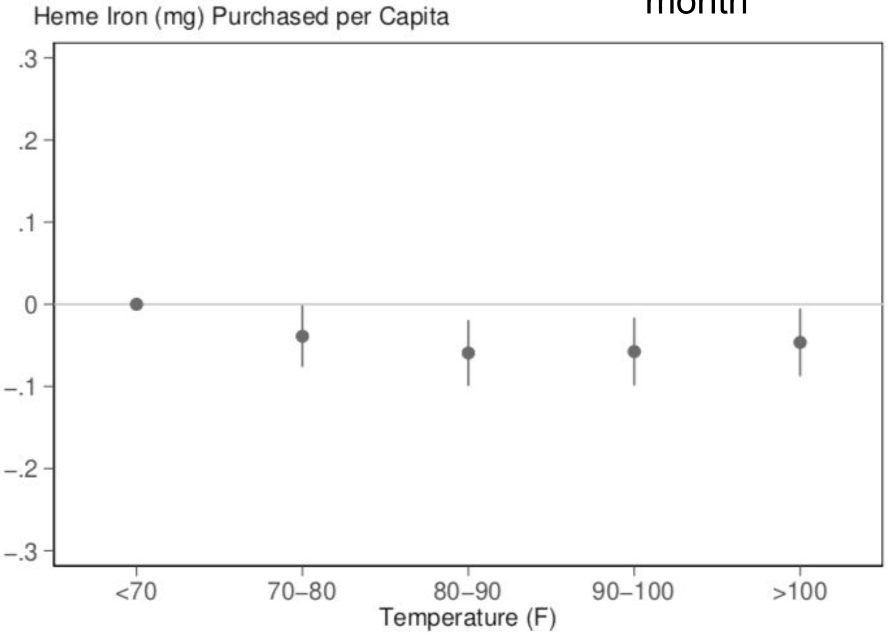
A) Home-Raised

0.5mg/cap-month



B) Purchased

10mg/cap-month



After a hot growing season, households buy less meat.

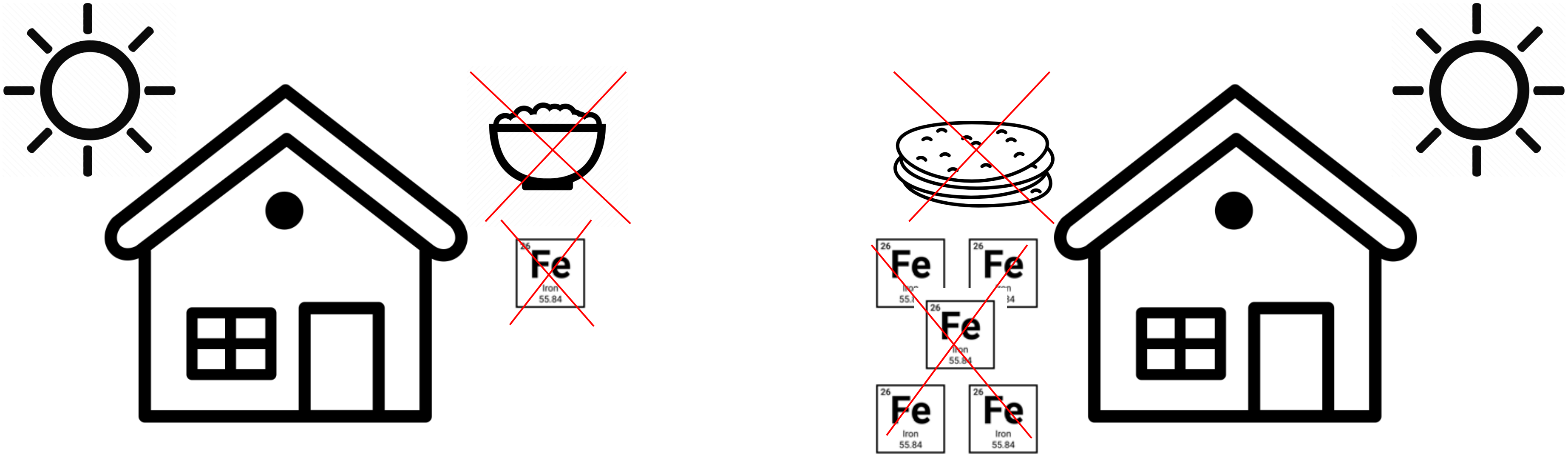
Wheat and Rice

- Top 2 iron contributors in the sample
- Wheat: 49 mg iron/kg

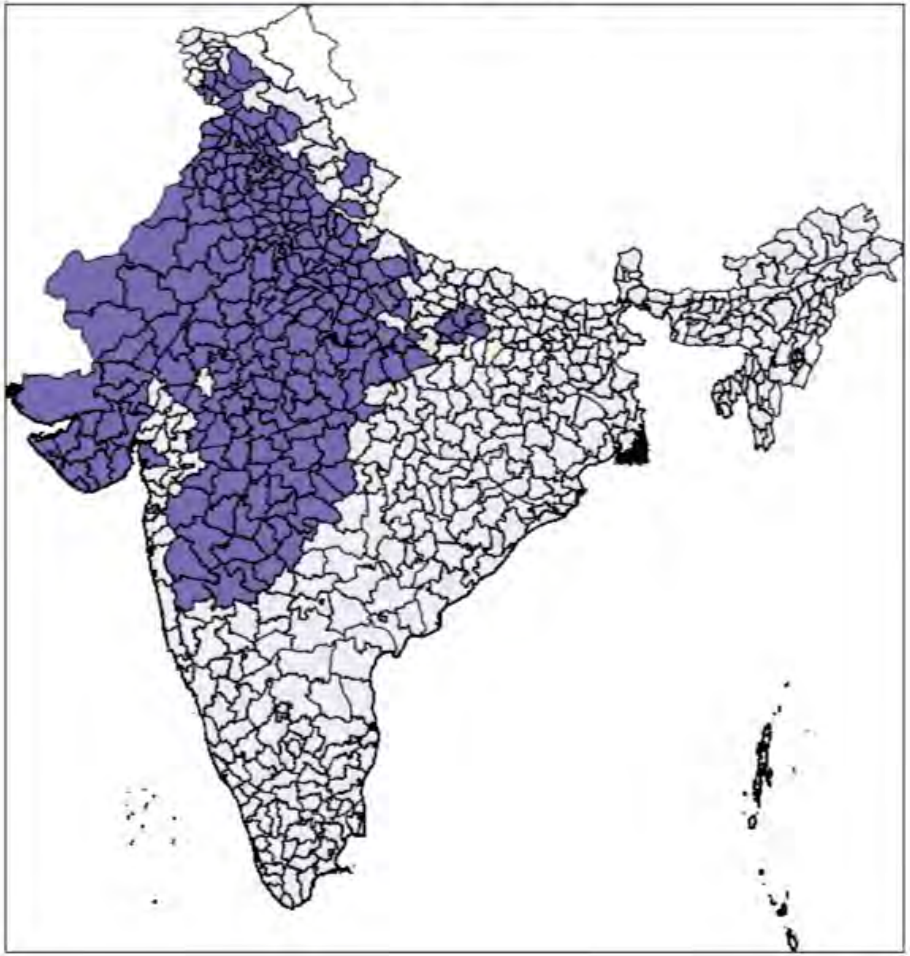
- Rice: 10 mg iron/kg

Wheat and Rice

- Where staple crop is wheat:
  - Does iron intake drop by more?



Wheat Districts

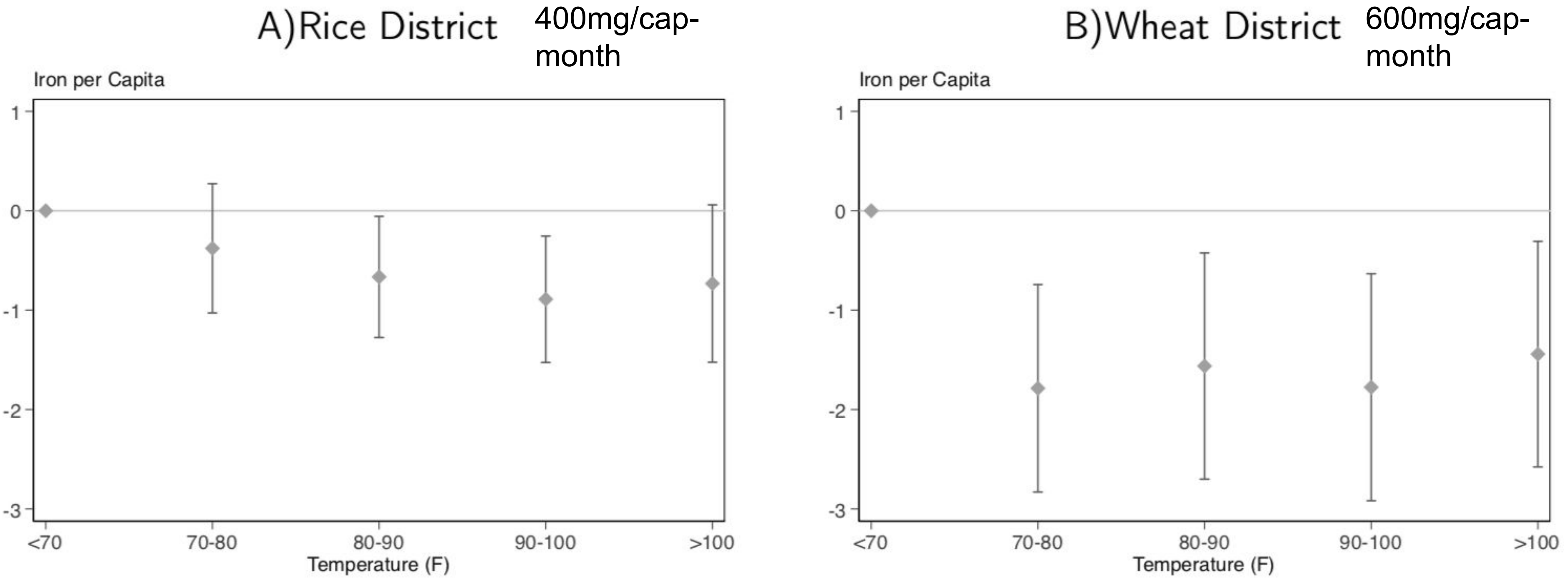


Iron per Capita

A)Rice District 400mg/cap-month

B)Wheat District 600mg/cap-month

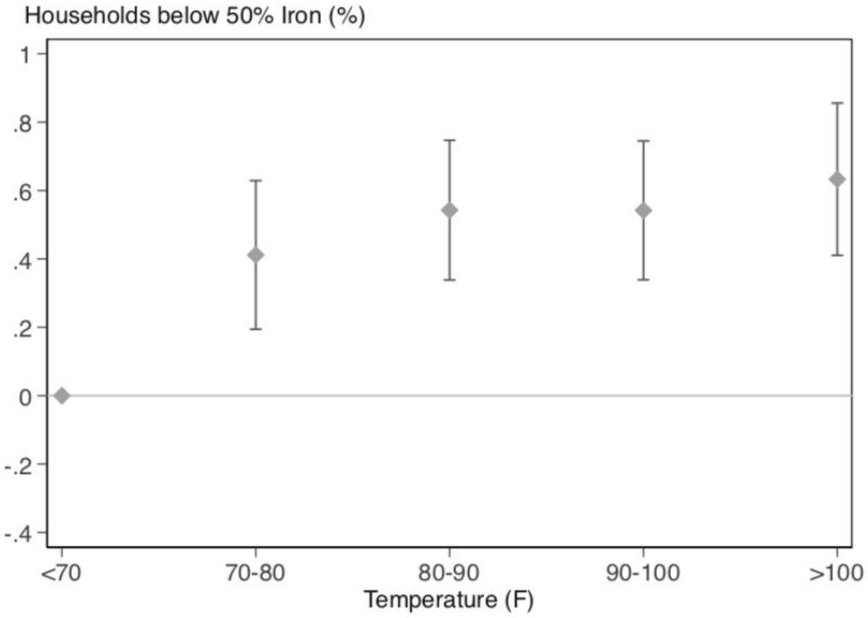
Iron per Capita



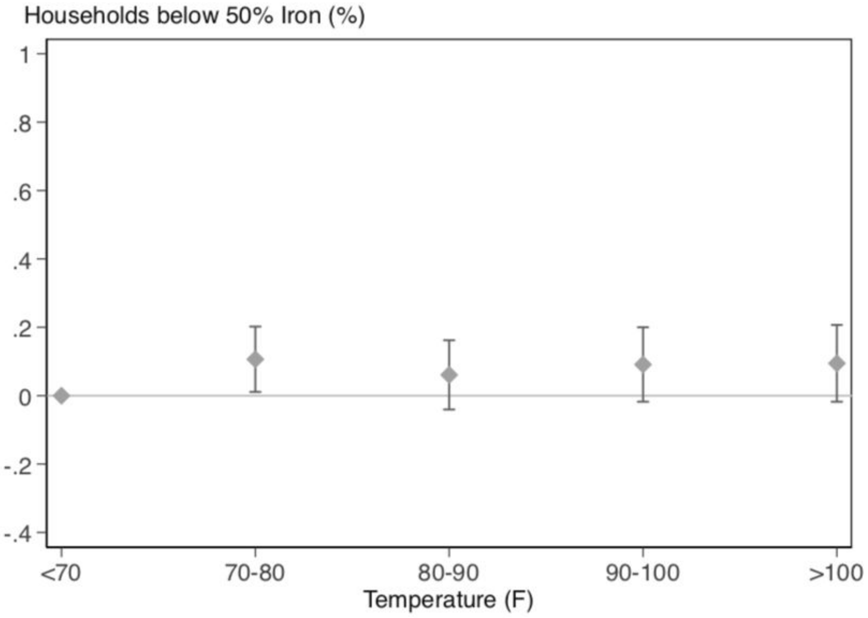
Hot weather leads to larger average iron losses in wheat districts.

Below 50% Iron Adequacy

A)Rice District 23.2%



B)Wheat District 2.8%



Hot weather leads to more households pushed below 50% in rice districts.

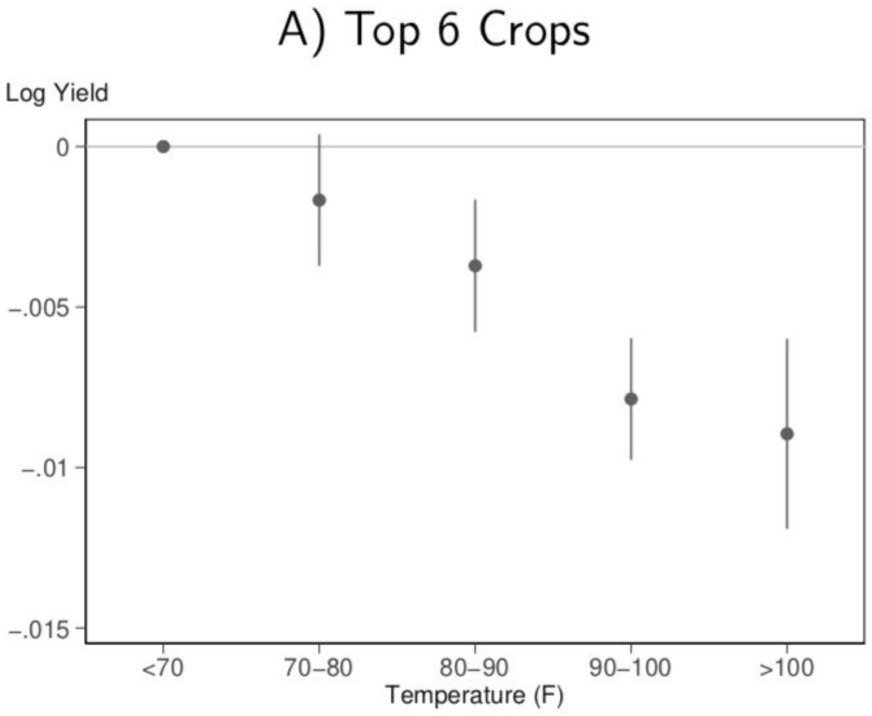
Major Takeaways

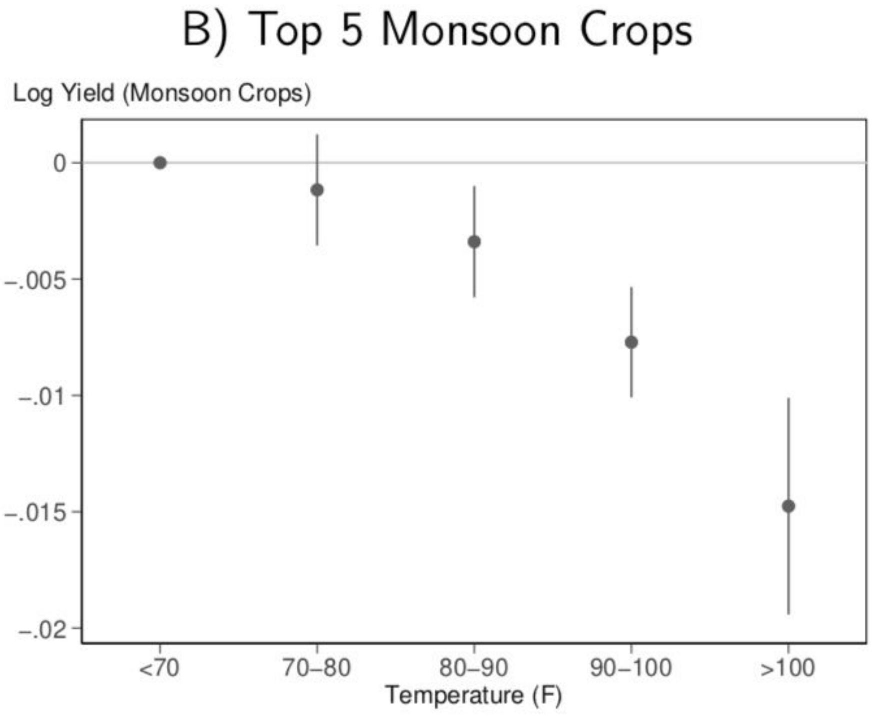
- One growing-season day above 100F lowers iron intake (0.3%) twice as much as calories (0.15%)
- The losses are primarily in home-grown crops
- Wheat districts lose twice as much iron per capita
- Rice districts have more households pushed below 50% threshold than wheat districts

Thank you. Questions?

Thanks to Alan Barreca, Teevrat Garg, Vis Taraz, Manisha Shah

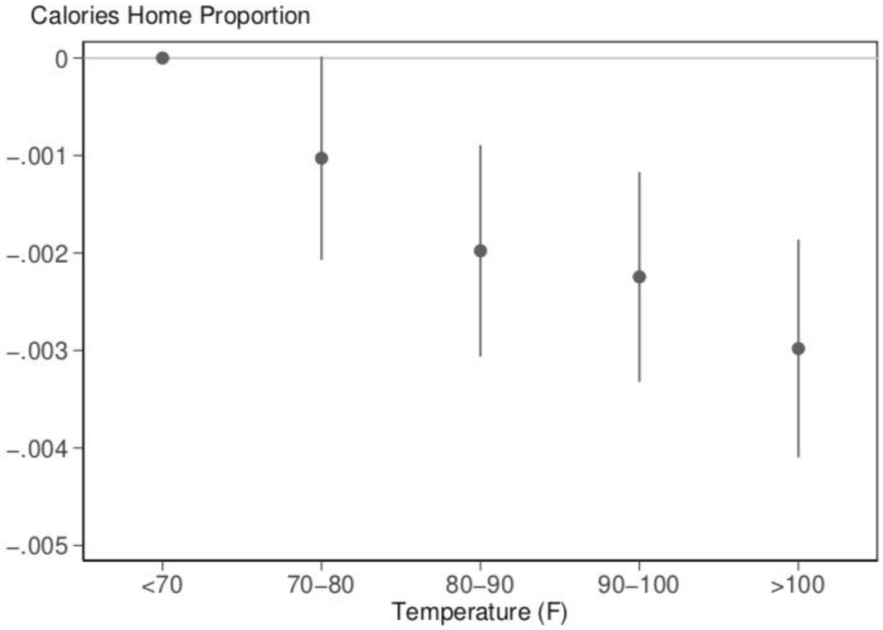
Yields


A) Top 6 Crops
Log Yield
0
−.005
−.01
−.015
<70
70−80
80−90
90−100
>100
Temperature (F)

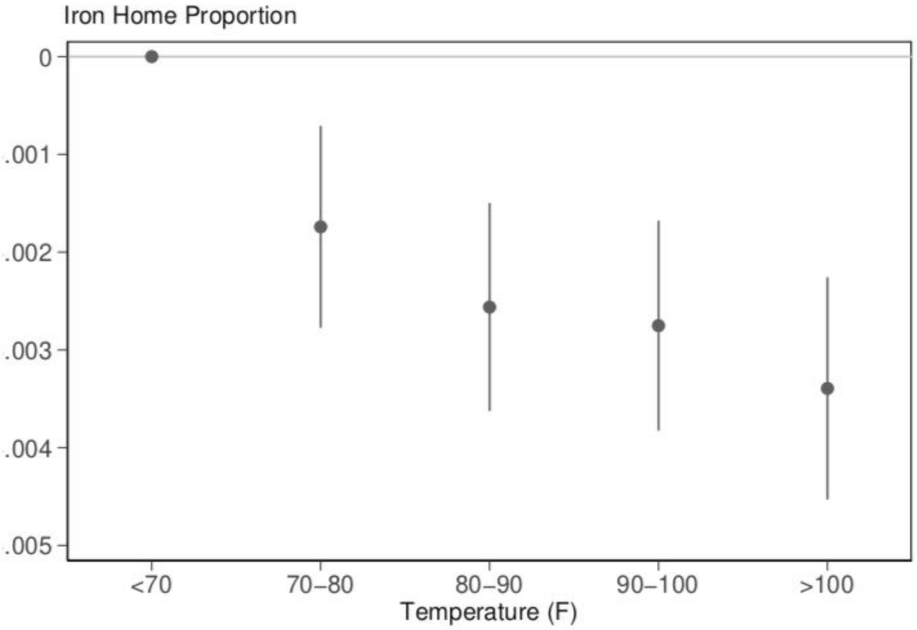

B) Top 5 Monsoon Crops
Log Yield (Monsoon Crops)
0
−.005
−.01
−.015
−.02
<70
70−80
80−90
90−100
>100
Temperature (F)

Share of Food from Home

A) Calories

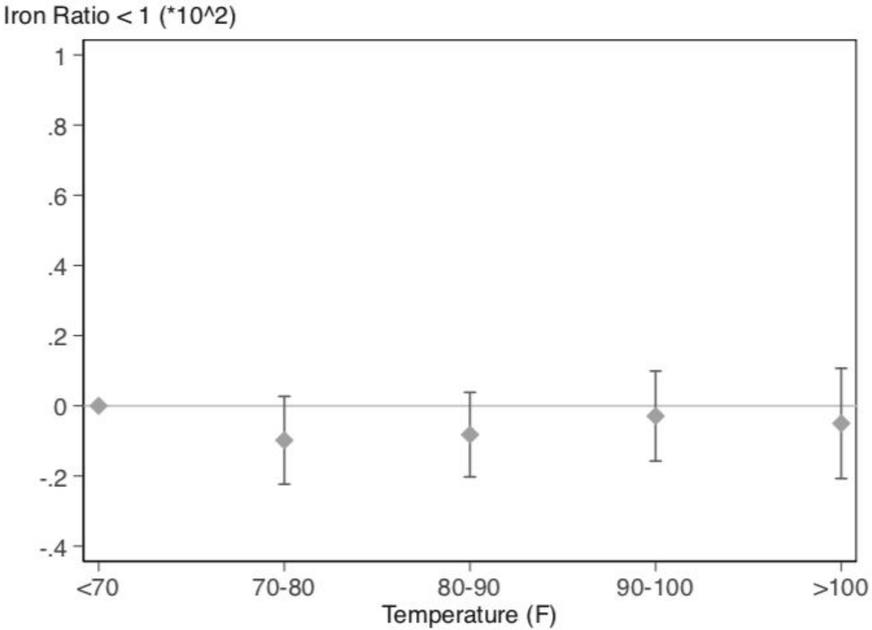


B) Iron

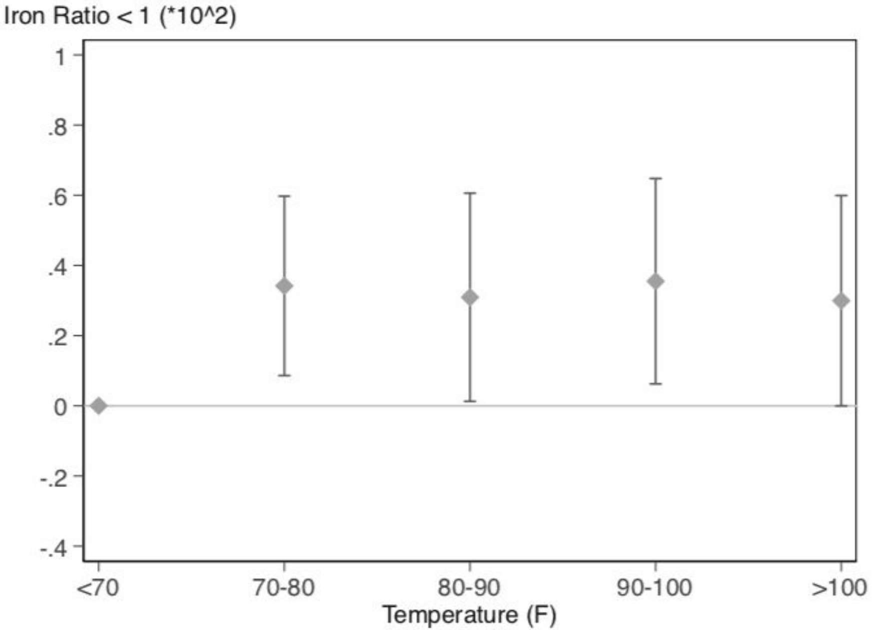


Below 100% Iron Adequacy

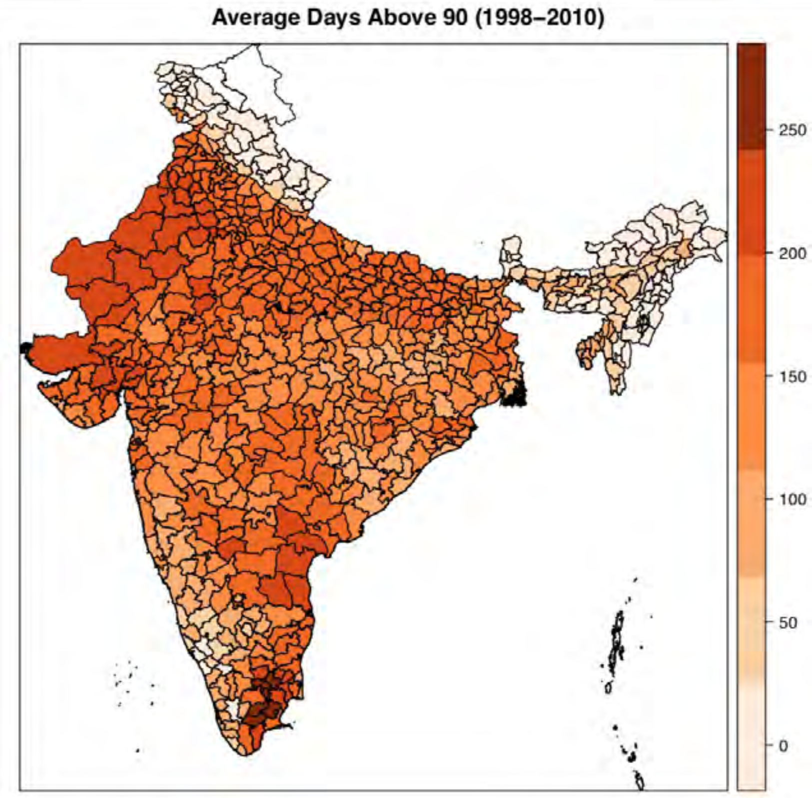
A)Rice District

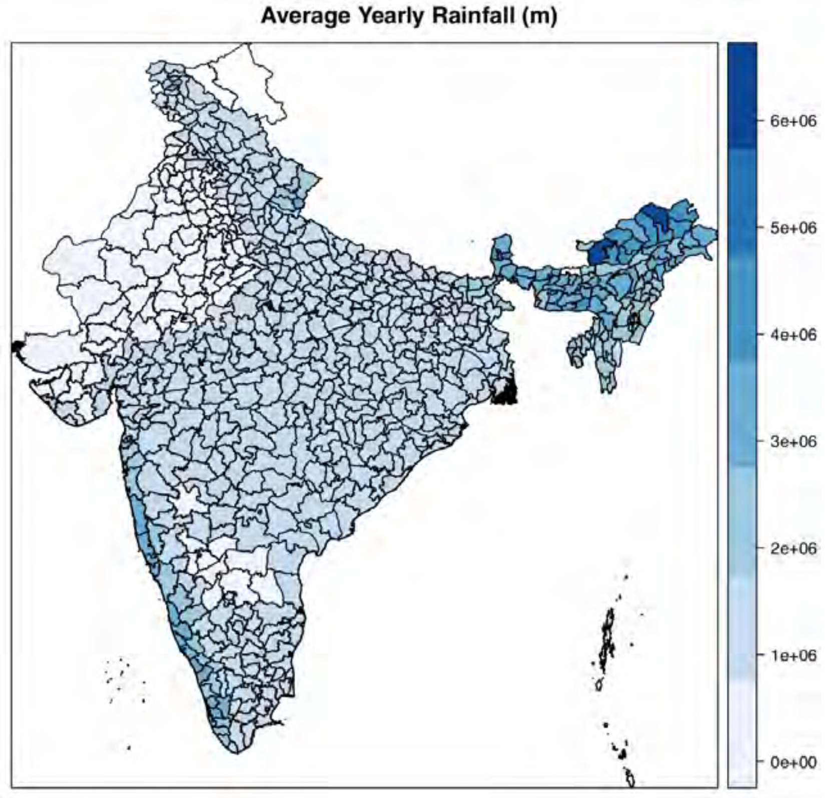


B)Wheat District



Summary Stats: ERA5





Home-grown vs. Purchased

- NSS data asks about home-grown vs. purchased food
  - e.g. “In last 30 days, we ate 17 bananas, 7 from home”
  - NSS assigns market value of food at point of production as “home-grown value”

Empirical Strategy

$$N_{hdmy} = \sum_{j=1}^{J} \beta_{1j} T_{1jdy} + \sum_{j=1}^{J} \beta_{0j} T_{0jdy} + \delta H + \beta_{prec,1} P_1 + \beta_{prec,0} P_0 + \gamma_{dm} + \tau_{ym} + \epsilon_{hdy},$$

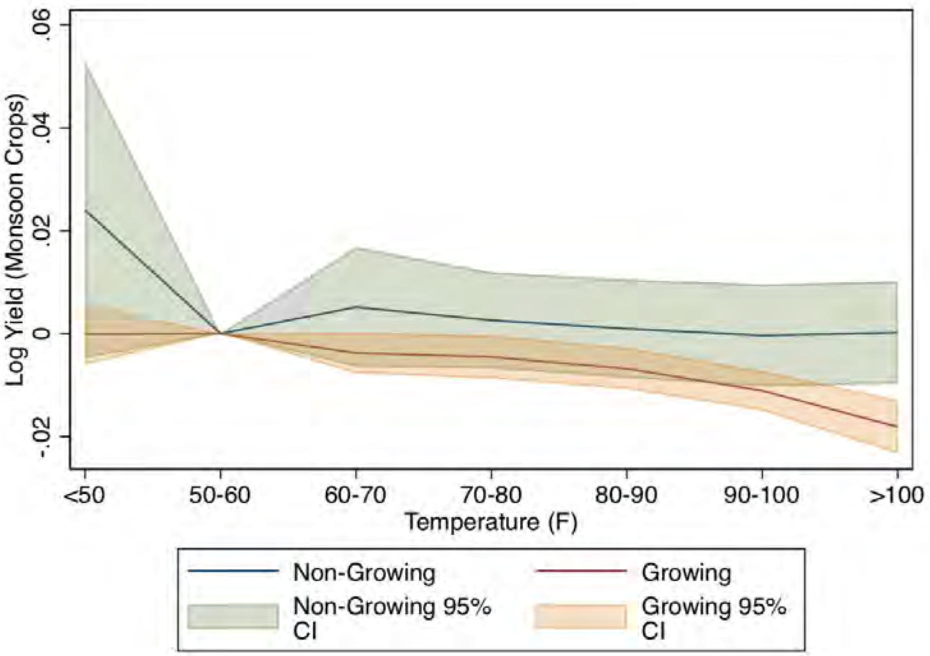
N: nutritional outcome, h: household, d:district, y: year, m: month, T_{1j}: days in temperature bin for growing season (0 means non-growing season), H:household-level controls (social group, religion, education), ɣ:district-month fixed effect **τ**: year month fixed effect, ϵ: error term (clustered at district level)

Heme vs. non-heme iron

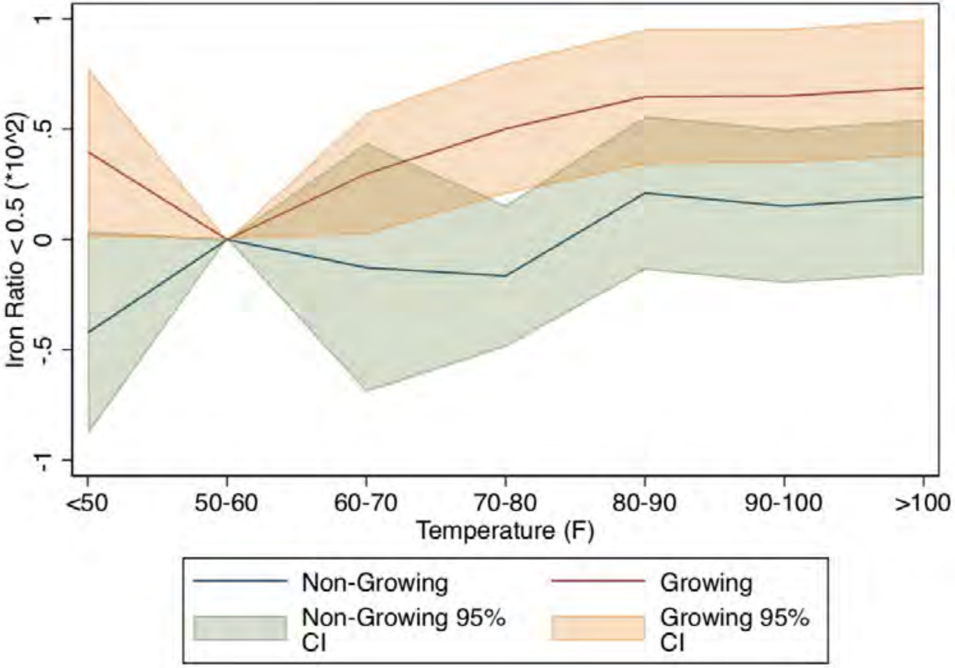
- Heme iron (meat) more easily absorbed
- For meat eaters: heme is 10-15% of iron intake, >40% of absorbed
- For my sample, heme is 2.7% of iron intake
  - 4% for non-vegetarians
- Absorption is complex

Agricultural Mechanism: Yields and Iron Ratio < 0.5

Yields



Iron Ratio < 0.5



KEYNOTE ROUNDTABLE | 12:30-1:30PM PT

Setting the Research Agenda: Upcoming Priorities for Adaptation Researchers

Eleni Myrivili
Chief Heat Officer
City of Athens, Greece

Jonathan Parfrey
Executive Director,
Climate Resolve

Lauren Sanchez
Senior Climate Advisor, Office
of CA Governor Newsom

CLIMATE ADAPTATION
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MEASURING & REDUCING SOCIETAL IMPACTS

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Thanks for tuning in!

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