Long-range forecasts as climate adaptation: Experimental evidence from developing-country agriculture

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Climate change will harm the world's farming poor

65% of the world's working poor depends on agricultural livelihoods (Castaneda et al 2010)

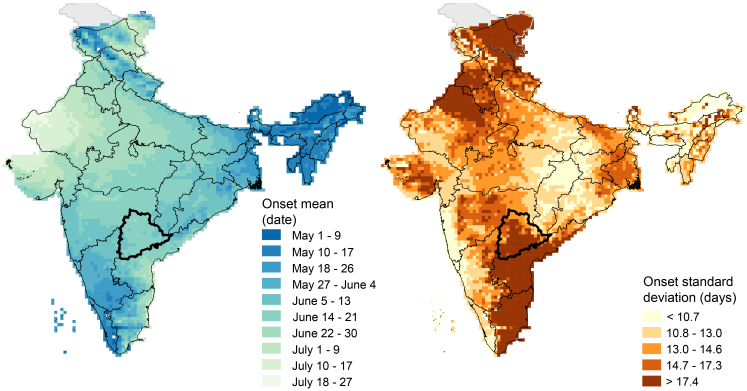
Agricultural risk is significant in poor countries:

- Uninsured risk leads farmers to underinvest (Rosenzweig and Binswanger 1993)
- This in turn raises the agricultural productivity gap between rich and poor countries (Donovan (2021)

Climate change is disrupting weather patterns

- Timing of rainfall is becoming more variable

These issues are particularly salient in Indian monsoon-fed agriculture



- 70% of rainfall: during the monsoon season; highly variable (Kumar et al 2013)
- Onset timing matters: Effect of late monsoon on yields is 3x worse for cotton than rice
- Relevant beyond India: $>$ 33% of global pop lives in the Asian monsoon region

We introduce a new tool: long-range monsoon forecasts

Long-range monsoon forecasts:

- Provide information about the monsoon well in advance of its arrival (4-6 weeks)
- Provide information relevant to the full growing season, not just tomorrow
- Come in two types:
  - Onset timing: Says when the monsoon will arrive
  - Quantity: Says how much rain will fall

Forecasts are promising:

1. Farmers have inaccurate beliefs about onset, and demand for information is high
2. Forecasts can be delivered at low cost (e.g. via SMS)
3. They enable non-marginal behavioral change

Important note: Monsoon forecasts are **distinct from** short-range weather forecasts!

Our forecast is a significant advance over previously-available options

Our forecast:

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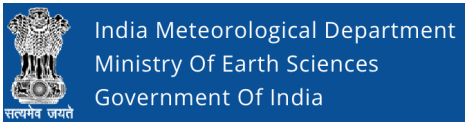
- Monsoon onset forecast
- Useful over agricultural regions (Telangana)
- Correct 10 / last 10 years
- Issued $\approx$ 40 days in advance

Existing forecast:



- Monsoon onset forecast
- Useful only over Kerala (not ag region)
- Issued $\approx$ 14 days in advance
- Quantity forecast uncorrelated with actual rainfall (Rosenzweig & Udry 2019)

Science of monsoon has not changed $\rightarrow$ even as variability increases, PIK forecast is viable

We use a cluster-randomized trial to evaluate monsoon forecasts

This paper: What are the causal impacts of long-range monsoon forecasts for farmers?

- How do forecasts affect farmer beliefs?
- How do farmers adjust their *ex ante* inputs in response to the forecast?
- What effects does the forecast have on agricultural outcomes and welfare metrics?
- How do these impacts compare to those of index insurance?

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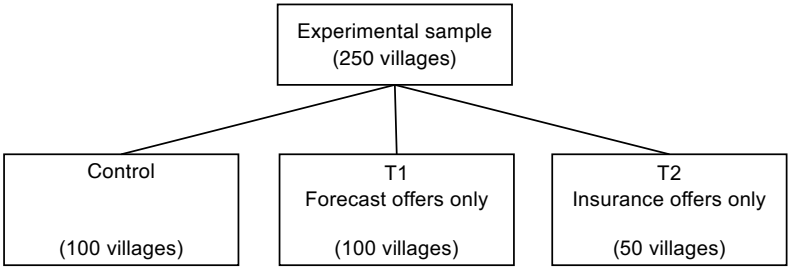
Why evaluate? In theory, providing accurate information should improve welfare, but...

- These forecasts are a new technology $\rightarrow$ adoption may be low
- Farmers must trust information for it to be useful; status quo is low-quality forecasts
- Farmers may not know how to productively use info
- Prior evidence on info & extension services is mixed (J-PAL 2023)

We use a cluster-randomized trial to evaluate the impacts of forecasts

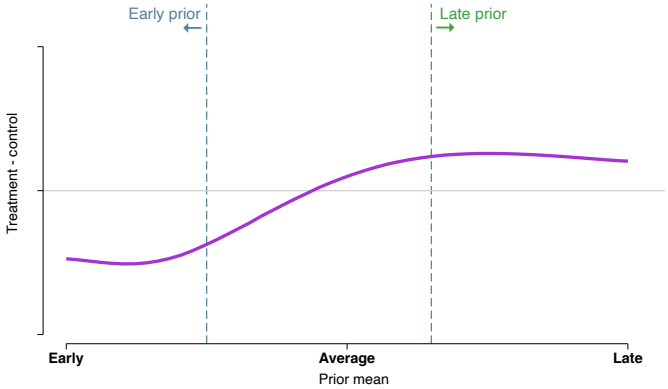


- Sample frame: Villages in Mahabubnagar and Medak districts with low levels of irrigation
- Village-level randomization stratified by district, sampled 5-10 farmers per village
- Implemented in partnership with ICRISAT
- Pre-analysis plan registered with *JDE*

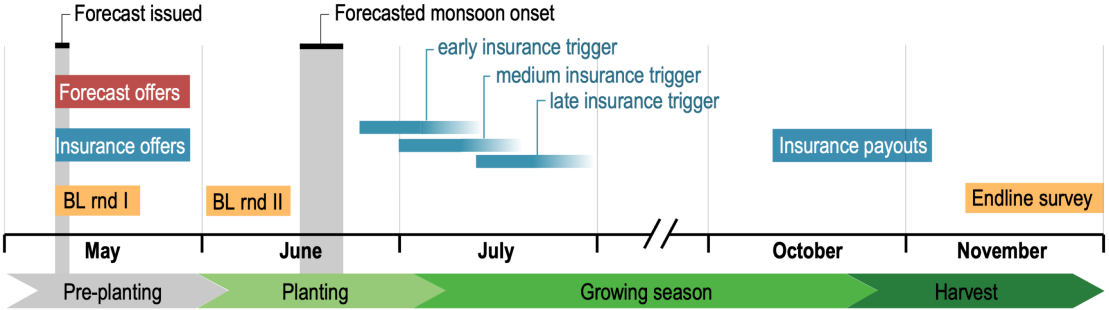
The effect of the forecast on investments depends on farmer priors

Forecast effects in the model:

- Causes farmer to update beliefs
- And optimize inputs to states
- Direction of adjustment depends on a farmer's prior
  - Early priors (optimistic)
    - → receive bad news
    - → reduce investment
  - Late priors (pessimistic)
    - → receive good news
    - → increase investment



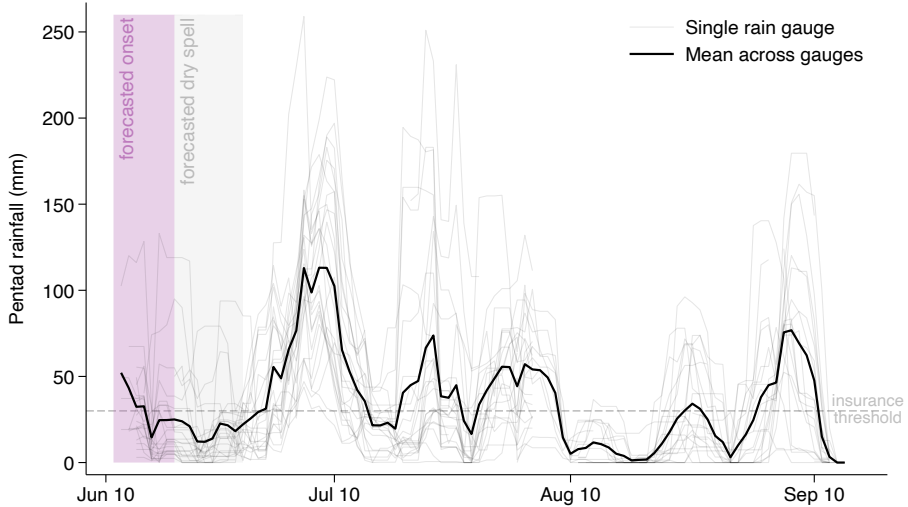
Our experiment took place in Kharif 2022



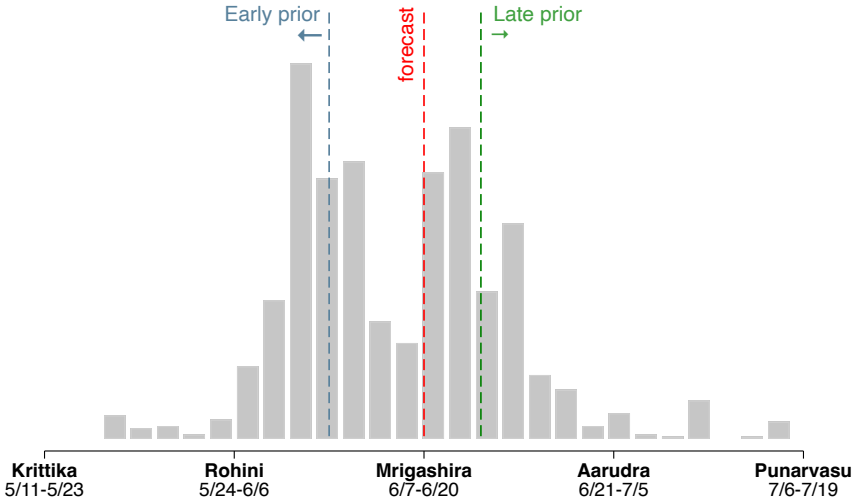
Key survey details:

- **Baseline I:** Elicits priors before forecast was presented
- **Baseline II:** Elicits posteriors after forecast was presented
- **Endline:** Collects growing season details (crops, inputs, yield, profit, etc)

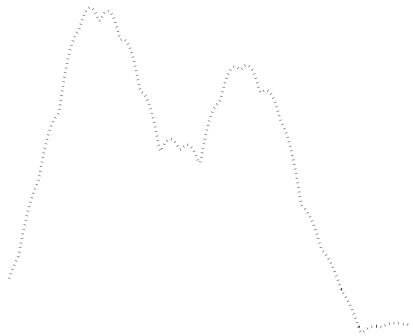
The 2022 forecast was accurate



Farmers' priors are centered on the onset date



The forecast shifts farmers' posterior beliefs toward the forecast



Rohini 5/24-6/6 | **Mrigashira** 6/7-6/20 | **Aarudra** 6/21-7/5 | **Punarvasu** 7/6-7/19 | **Pushya** 7/20-8/2

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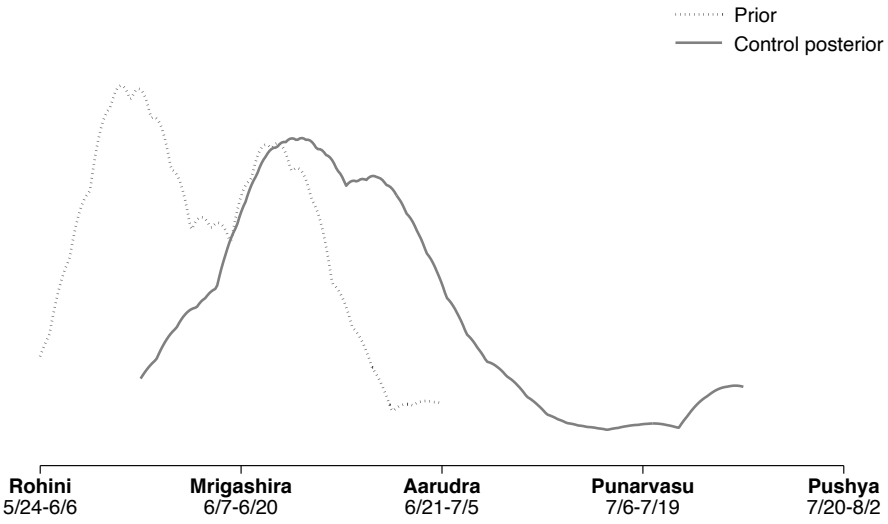

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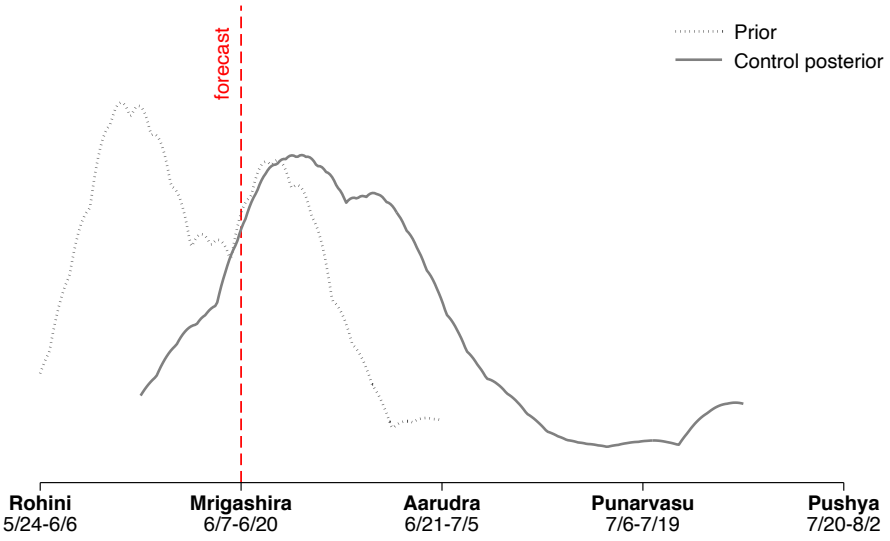

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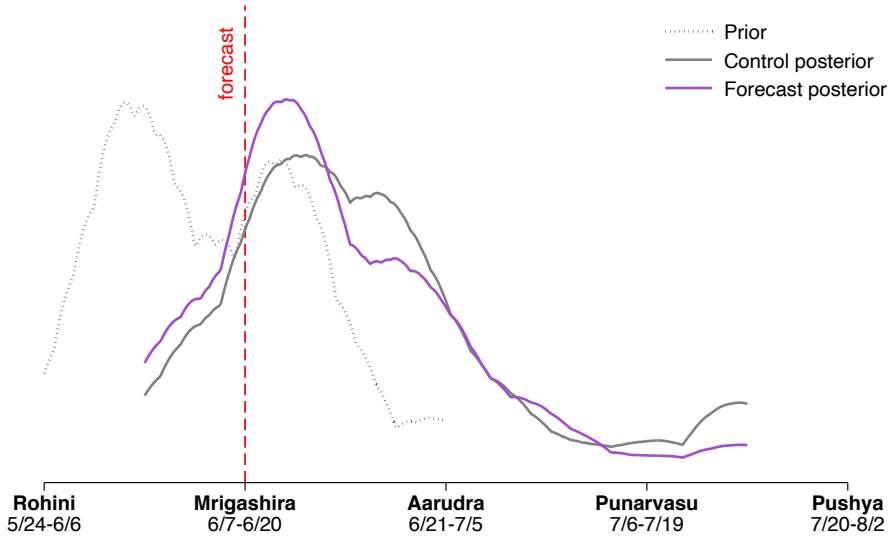

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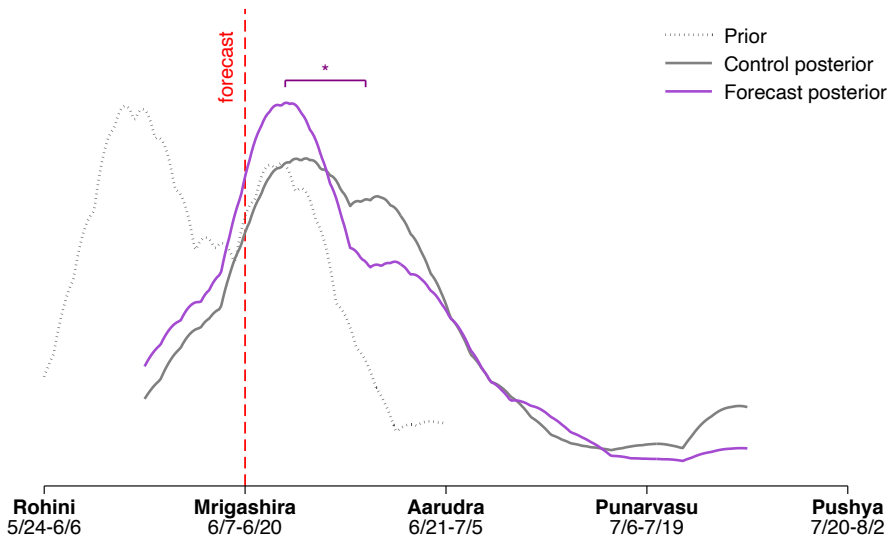
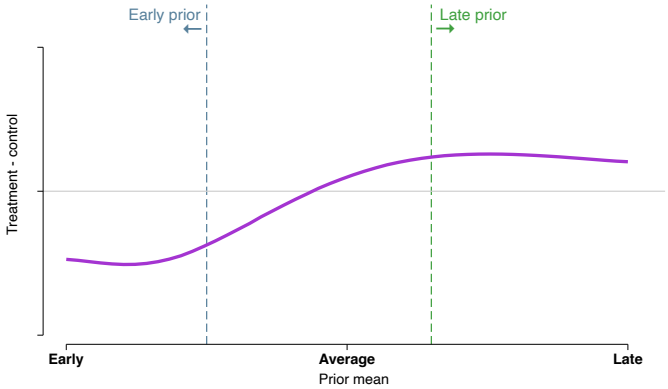
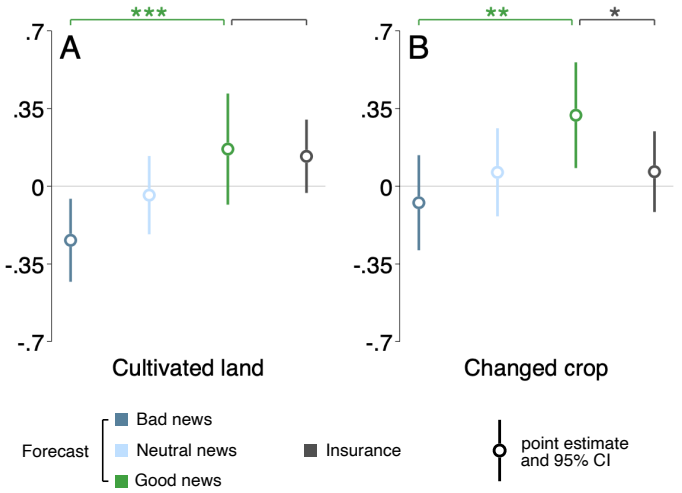


Recall theoretical prediction: expect heterogeneity by beliefs

- Early priors → **bad news**
- Average priors → **neutral news**
- Late priors → **good news**

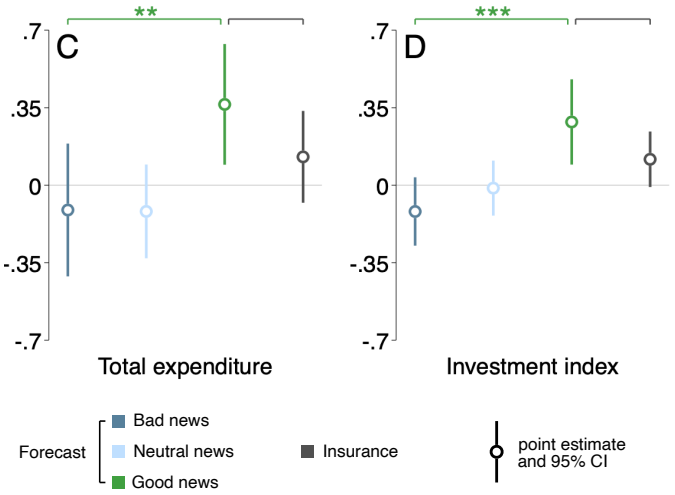


The forecast substantially changes land use and cropping (all figs in SD)



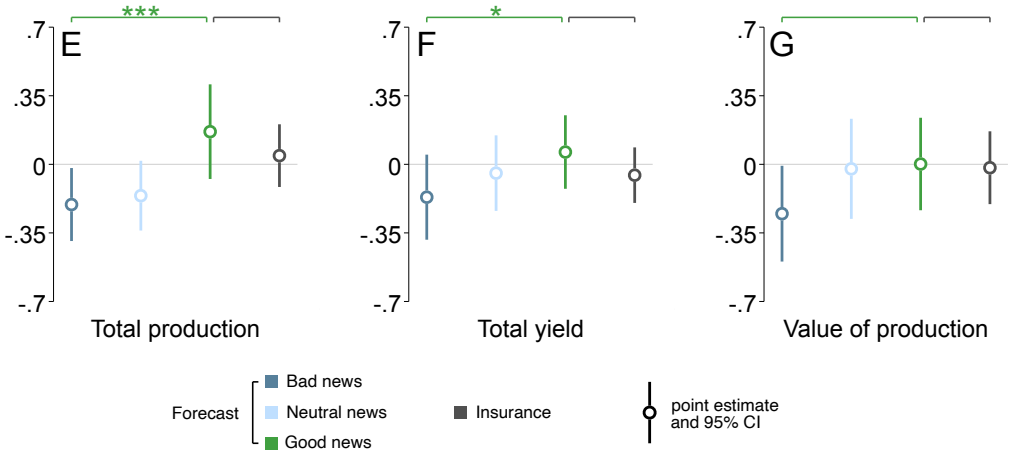
Crop change driven by new cash crops for good-news farmers

Farmers change investments in response to the forecast



Good-news farmers: 34% increase in total input expenditure

Bad-news farmers produce less ag value, good-news null results



Bad-news farmers: production & value decline consistent with investment reduction

Good-news farmers: production increase, but no change in value

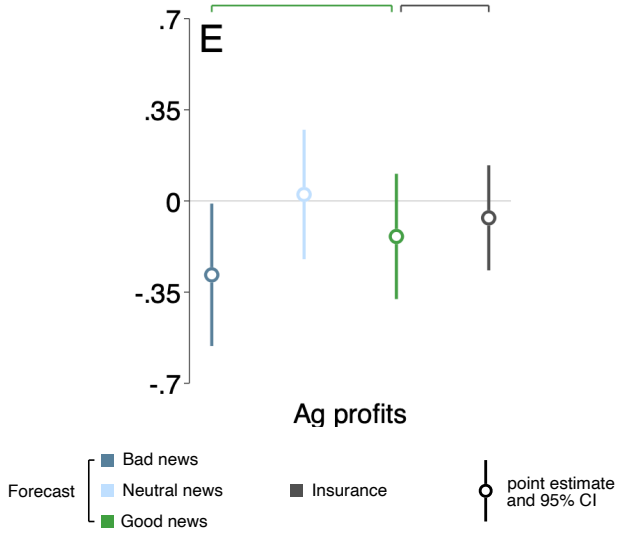
Changes in investments & cropping outcomes → changes in ag profits

Ag profit effects by type of news:

Bad: Invest ↓, profits ↓

Neutral: No Δ

Good: Invest ↑, profits **no** Δ**?**

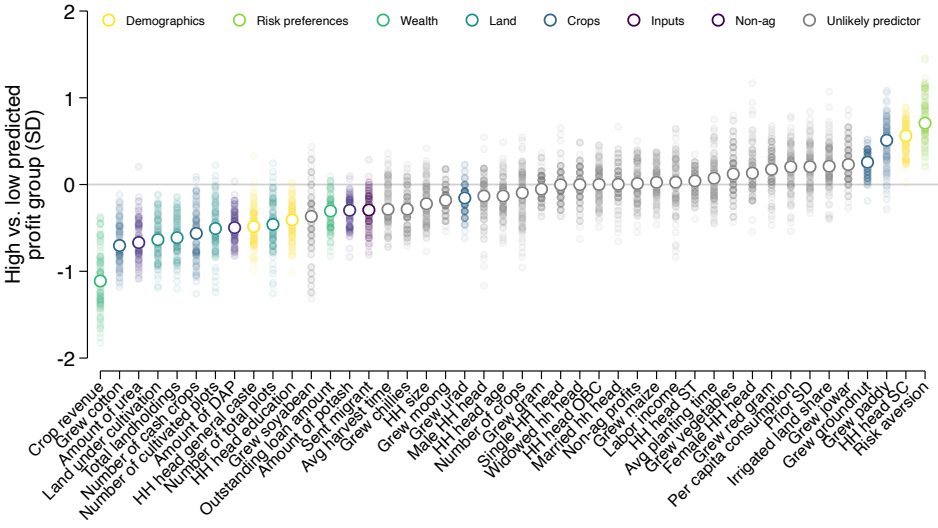


Lack of agricultural profit impacts for good news farmers is a puzzle

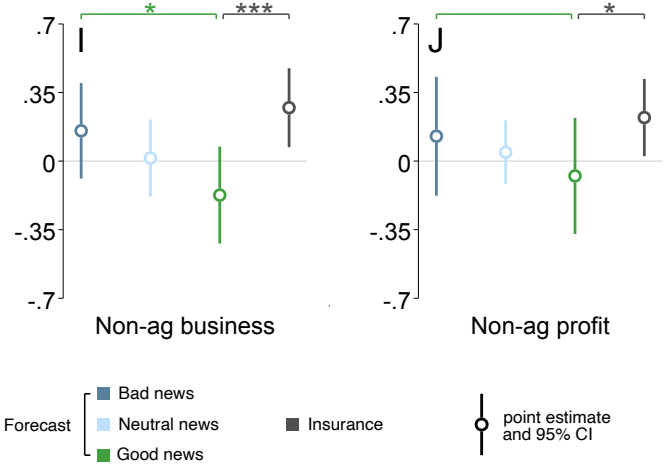
We are evaluating a series of possible explanations:

- **The forecast was inaccurate?** Ruled out: rain gauges align with forecasted onset
- **Farmers did not change beliefs?** Ruled out: farmer beliefs move towards forecast
- **No resulting behavior change?** Ruled out: substantial changes in investment
- **GE effects?** Ruled out: intervention small; no impact on prices
- **Issues with price data?** Survey relatively early, sales endogenously poor? (TBD)
- **Onset is not binding constraint?** Was 2022 a long but bad (e.g., hot) season? (TBD)
- **Farmers don't know how to use forecast?** Were investments low-return?
- **Others?** We welcome feedback on what else to examine!

If anything, higher (predicted) profit effects among least well-off

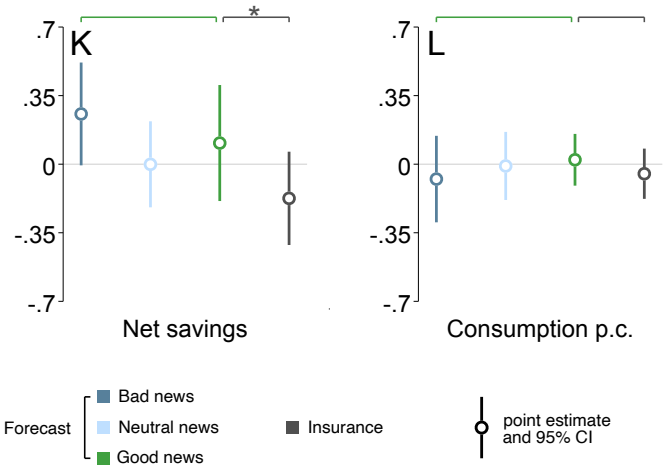


Suggestive evidence that **bad-news** farmers do more off-farm work



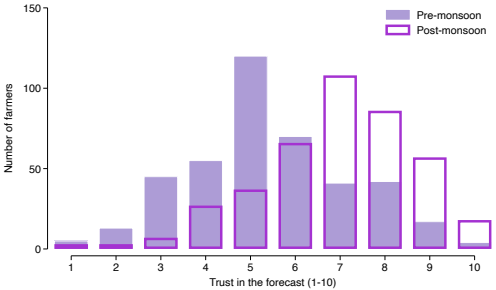
Bad-news farmers substitute out of agriculture

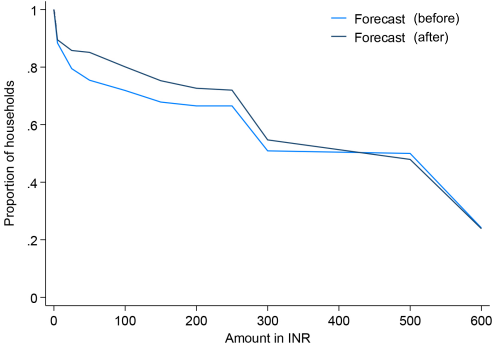
Suggestive evidence that forecast farmers are weakly better off



Bad-news farmers increase net savings by $560; 50% reduction in debt

How do farmers perceive the forecast after the fact?





Trust in the forecast increases, WTP does not decline (vs people who have not gotten forecast before)

We evaluate forecasts' potential as climate adaptation

We use simple theory and an RCT to study a new and an old approach to coping with risk.

Forecasts:

- Shift farmers' beliefs about monsoon onset towards the forecast
- Heterogeneity by priors: good news invest more, bad news less, and change crops
- Profit heterogeneity suggests helps poor most; weak positive welfare effects

Insurance:

- Insurance causes farmers to expand operations
- Increases in expenditures, no change to cash cropping
- Heterogeneity by priors: optimistic do more, pessimistic do nothing

In progress:

- Unpack profit effect puzzle further
- Scale: Indian MoA&FW disseminating SMS-based forecasts

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Thank you!

Comments? Questions?

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