The Light and the Heat
Productivity Co-bene ts of Energy-saving Technology

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Motivation: climate change and mitigation

- The IPCC estimates that end-century warming will exceed 1.5^{o}C (IPCC, 2013)
  - Impacts disproportionately located in developing countries (Mendelsohn et al., 2006)
- Great interest in identifying
  - impact of temperature on economic outcomes (Deschenes & Greenstone 2007, 2011; Guiteras 2009; Burgess et al. 2013; Hsiang et al. 2013; Barreca, Clay, Deschenes, Greenstone, & Shapiro 2014, Sudarshan & Tiwari 2014)
  - e ective mitigation strategies { not easy to convince individual/ rms to adopt, given wedge between public and private returns (Bollen et al. 2009; Knittel & Sandler 2011; Deschenes et al. 2013)

Motivation: energy e ciency and India

- India fourth-largest energy consumer globally (International Energy Agency)
- Indian industry second largest consumer of primary commercial energy (Bhattacharya and Cropper, 2010)
- Lighting represents almost 20% of global electricity consumption (International Energy Agency)
- Energy e ciency projected to potentially close the gap between projected energy demand and supply (Bureau of Energy E ciency)
  - But very di cult to get rms to adopt \green" technologies (Knittel & Sandler, 2011)

Research questions

Our case: ready-made garments

1. Garment sector has high absorption capacity for in ux of unskilled workers (particularly young women) (Heath & Mobarak 2014)
   - Partner rm alone employs 90,000 workers (80% female), growing at 10% p.a.
2. Several frictions hinder potential of this industry and its workers:
   - Absenteeism high and retention low
   - Labor productivity low (average e ciency in our sample is 53%)
3. **What role does the work environment play in productivity and attendance? What can rms do to mitigate the generated in-e ciencies?**

Overview

1. Estimate temperature-productivity gradient using line-level, daily production data for 29 garment factories and mean daily temperatures in Bangalore, India
2. Estimate extent to which introduction of LED lighting mitigates negative e ects of temperature on productivity
3. Using actual rm costing data, generate cost-bene t calculations for LED lighting adoption with / without estimated productivity gains

Data

Timeline: May 2010-September 2013

Workplace outcomes

- 29 factory units: 446 production lines over 941 days
- Daily line-level data on e ciency (produced/target q), budgeted e - ciency
- Daily worker-level data on attendance

Temperature and Humidity

- Daily temperature: National Climatic Data Center (NCDC) at the National Oceanic and Atmospheric Administration (NOAA)
- Monthly Relative Humidity: NOAAs National Data Center (NNDC)

LED Rollout: 25 garment factories

- Month and year of replacement of orescent lighting with LEDs

Summary Statistics

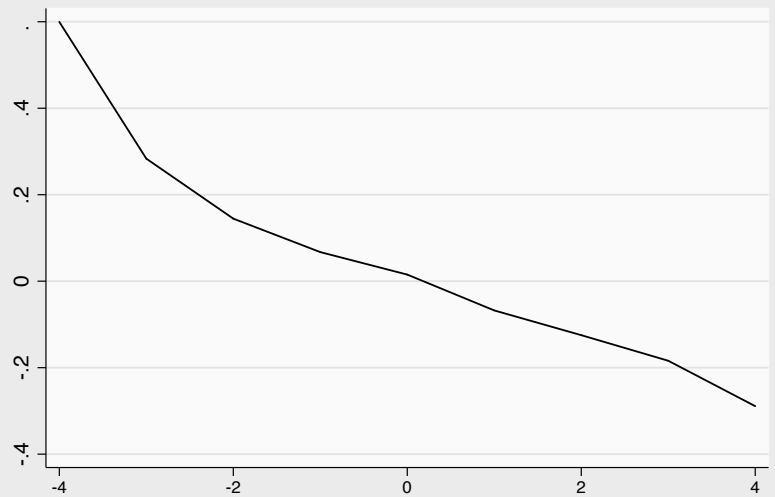
Temperature and E ciency Time Series

Introduction

Temperature-E ciency Gradient

Heat Index

Wet Bulb Globe



Empirical Speci cation: E ects of Temperature

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Temperature - E ciency Gradient Before LED

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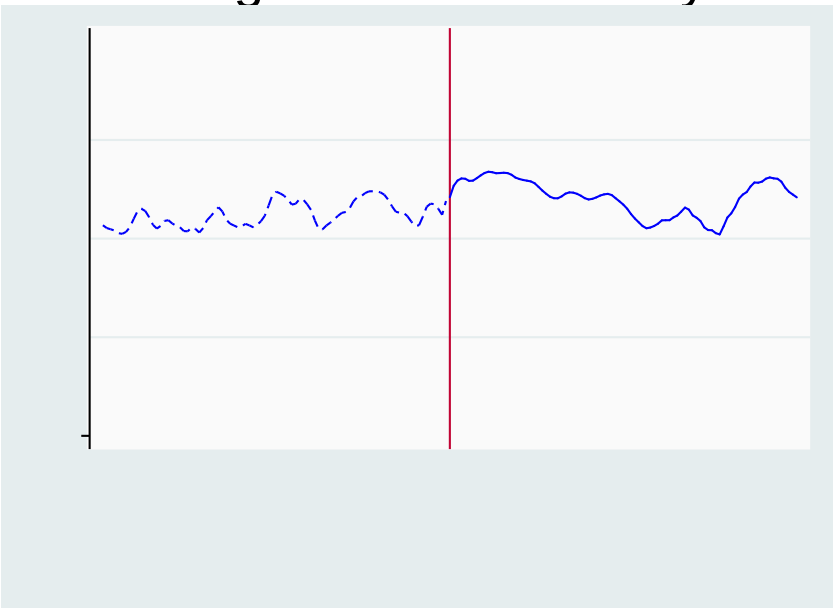
Attendance on Temperature Lags Before LED

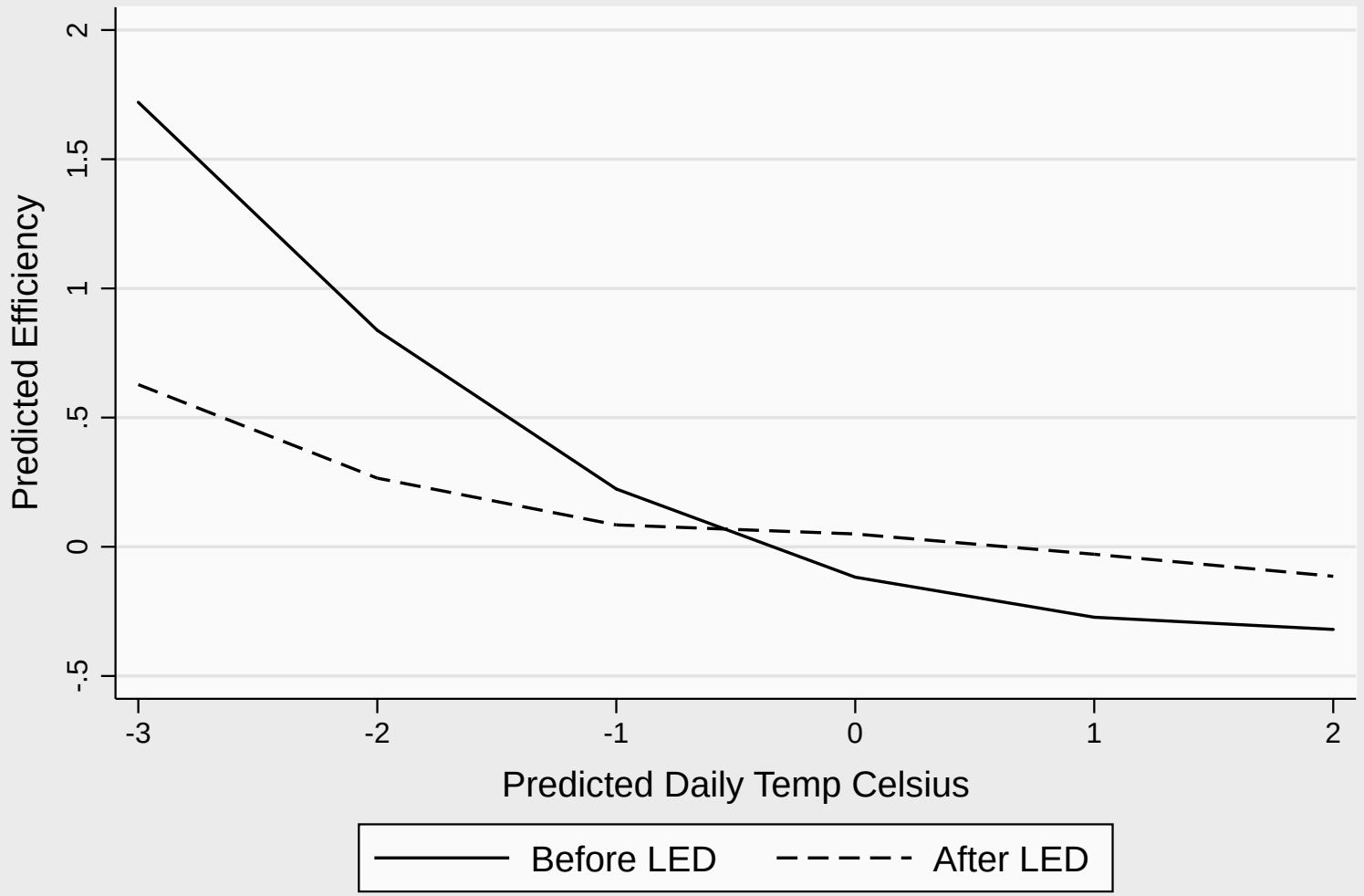
Before and After LED

Actual Efficiency

Budgeted Efficiency



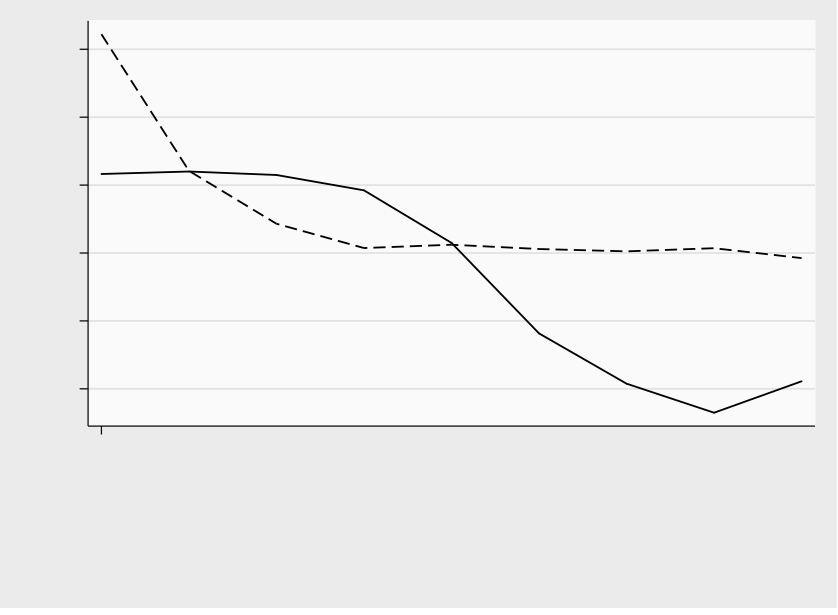
Mitigative Impact of LED



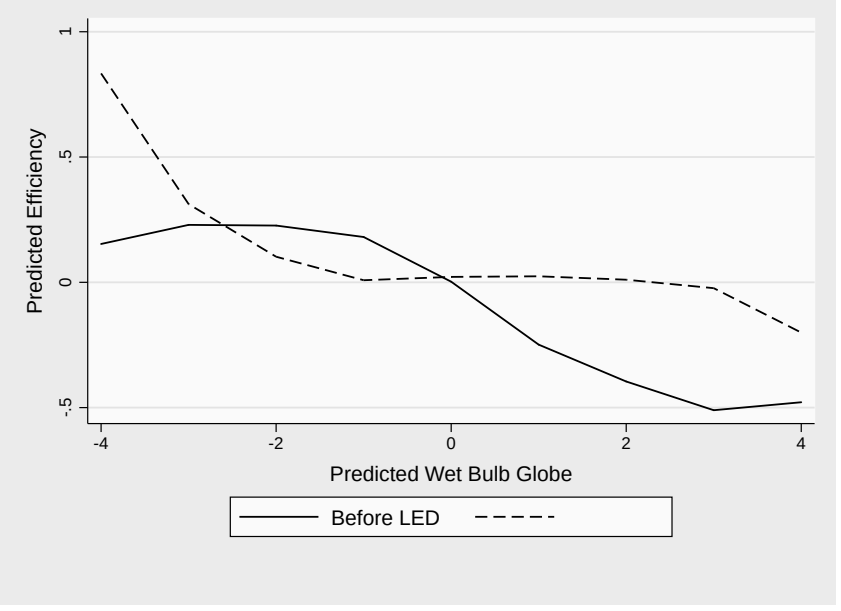
Notes: The plot is lowess-smoothed. Predicted temperature is trimmed at the 5th and 95th percentiles.

Mitigative Impact of LED

Heat Index



Wet Bulb Globe



Mitigative Impact of LED

Cost-bene t Analyses

- At average heat index (30 C), LED introduction associated with e ciency gain of .6 pp
- Translated to pro t per factory unit per day = 41 USD (13K USD

Conclusions

- Temperature has substantial impacts on industrial labor productivity in India
- Reducing this elasticity is good for both workers and rms
- We show that energy-saving LED lighting has an additional productivity bene t via temperature mitigation
- Accounting for this \hidden" return drastically changes the cost-bene t calculations of LED adoption (break-even in 5-6 months as opposed to 2 years)