The Light and the Heat: Productivity Co-Benefits of Energy-Saving Technology

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Hard to agree on the returns to energy-efficiency investment

A recent exchange on residential insulation is a case-in-point

- Fowlie, Greenstone and Wolfram (2015) estimate negative returns to residential insulation using a randomized experiment. Present discounted costs of US$ 4,600, energy savings of US$ 2,400.
- Department of Energy (DOE) responds. No, returns are positive! Costs of US$ 5,900, energy savings of US$ 2,300.

Why the argument?

$$2,400 - 4,600 > 2,300 - 5,900$$

Q. and A.: Lab Explains Its Evaluation of Weatherization

By EDUARDO PORTER OCT. 6, 2015

Q. Why did you remove the costs of administration, training, etc., from your estimate of the costs of the weatherization program? Shouldn't a cost/benefit analysis of weatherization include all these costs?

A. The Weatherization Assistance Program (WAP) is not a simple energy program. It has multiple stakeholders, including state and local weatherization agencies, utilities, home occupants, public health officials, advocacy groups, taxpayers and others, and produces **energy and nonenergy benefits. [Emphasis added]**

This paper: study whether there are "private co-benefits" for Indian garment manufacturers

LED lights use less energy for the same light as flourescent

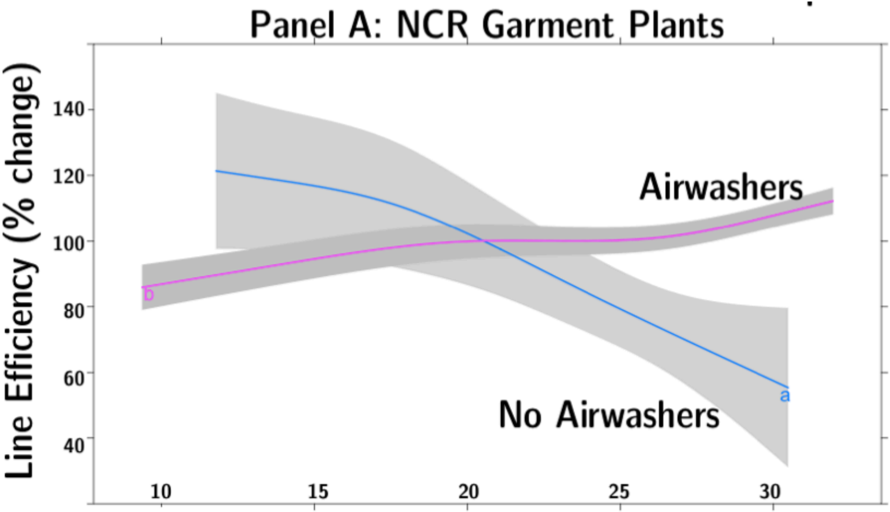
- Emit less heat ⇒ Indoor temperature lower
- Temperature lower ⇒ Worker productivity higher (Sudarshan et al., 2015)

High-frequency measure of productivity

Research questions

- Is there a productivity effect of temperature?
- What are the returns to LED adoption, inclusive of any productivity gains?
- Do firms account for productivity effects in making adoption decisions?

Sudarshan et al. 2015 take on a similar question



This paper: study whether there are “private co-benefits” for Indian garment manufacturers

Study garment production as a fraction of targets for 30 factories

- 523 production lines observed daily for about three years
- Outdoor temperature in Bangalore from three outdoor stations

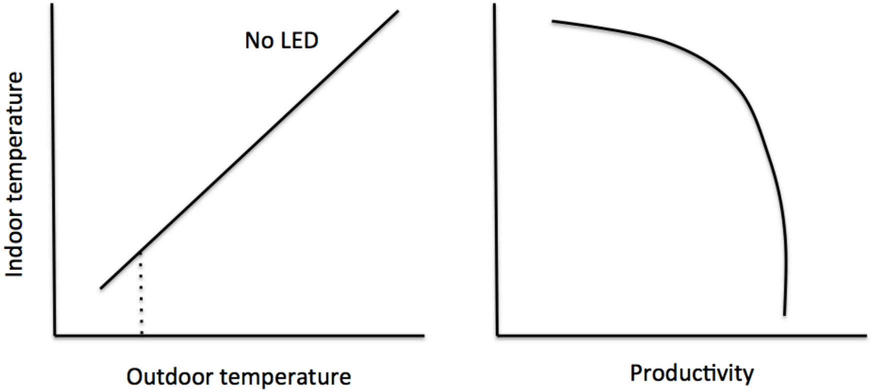
Table : Rollout of LEDs

Year	Number
2009	2
2010	12
2011	4
2012	6
2013	1

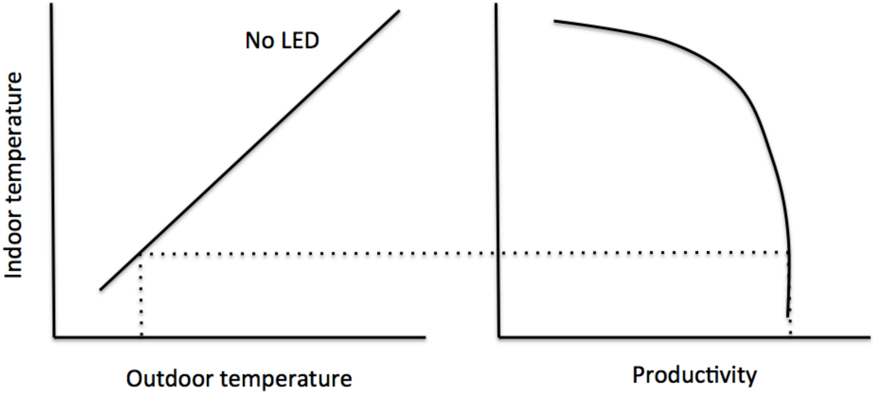
Factories install LEDs over time

- Each rollout within a single month

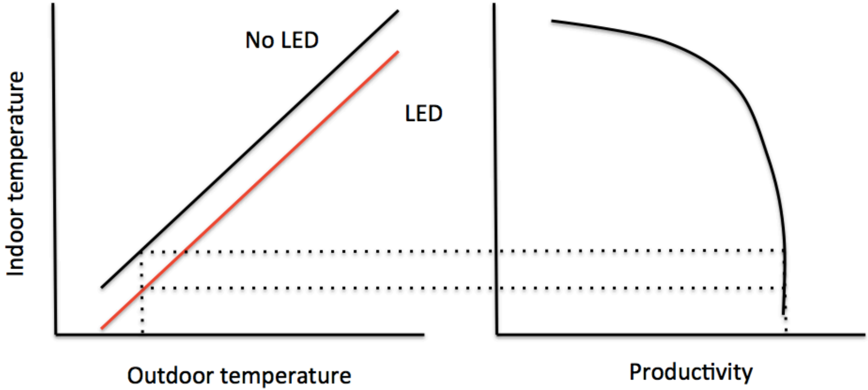
Temperature and productivity



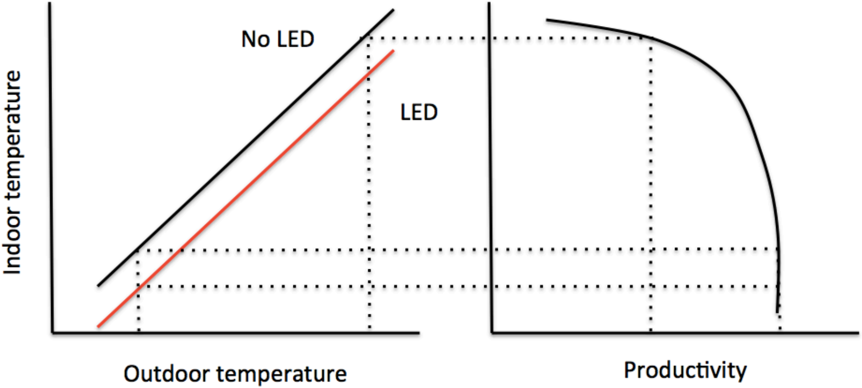
Temperature and productivity



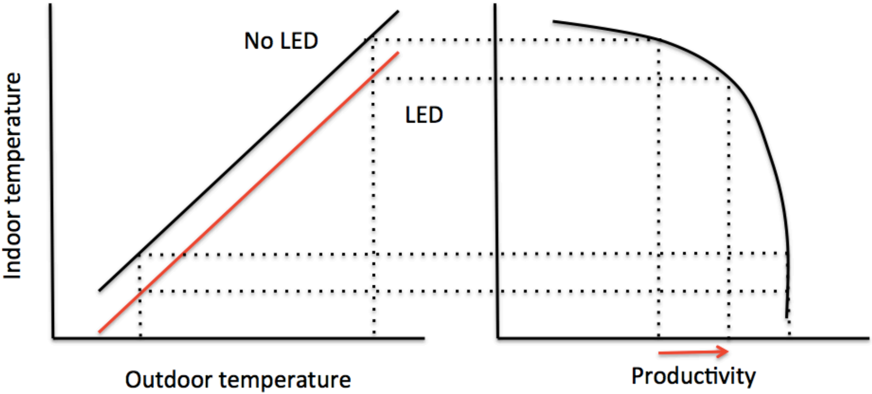
Temperature and productivity



Temperature and productivity



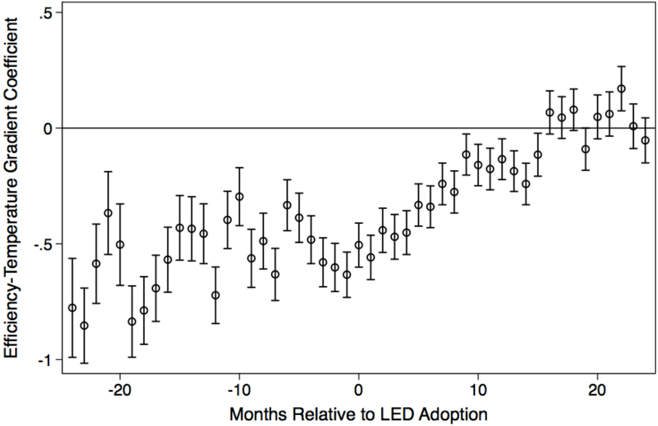
Temperature and productivity



Three comments

1. Are productivity gains due to LED adoption?
   - Difference-in-difference and productivity-gradient trends
2. Strive to measure total returns
   - Electricity bills and maintenance costs could be observed.
3. What returns do firms perceive?

Are productivity gains due to LEDs?



- Concern that LED effect is picking up a dampening of temperature-productivity gradient for some factories over time
- Allow more flexible factory-level time controls

Are productivity gains due to LEDs?

Traditional difference-in-difference design

- Are lines in factories that get LEDs more productive on hotter days, relative to lines in factories without?
- *Assume*: Conditional on factory $\times$ year, month-of-year, day-of-week and line effects, there are no omitted factors that determine productivity and are correlated with LED adoption
- Estimate relationship between temperature and productivity around the time of LED adoption using daily temperature

Are productivity gains due to LEDs?

Model now:

$$\begin{aligned} y_{ulymd} &= \beta_1 f(T_{ymd}) + \beta_2 POST_{LED} \cdot T_{ymd} + \beta_3 POST_{LED} + \\ &\quad \gamma_{uy} + \eta_m + \alpha_l + \delta_d + \varepsilon_{ulymd} \end{aligned}$$

- Some flexibility in temperature
- Less so in time: factory × year effects and month effects, but no factory-specific trends

Are productivity gains due to LEDs?

Suppose time p indicates months until you get LEDs for the first time.

Alternate model:

$$\begin{aligned} y_{ulymd} &= \sum_{t \in \mathcal{T}} \sum_{p \in \mathcal{P}} \beta_{t,p} \mathbf{1}\{T_{ymd} = t\} \mathbf{1}\{P_{uym} = p\} + \\ &\quad \gamma_u \cdot f(p|\theta_u) + \eta_m + \alpha_l + \delta_d + \varepsilon_{ulymd} \end{aligned}$$

- Some smooth control for periods to adoption p for each factory.
- Run this regression and plot $\beta_{t,p}$ for different temperatures and times to adoption.
- Allows flexibility in temperature and time. Can reduce bins $\mathcal{T}$ if power is lacking, but with 200,000 observations should be fine.

Strive to measure total returns

Why not verify energy savings projections also?

- Many studies measure only energy consumption, not co-benefits, because co-benefits are hard to measure
- Here seems like an opportunity to do *both*, by collecting electricity bills for factories in the study

Ancillary benefit of showing first-stage

- No indoor temperature data during roll-out. Now we have to take this component on faith.
- Showing energy savings would give some window into LED direct effects, building up to reduced-form effect on productivity. Could calculate engineering model for temperature effect.

Strive to measure *perceived* total returns

Larger question in the policy debate is what kind of co-benefits firms and consumers *recognize*

- Seems likely that there are productivity / comfort / health etc. co-benefits or co-costs from efficiency measures. E.g., gas mileage improves car range.
- Economic distinction in whether they are *recognized* by people making investment decisions. If so, then no policy rationale to push these investments more than others.
- Need for research on adoption decisions and whether they account for any such co-benefits and co-costs. What attributes are "shrouded", and when?