Heat Adaptation, Technology, and Inequality

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Introduction

Motivation

- Large evidence about the **welfare costs** of extreme heat for individuals
  (e.g., Deschenes and Greenstone 2011, AEJ; Park et al. 2020, AEJ; Somanathan et al. 2021, JPE; Carleton et al. 2022, QJE)

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  - $\hookrightarrow$ Is there a **trade-off** cost vs protection?
  - $\hookrightarrow$ If there is **imperfect** substitution $\Rightarrow$ inequality in exposure to extreme heat

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$\Rightarrow$ Q1. Is there heterogeneous technological response of households to extreme heat?

$\Rightarrow$ Q2. Do air conditioners and evaporative coolers provide different level of protection?

This Paper

1. Examine the heterogeneous technological responses of households to hot days

    - **Household ($>$ 200k) panel** data from India combined with high-quality **weather** information
    - Document the **extensive margin** response: technology adoption
    - Document the **intensive margin** response: electricity consumption

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2. Test whether technology determines the level of protection from extreme heat
   - Administrative **district-level** annual **mortality** data (all-age, all-causes)
   - Re-construct district-level **ownership rates** of air conditioners and evaporative coolers
   - Evaluate the **interactions** between ownership rates and extreme heat

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3. Determine the consequences of technological inequality in heat adaptation
    - Number of **prevented deaths**
    - Implications for policy: back-to-the-envelope **cost-benefit analysis**

India

- **Extreme heat**:
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- **Cooling adaptation**:
  - ↪ Rising incomes and temperatures ⇒ boost in cooling demand
    (IEA, 2018; Davis et al. 2021; Pavanello et al. 2021, NC)
  - ↪ One of the first countries to develop a **Cooling Action Plan** (2019)

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  - $\hookrightarrow$ larger effects for rural and poorer population
- Air conditioners are two times more effective against extreme heat
  - $\hookrightarrow$ **Evaporative coolers** prevented 23% of heat-related deaths
  - $\hookrightarrow$ If similarly widespread, **air conditioners** would have prevented 46% of heat-related deaths

Related Literature

1. Air-conditioning adoption, temperature and income
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   $\hookrightarrow$ **Contributions**: alternative technologies, prevalence and adoption, heterogeneity

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4. Mediator effect of cooling technologies
   (Barreca et al 2016, JPE; Park et al. 2020, AEJ; Somanathan et al. 2021, JPE; Hua et al. 2022, JPopE)

   ↪ **Contributions**: technological dimension, first application to mortality in India, cost-benefit analysis

Theoretical Framework

Set-up

A representative household maximises its utility function:

$$\max_{q_S, q_N, k, x} u = D\left[T, a, q_S, k\right] \cdot z\left[q_N, x\right] \quad \text{s.t. } y \geq p\left[q_S + q_N\right] + rk + x$$

$\hookrightarrow$ Assumption: (1) $\partial u / \partial D < 0$ (2) $\partial u / \partial z > 0$

- T = ambient temperature
- q_S = electricity for cooling
- k = space conditioning capital (total capacity)
- p = electricity price, r = discounted capital cost
- y = income, q_N = electricity for other uses, x = numeraire good
- a = loss of effectiveness

Damage Function

The damage function is defined as follows:

- Higher-than-optimal indoor temperatures T^* incur a linear utility penalty D with marginal disutility coefficient δ

$$D = 1 - \delta \left(\frac{1}{A\left[q_S, k\right]} T - T^* \right)$$

  where we assume that $A^{(-1)} T \geq T^*$

- For simplicity, let A being a **Leontieff** function

$$A = a^{(-1)} \ \mathbf{min} \left[q_S, k\right]$$

Solution

Solve the model:

- Closed-form solution for electricity consumption and cooling capital

$$q_S^*, \overline{k}, q_S^* = k^* \propto \sqrt{T}\sqrt{Y}$$

  $\hookrightarrow$ importance of **temperature-income interactions**

  $\hookrightarrow$ diminishing returns to adaptation

- **Income inequality** $\Rightarrow$ how much a household can adapt
- Current assumption: no technological differences

Technology

- Assume that there exists two type of technologies $\theta \Rightarrow$ **conditional maximisation utility problem**
- The two technologies only differ in **loss of effectiveness** a and **cost** r
- The optimal disutility due to temperature becomes:

$$D_\theta^* \propto \sqrt{r_\theta}, \sqrt{a_\theta}$$

- Coolers are cheaper than air conditioners ($r_C < r_{AC}$)
- If coolers are **less effective** at bringing thermal comfort ($a_{AC} < a_C$)

$\hookrightarrow$ There is a **trade-off**

Moving to Empirical Analysis

Our empirical analysis:

1. Identify how Indian households are adapting and through which technology

   $\hookrightarrow$ **revealed preferences**

2. Estimate the **marginal disutility** $\partial D / \partial T$

   $\hookrightarrow$ mortality—temperature relationship

3. Determine **differences at reducing thermal discomfort** a_θ

   $\hookrightarrow$ mortality—(temperature $\times$ technology)

Cooling Adaptation

Data

- **Household panel data**: Consumer Pyramid Dx survey (2014-2019):
  - Four-month air-conditioning and coolers ownership
  - Monthly electricity expenditure
  - Households' socio-economic and demographic characteristics
- Actualised **electricity prices**: 2011 National Socio-Economic Survey
  - Aggregated at the district-urban/rural level
- Population-weighted **climate data** from ERA5 ($0.25^\circ \times 0.25^\circ$ cells):
  - Daily average temperature
  - Daily total precipitation

The Choice of the Heat Adaptation Technology

- Our data feature allows to look at both ownership and adoption of cooling appliances
- The investment decision is a **slow adjustment** process $\Rightarrow$ long lifetimes of cooling appliances
- Households invest based on expectations about climate $\Rightarrow$ average weather over long periods (Cohen et al. 2017)
- In our setting **adoption** occurs in a short period of time
  $\hookrightarrow$ driven only by economic development but **conditional on climatic conditions** Trend State
- How we model **unobserved heterogeneity** determines the dimension of study

Empirical Framework

Estimating the impact of **temperature and income** on the **ownership** and **adoption** of the cooling appliances:

$$C_{ciw} = \gamma_0 + \gamma_1 \overline{CDD}_{d(i)w} + \gamma_2 I_{iw} + \gamma_3 g(P_{d(i)w}) + \lambda X_{iw} + \mu_k + \delta_w + \theta_{s(i)} y + \theta^2_{s(i)} y^2 + \zeta_{iw}$$

- C_{ciw}: dummy if household i in wave w has a cooling appliance c
- $\overline{CDD}_{d(i)w}$: 10-year moving average of quarterly CDD in the previous decade
- I_{iw}: natural logarithm of quarterly income of household i
- Controls: second-degree polynomial of precipitation and household characteristics
- μ_k: unobserved heterogeneity (state or household FE)
- Additional fixed-effects: wave FE, quadratic state-year trend
- All regressions are weighted using survey weights that also correct for attrition

Ownership

Evaporative coolers are climate sensitive, air conditioners respond only to income

	Both Appliances (1)	Air Conditioner (2)	Evaporative Cooler (3)
$\overline{\text{CDD}}$ (100s)	0.0146***	0.0000542	0.0145***
	(0.002)	(0.001)	(0.003)
Log(Income)	0.0861***	0.0607***	0.0597***
	(0.007)	(0.006)	(0.010)
Precipitations Controls	Yes	Yes	Yes
Household Controls	Yes	Yes	Yes
State FE, Wave FE	Yes	Yes	Yes
Quadratic State $\times$ Year Trend	Yes	Yes	Yes
R^2	0.51	0.21	0.51
Observations	2442730	2442730	2442730

Notes: (1)-(3) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are conducted using survey weights.

Additional Drivers

Air conditioners:

- **Living in an urban area** ($\Uparrow\Uparrow$)
- Hours of power availability during the day and ownership of generators ($\Uparrow$)
- **Education level** ($\Uparrow\Uparrow$), female head ($\Downarrow$), house materials ($\Uparrow$), head age ($\Downarrow$)

Coolers:

- Hours of **power availability** during the day and **ownership of generators** ($\Uparrow\Uparrow$)
- Education level ($\Uparrow$), female head ($\Downarrow$), house materials ($\Uparrow$), head age ($\Uparrow$)

Adoption

Adoption is a matter of **economic development**

	Both Appliances	Air-conditioning	Evaporative Cooler
	(1)	(2)	(3)
$\overline{\text{CDD}}$ (100s)	-0.000666	0.000216	-0.000764*
	(0.000)	(0.000)	(0.000)
Log(Income)	0.0410***	0.0135***	0.0344***
	(0.003)	(0.001)	(0.003)
Precipitations Controls	Yes	Yes	Yes
Household Controls	Yes	Yes	Yes
Household FE, Wave FE	Yes	Yes	Yes
Quadratic Trend $\times$ State	Yes	Yes	Yes
R^2	0.05	0.02	0.06
Observations	2432366	2432366	2432366

Notes: (1)-(6) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are conducted using survey weights..

Robustness

Our results remain **robust** to sevaral alternative specifications:

- Alternative time and time-invarying fixed-effects
- Clustering standard errors at state level
- Changing CDD thresholds
- Specifying temperature up to degree 3 polynomials
- GLDAS rather than ERA5 climate data

Electricity Consumption

- Consumption electricity in response to temperature is a short-term decision
- Technology modulates household response
- Using the monthly information we observe the **causal effect** of short-term variation in temperature
- **Heterogeneity** in the response should be confirmatory of the **distribution** of the technologies

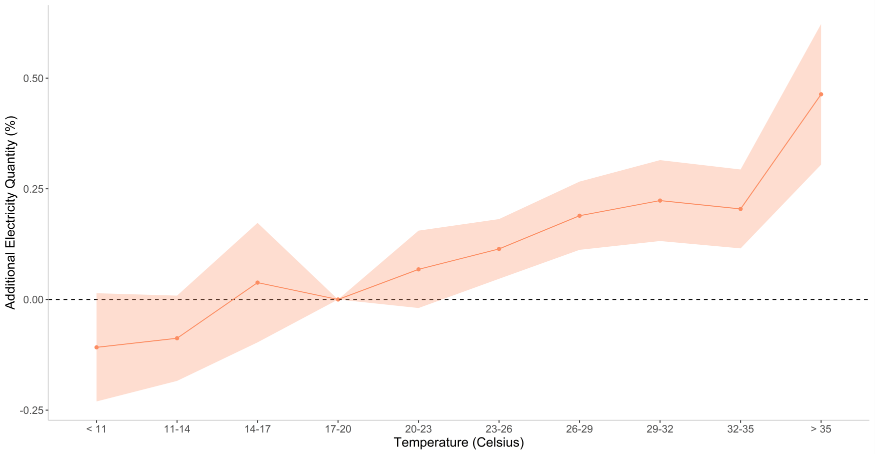
Empirical Framework

Estimating the impact of **temperature** on electricity quantity:

$$Q_{imy} = \alpha + \sum_{j=1}^{k} \theta_j T^j_{d(i)my} + \beta_2 f(P_{d(i)my}) + \beta_3 I_{imy} + \mu_i + \delta_{my} + \epsilon_{imy}$$

- Q_{imy}: natural logarithm of electricity quantity of household i in month m and year y
- $T_{d(i)my}$: 3°C bins of daily average temperature in district d (17-20 as reference category)
- Controls: second-degree polynomial of total precipitation and natural logarithm of monthly income
- Fixed-effects: household FE (μ_i) and month-year FE (δ_{my})
- All regressions are weighted using survey weights that also correct for attrition

Temperature-electricity



An additional day $\geq 35\ ^\circ\mathrm{C}$ (wrt $17 - 20$) increases electricity consumption by **0.46%**

Heterogeneity

Het II Het III

We test the **heterogeneity** of the response across different sub-samples

	Rural			Urban		
	Poor	Middle	Rich	Poor	Middle	Rich
	(1)	(2)	(3)	(4)	(5)	(6)
≥ 35	0.00345***	0.00271***	0.00422***	0.00566***	0.00748***	0.00779***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes	Yes	Yes
Month-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.02	0.01	0.01	0.04	0.04	0.09
Observations	791899	1293061	236447	854902	2698269	1297719
Avg. kWh	69.35	103.86	171.59	83.37	117.99	195.08
Δ(kWh)	+0.24	+0.28	+0.72	+0.47	+0.88	+1.51

Notes: (1) to (6) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are conducted using survey weights.

Robustness

Our results remain **robust** to alternative specifications:

- Alternative time and time-invarying fixed-effects
- Electricity quantity in levels
- Clustering standard errors at state level
- Specifying temperature as 5-degree bins, up to degree 3 polynomials, as Cooling Degree Days (CDD)
- CRU rather than ERA5 climate data

Health and Extreme Heat

Data

- District-level annual **mortality data**: Civil Registration System (2009-2019)
  - Digitalise the reports
  - All-age and all-causes
  - Distinction between total, urban and rural deaths

- District-level data on **heat adaptation**: Consumer Pyramid Dx survey (2014-2019)
  - District and state-level penetration rates of air conditioners and evaporative coolers

- Population-weighted **climate data** from ERA5 ($0.25^\circ \times 0.25^\circ$ cells):
  - Daily average temperature
  - Daily total precipitation
  - Daily specific humidity

Empirical Framework

Estimating the impact of **temperature** on mortality:

$$M_{dt} = \alpha_0 + \sum_{j=1}^{8} \theta_j T_{dtj} + \sum_{r} \delta_r \{P_{dt} \in tercile\, r\} + \mu_d + \rho_t + \lambda_{r(d)} t + \lambda^2_{r(d)} t^2 + \epsilon_{dt}$$

- M_{dt}: natural logarithm of mortality rate in district d and year y
- $T_{d(i)my}$: 5°C bins of daily average temperature in district d (15-20 as reference category)
- Fixed-effects: district FE (μ_d), year FE (ρ_t), climatic region × quadratic trend ($\lambda_{s(d)} t + \lambda^2_{s(d)} t^2$)
- Square root of district population used as weight for the regression
  (Barreca et al. 2016, JPE; Burgess et al. 2017)
- Additional regressions: (1) bins of **humidity**, (2) interaction **warmest × most humid bin**

The Role of Cooling

Estimate **an augmented regression model**:

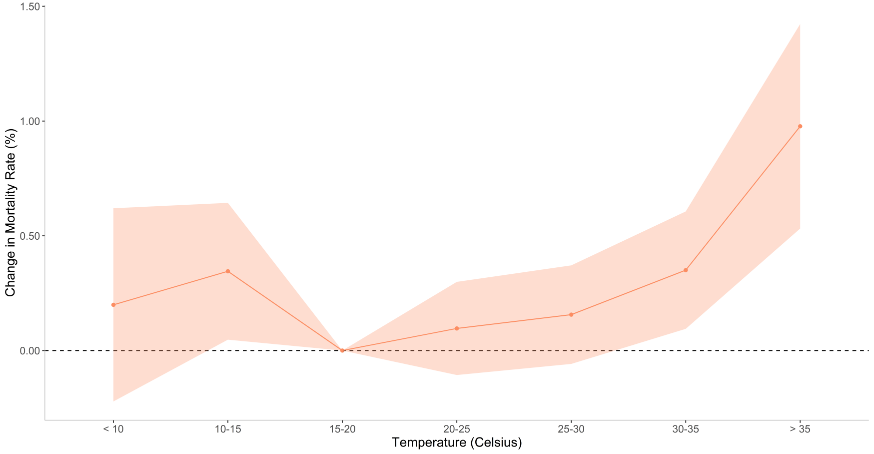
$$M_{dt} = \alpha_0 + \sum_{j=1}^{8} \theta_j T_{dtj} + \sum_{l=1}^{2} \gamma_l T_{dt}^{\geq 35} \times C_{dtl} + \sum_{l=1}^{2} \phi_l C_{dtl} + \\ + \sum_{r} \delta_r \{P_{dt} \in tercile\, r\} + \mu_d + \rho_t + \lambda_{r(d)} t + \lambda_{r(d)}^2 t^2 + \epsilon_{dt}$$

- C_{dtl}: penetration rate in district d of technology l
- Additional regressions: interactions with (1) bins of humidity, (2) warmest × most humid bin
- **Drawback**: no quasi-experimental design

↪ **Key for identification**: the two shares do not have to correlate with other drivers of mortality

↪ **Robustness**: log of income per capita, log of income per capita × all bins, ownership rates × with all bins

Temperature-mortality



An additional day $\geq 35\ ^{\circ}\mathrm{C}$ (wrt $15 - 20$) increases mortality rates by **1%**

Controlling for Humidity

	FE (1)	FE (2)	FE (3)	FE (4)
T ($\geq$ 35)	0.00943***		0.00996***	0.000320
	(0.002)		(0.002)	(0.003)
H (0 − 3)		0.000660	-0.000505	-0.000102
		(0.003)	(0.003)	(0.003)
H ($\geq$ 18)		-0.000102	0.000756	0.000110
		(0.001)	(0.001)	(0.001)
T ($\geq$ 35) $\times$ H ($\geq$ 18)				0.000123***
				(0.000)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Quadratic Trend $\times$ Region	Yes	Yes	Yes	Yes
R^2	0.03	0.02	0.03	0.04
Observations	3908	3908	3908	3908

Notes: (1)-(4) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are weighted by the square root of district population.

Heterogeneity I

Heat-related deaths mostly occur in **rural areas**

	Rural		Urban	
	(1)	(2)	(3)	(4)
T ($\geq$ 35)	0.00909**	-0.00191	0.00549*	0.00229
	(0.004)	(0.005)	(0.003)	(0.004)
T ($\geq$ 35) $\times$ H ($\geq$ 18)		0.000153**		0.0000533
		(0.000)		(0.000)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Quadratic Trend $\times$ Region	Yes	Yes	Yes	Yes
R^2	0.03	0.04	0.02	0.02
Observations	2520	2520	1549	1549

Notes: (1)-(4) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are weighted by the square root of district rural and urban population.

Heterogeneity II

Heat-related deaths mostly occur in district with a **higher share of poor individuals**

	Below Median		Above Median	
	(1)	(2)	(3)	(4)
T ($\geq$ 35)	0.00430*	0.00410	0.0173***	0.00147
	(0.003)	(0.003)	(0.004)	(0.006)
T ($\geq$ 35) $\times$ H ($\geq$ 18)		0.0000199		0.000168**
		(0.000)		(0.000)
District FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Quadratic Trend $\times$ Region	Yes	Yes	Yes	Yes
R^2	0.04	0.04	0.06	0.07
Observations	1369	1369	1384	1384

Notes: (1)-(4) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are weighted by the square root of district population.

Evaporative Cooler vs Air conditioner

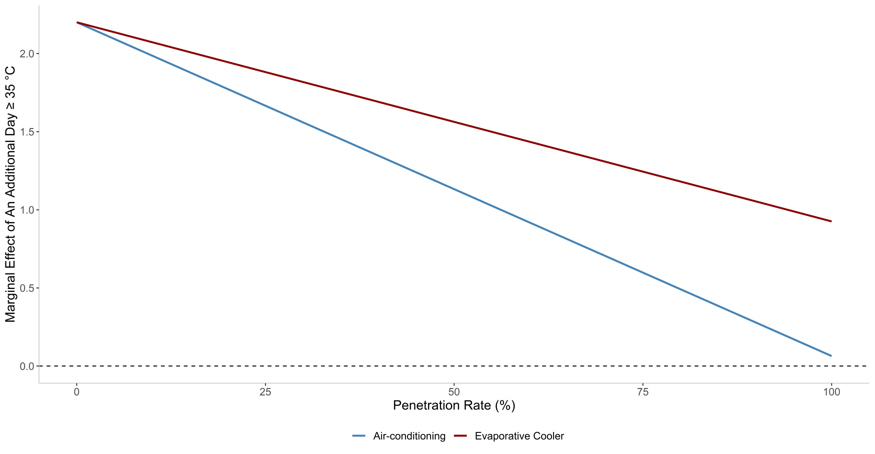
Evaporative coolers are **more than two times** less effective than air conditioners

	Temperature			Humidity			Temperature × Humidity		
	Air conditioner (1)	Cooler (2)	Both (3)	Air conditioner (4)	Cooler (5)	Both (6)	Air conditioner (7)	Cooler (8)	Both (9)
AC × T ($\geq$ 35)	-0.0302***		-0.0268***						
	(0.009)		(0.009)						
Cooler × T ($\geq$ 35)		-0.0132**	-0.0123**						
		(0.005)	(0.005)						
AC × H ($\geq$ 18)				-0.000661		-0.000685			
				(0.002)		(0.002)			
Cooler × H ($\geq$ 18)					0.000506	0.000538			
					(0.001)	(0.001)			
AC × T ($\geq$ 35) × H ($\geq$ 18)							-0.000436***		-0.000368***
							(0.000)		(0.000)
Cooler × T ($\geq$ 35) × H ($\geq$ 18)								-0.000131**	-0.000113**
								(0.000)	(0.000)
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quadratic Trend × Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06
Observations	2753	2753	2753	2753	2753	2753	2753	2753	2753

Notes: (1)-(9) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are weighted by the square root of district population.

Discussion

Residual Effect of Extreme Heat



Residual Effect of Extreme Heat

Let's make an example:

Residual Effect of Extreme Heat

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- **Delhi**:
  - $\hookrightarrow$ income = 42183 rupees, CDD = 465 degree-days

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  - $\hookrightarrow$ increase by 30% p.p. in air-conditioning penetration rate (25% to 55%)

Residual Effect of Extreme Heat

Let's make an example:

- **Delhi**:
  - $\hookrightarrow$ income = 42183 rupees, CDD = 465 degree-days
  - $\hookrightarrow$ increase by 30% p.p. in air-conditioning penetration rate (25% to 55%)
  - $\hookrightarrow$ heat-related mortality from extreme heat reduced by 36%

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- **Uttar Pradesh**:
  - $\hookrightarrow$ income = 14844 rupees, CDD = 454 degree-days

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- **Uttar Pradesh**:
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Residual Effect of Extreme Heat

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- **Delhi**:
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  - $\hookrightarrow$ increase by 30% p.p. in air-conditioning penetration rate (25% to 55%)
  - $\hookrightarrow$ heat-related mortality from extreme heat reduced by 36%
- **Uttar Pradesh**:
  - $\hookrightarrow$ income = 14844 rupees, CDD = 454 degree-days
  - $\hookrightarrow$ increase by 30% p.p. in evaporative cooler penetration rate (25% to 55%)
  - $\hookrightarrow$ heat-related mortality from extreme heat reduced by 19%

Avoided Deaths

Without adaptation $\Rightarrow$ **1.01 million people** excess deaths due to extreme heat

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- Percentage of **avoided deaths** in the period 2014-2019:

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Avoided Deaths

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- Percentage of **avoided deaths** in the period 2014-2019:

  $\hookrightarrow$ with heat adaptation $\Rightarrow$ 30%

- **Gross welfare gains** from heat adaptation in the period 2014-2019

  $\hookrightarrow$ $1.05 \times 30\% \times VSL \Rightarrow 55$ billion \$

  $\hookrightarrow$ yearly: **9 billion \$** $\Rightarrow$ **0.34% of the annual GDP**

Avoided Deaths

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- Percentage of **avoided deaths** in the period 2014-2019:
  - $\hookrightarrow$ with heat adaptation $\Rightarrow$ 30%
- **Gross welfare gains** from heat adaptation in the period 2014-2019
  - $\hookrightarrow$ $1.05 \times 30\% \times VSL \Rightarrow 55$ billion \$
  - $\hookrightarrow$ yearly: **9 billion \$** $\Rightarrow$ 0.34% of the annual GDP
- What would have happened if air conditioners were **as spread as** evaporative cooler?
  - air-conditioning **alone** $\Rightarrow$ 46%
  - $\hookrightarrow$ gross welfare gains $\Rightarrow$ **14 billion \$** $\Rightarrow$ 0.46% of the annual GDP

Implications for Policy

- Subsidise air conditioners may be a very **expensive policy**
  - $\hookrightarrow$ the annualised cost is around 3083 rupees (37 \$)
  - $\hookrightarrow$ 100% subsidy for having same rate of coolers $\Rightarrow$ 252 billion rupees (**3 billion \$**)
- Evaporative coolers seems a **stop-gap** solution
  - $\hookrightarrow$ better an evaporative cooler than no cooling
- Air conditioners are likely the solution in the **long-term**
  - $\hookrightarrow$ **extreme heat** will become more intense and frequent
  - $\hookrightarrow$ **income** is expected to largely increase in the next years
  - $\hookrightarrow$ need for investment in innovation United States

Conclusion

Conclusion

- There exists a **trade-off** between accessibility to cooling and health protection
- **Technology layer** in the heat adaptation inequality for low- and middle-income households
- Only rich urban households adopt and use the most effective technology
- Trade-off also for policy makers
- **Future research agenda**:
  - ↪ do competing strategies in other setting (e.g. agriculture) have similar inequality consequences?
  - ↪ is there a trade-off between adaptation and mitigation?
  - ↪ is the technological gap specific of India?

Thank you for your attention! **Any questions?**

Welfare Costs of Extreme Back

Examples of evidence about the welfare costs of extreme heat:

- Mortality and morbidity
  (Deschenes and Greenstone 2011, AEJ; Barreca et al. 2016, JPE; Burgess et al. 2017; Heutel et al. 2021, RESTAT; Carleton et al. 2022, QJE)
- Learning
  (Park et al. 2020, AEJ; Zivin et al. 2020, JEEM; Park 2022, JHR)
- Mental health and mood
  (Noelke et al. 2016, ER; Baylis 2020, JPubE; Hua et al. 2022, JPopE)
- Labour productivity
  (Dasgupta et al. 2021, Lancet; Somanathan et al. 2021, JPE)
- Aggressive behaviour and crime
  (Ranson et al. 2015, JEEM; Baysan et al. 2019; JEBO; Blakeslee et al. 2021; JEBO)

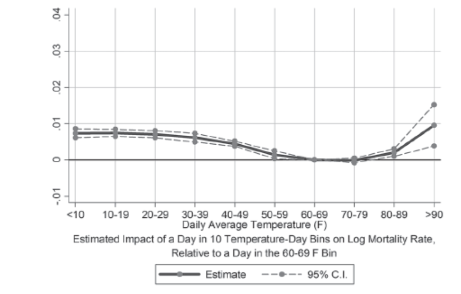
Mediating Effects of Air-conditioning

Back

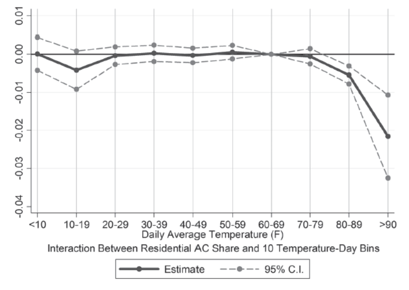
Mortality

(Barreca et al. 2016, JPE)

Without Air-conditioning



With Air-conditioning

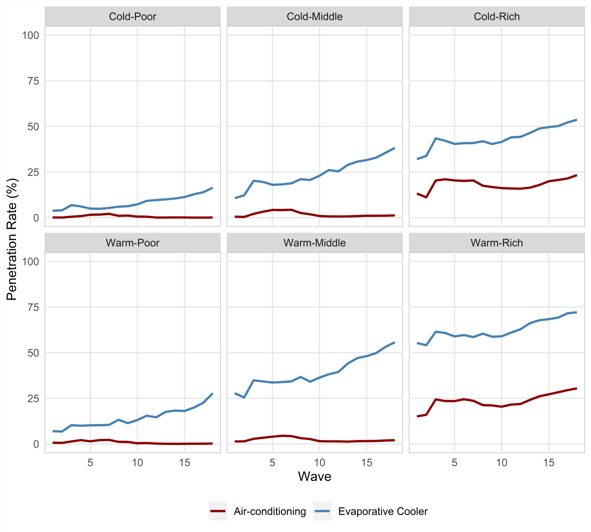


Further evidence: learning achievements, labour productivity and mental health

(Park et al. 2020, AEJ; Somanathan et al. 2021, JPE; Hua et al. 2022, JPopE)

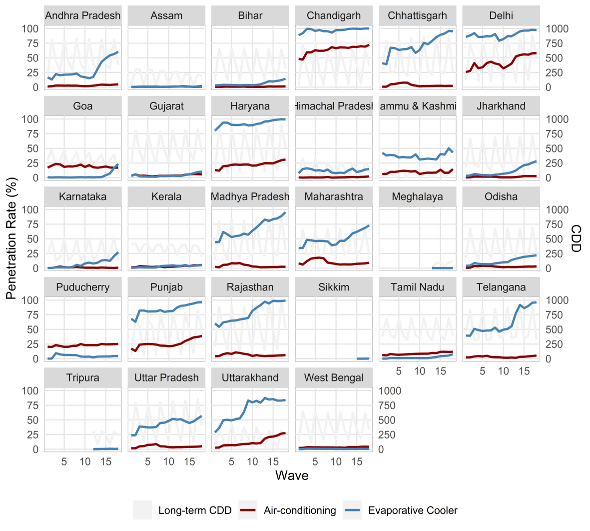
Trends in Ownership Rates by Income and Climate

Back State



Trends in Ownership Rates by States

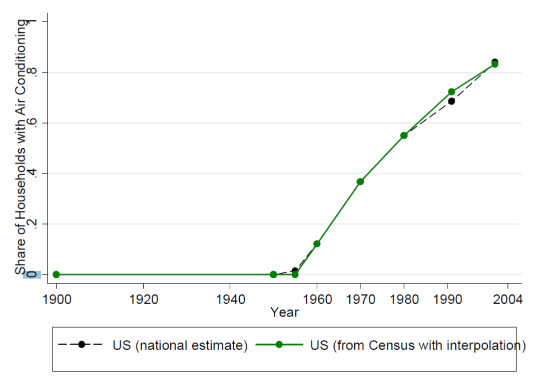
Back Trend Zoom



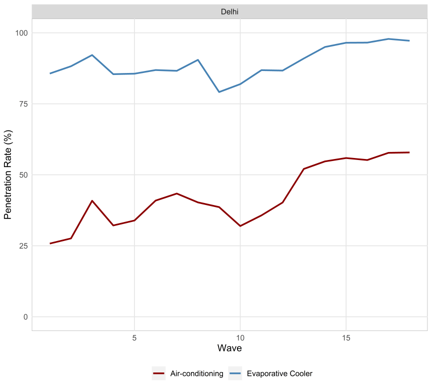
Zooming In

Back Trend State

United States (1900-2004)



Delhi (2014-2019)



Heterogeneity based on **technology**

	Air Conditioner	Evaporative Cooler
	(1)	(2)
≥ 35	0.00726***	0.00429***
	(0.002)	(0.001)
Precipitations Controls	Yes	Yes
Household FE	Yes	Yes
Month-Year FE	Yes	Yes
R^2	0.04	0.01
Observations	724127	3648335

Notes: (1) and (2) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are conducted using survey weights.

Electricity - Heterogeneity III

Back

Focusing on **high-income** families

	Air Conditioner	Evaporative Cooler
	(1)	(2)
≥ 35	0.00939***	0.00677***
	(0.002)	(0.001)
Precipitations Controls	Yes	Yes
Household FE	Yes	Yes
Month-Year FE	Yes	Yes
Within R^2	0.05	0.02
Observations	490613	995301

Notes: (1) and (2) clustered standard errors at district level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. All regressions are conducted using survey weights.

Innovation in the United States

Back

Rapson (2014, JEEM)