Empirical Approaches

Moritz A. Drupp

Why use empirics

- We use empirical approaches to
  - Test (and refine) theories
  - Calibrate models or simulations
  - Explore intended and unintended effects (e.g. policy evaluation)
  - Understand behavior and mechanisms
  - Inform policy choices
  - …

The diversity of empirical approaches

Discuss with your neighbor:

Which empirical approaches do you know of?

The diversity of empirical approaches

- Descriptive analyses (mostly describe past phenomena and their relation)
- Prescriptive analyses (describe future phenomena, e.g. surveys on what ought to be done)
- Experimental approaches
  - Lab experiment
  - Field experiment
- Quasi-experimental approaches
  - Natural experiment
  - Quasi-experimental approaches

Descriptive analyses: Examples

- Disparities in PM2.5 air pollution in the United States (Colmer et al. 2020 *Science*)

RESEARCH

AIR POLLUTION

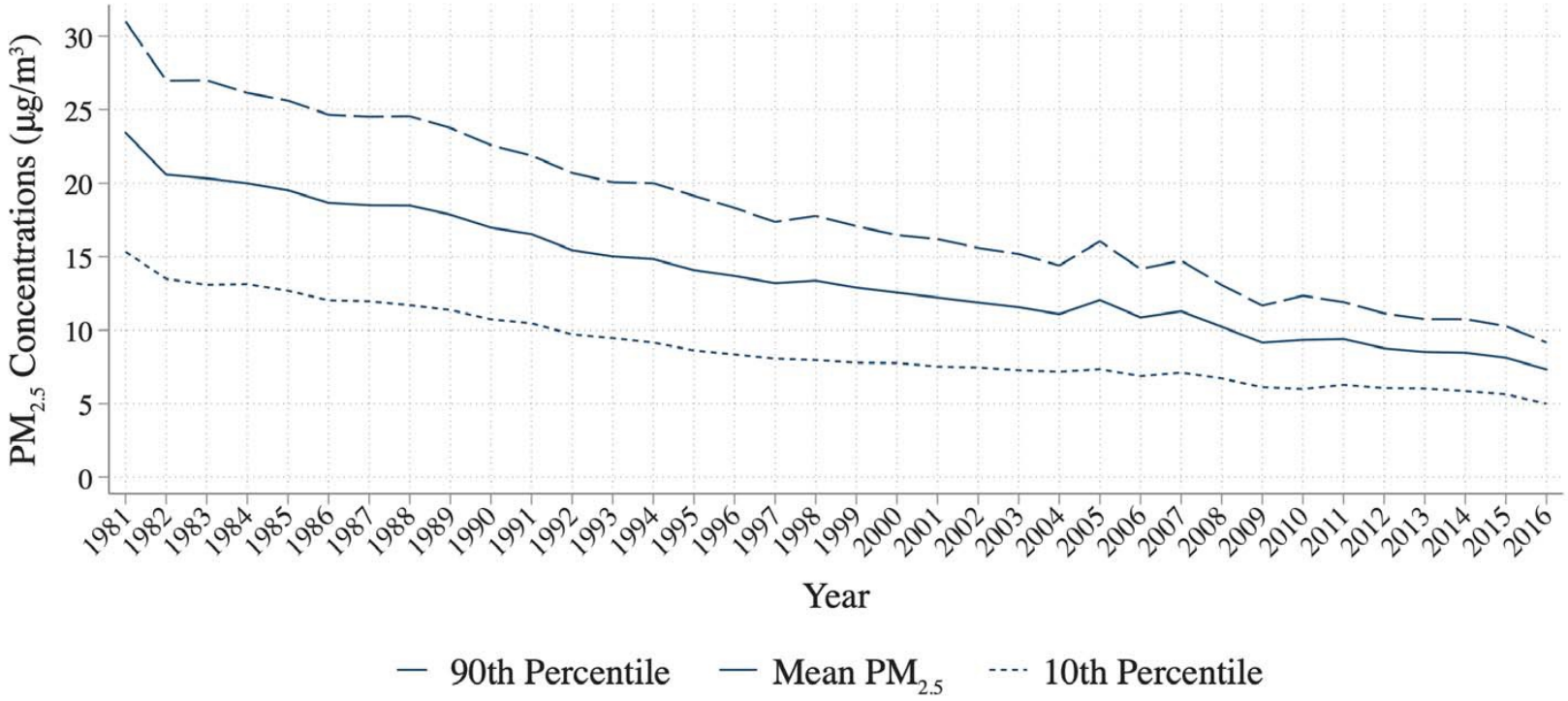
Disparities in $PM_{2.5}$ air pollution in the United States

Jonathan Colmer[1]*, Ian Hardman[2], Jay Shimshack[3], John Voorheis[4]

Air pollution at any given time is unequally distributed across locations. Average concentrations of fine particulate matter smaller than 2.5 micrometers in diameter ($PM_{2.5}$) have fallen over time. However, we do not know how the spatial distribution of $PM_{2.5}$ has evolved. Here, we provide early evidence. We combine 36 years of $PM_{2.5}$ concentrations measured over ~8.6 million grid cells with geographic, economic, and demographic data from ~65,000 U.S. census tracts. We show that differences in $PM_{2.5}$ between more and less polluted areas declined substantially between 1981 and 2016. However, the most polluted census tracts in 1981 remained the most polluted in 2016. The least polluted census tracts in 1981 remained the least polluted in 2016. The most exposed subpopulations in 1981 remained the most exposed in 2016. Overall, absolute disparities have fallen, but relative disparities persist.

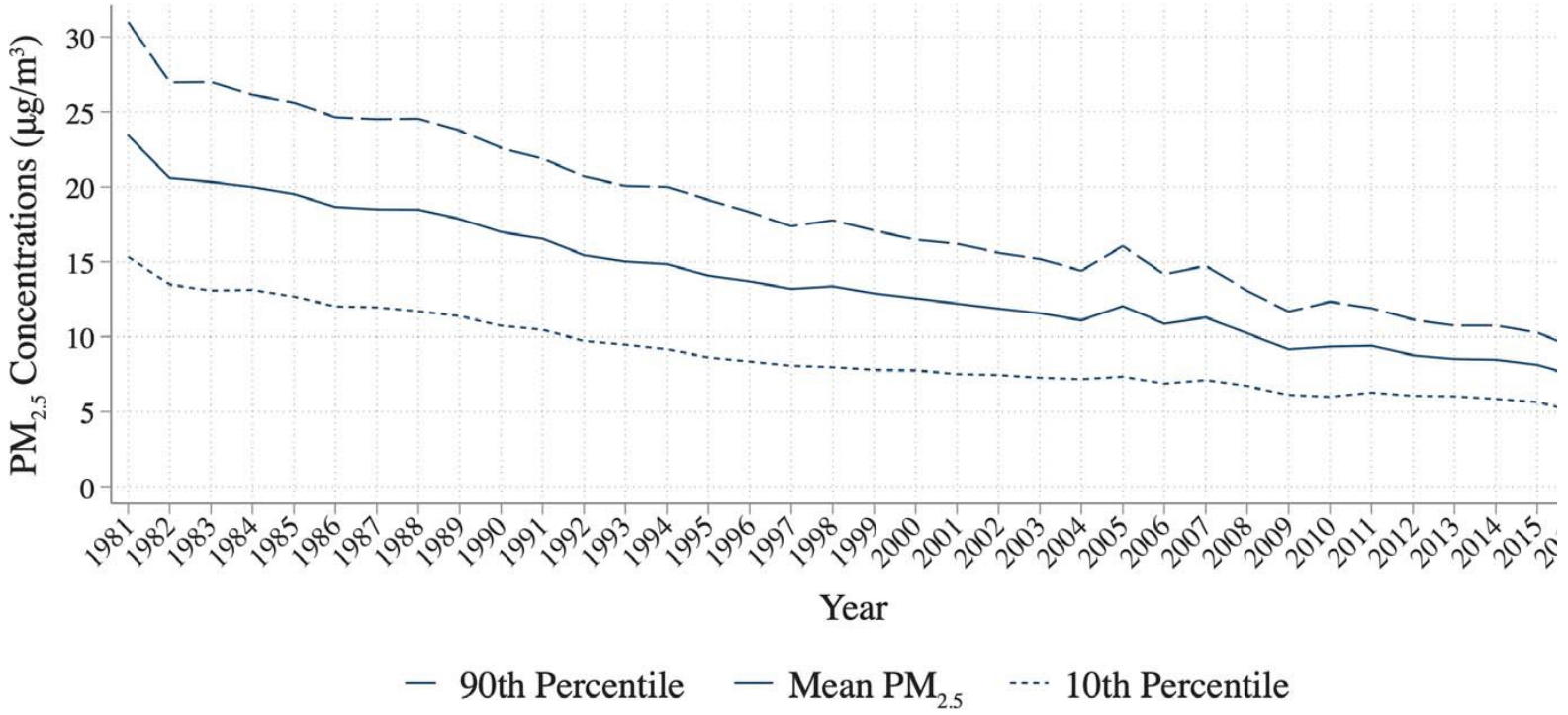
Descriptive analyses: Examples

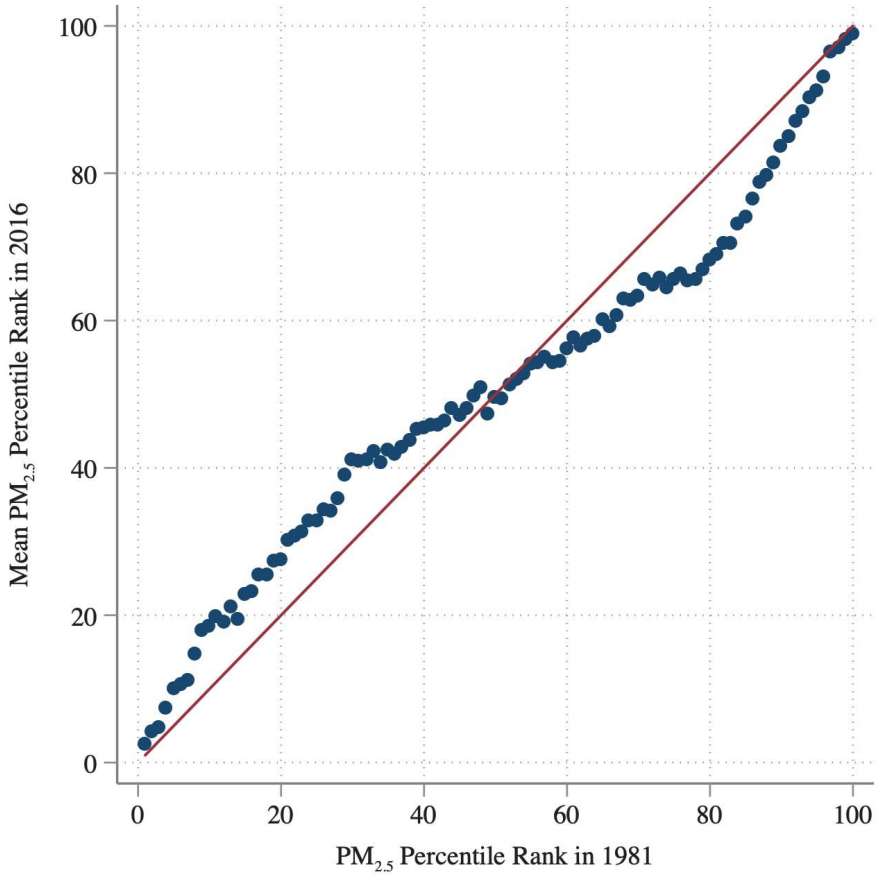
- Disparities in PM2.5 air pollution in the United States (Colmer et al. 2020 *Science*)



Descriptive analyses: Examples

- Disparities in PM2.5 air pollution in the United States (Colmer et al. 2020 *Science*)





Descriptive analyses: Examples

- Environmental Engel Curves (Levinson & Obrien 2019 *REStat*)

ENVIRONMENTAL ENGEL CURVES: INDIRECT EMISSIONS OF COMMON AIR POLLUTANTS

Arik Levinson and James O'Brien*

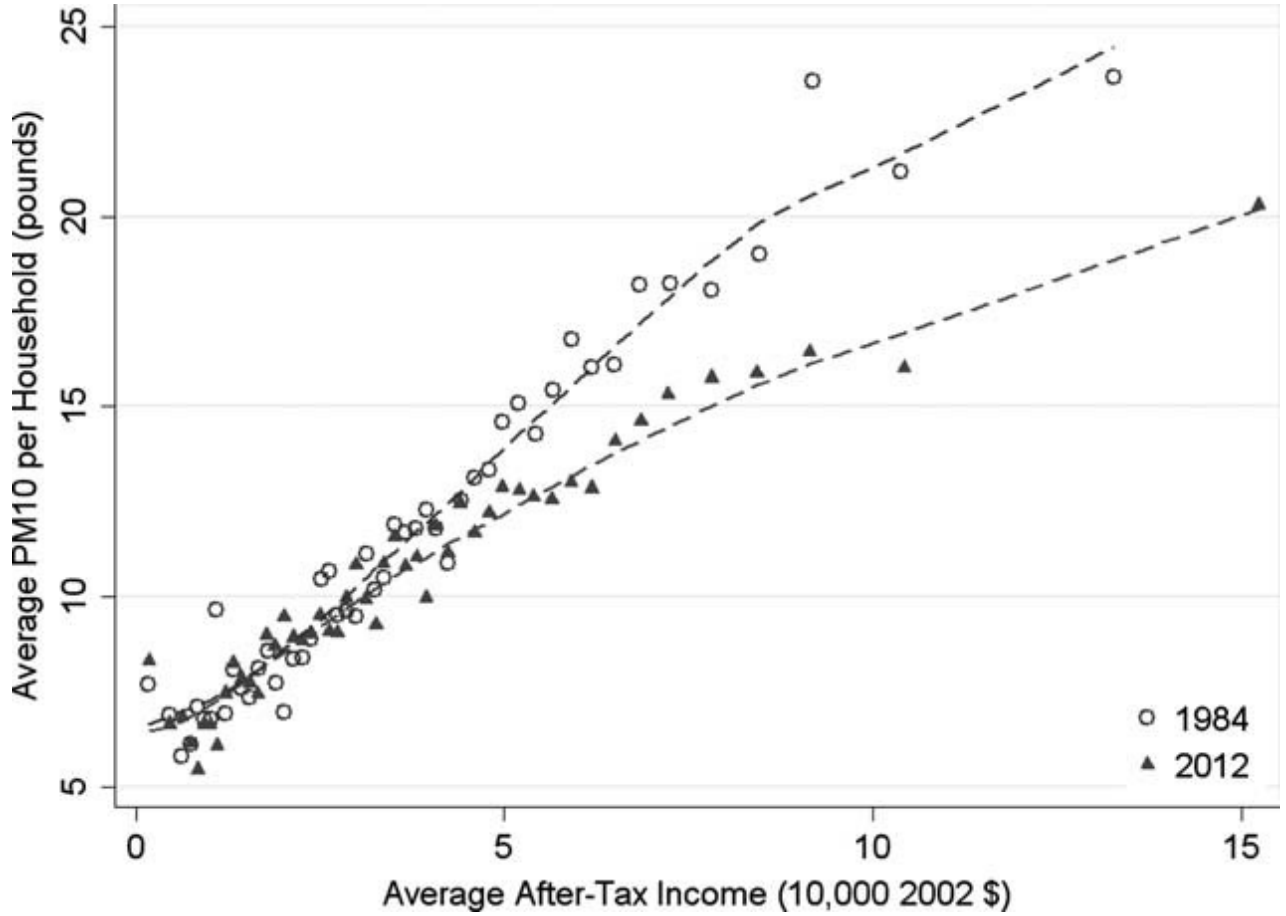
Abstract—Environmental Engel curves (EECs) describe households' incomes and the pollution necessary to produce the goods and services they consume. We calculate 29 annual EECs from 1984 to 2012 for point-source air pollutants in the United States, revealing three clear results: EECs slope upward, have income elasticities less than 1, and shift down over time. Even without changes to production techniques, pollution would have declined despite growing incomes. This improvement can be attributed about equally to two trends: household income growth represented by movement along inelastic EECs and economy-wide changes represented by downward shifts in EECs over time.

production has been more than offset by some combination of technique and composition.

Recent research has shown that pollution reductions in the United States have resulted mostly from changes in technique. Estimates range from 35% to nearly 100%, depending on the pollutant and time period studied.[1] The remaining change in the composition of production has two sources: consumption and trade. The United States can shift

Descriptive analyses: Examples

- Environmental Engel Curves (Levinson & Obrien 2019 *REStat*)



Experimental approaches: Lab experiment

- Inequality, communication, and the avoidance of disastrous climate change in a public goods game (Tavoni et al. 2011 *PNAS*)

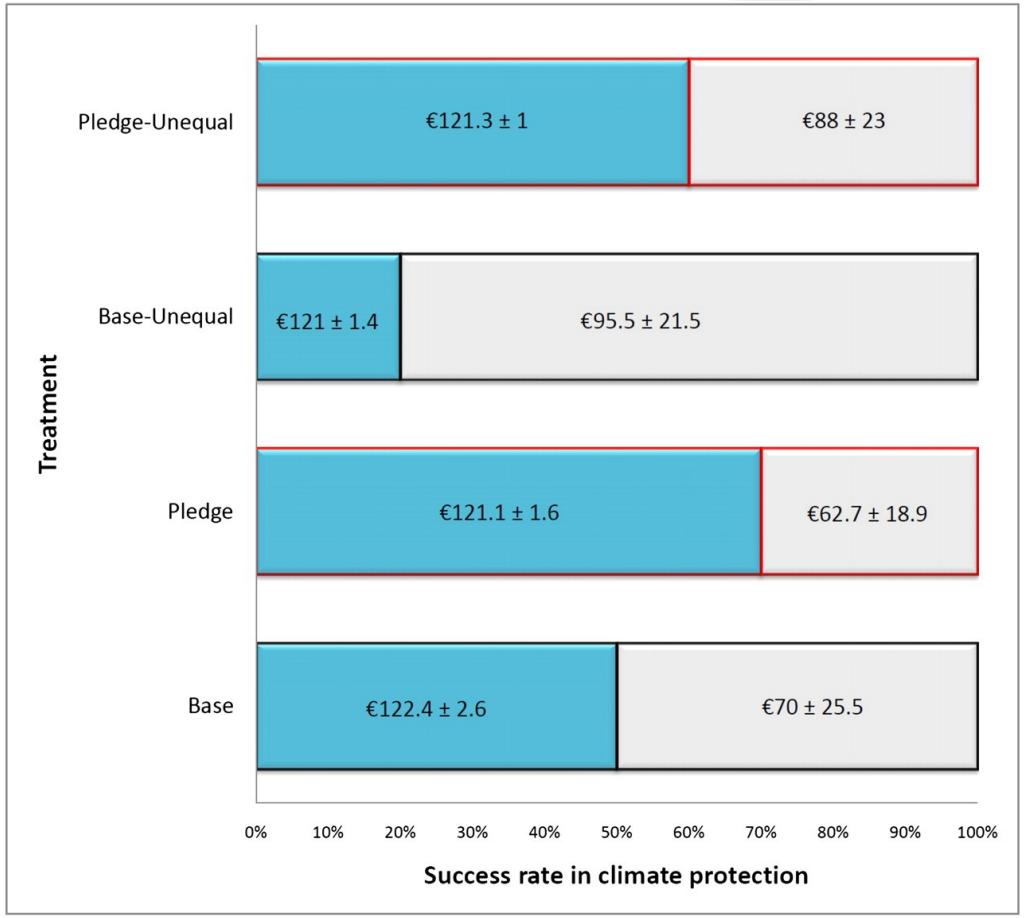
PNAS

Inequality, communication, and the avoidance of disastrous climate change in a public goods game

Alessandro Tavoni[a,1], Astrid Dannenberg[b], Giorgos Kallis[c], and Andreas Löschel[b,d,e]

[a]Grantham Research Institute and Centre for Climate Change Economics and Policy, London School of Economics, London WC2A 2AZ, United Kingdom; [b]Department of Environmental and Resource Economics, Centre for European Economic Research, 68161 Mannheim, Germany; [c]Institució Catalana de Recerca i Estudis Avançats, and Institut de Ciencia i Tecnologia Ambientals, Universidad Autonoma de Barcelona, 08193 Bellatera, Spain; [d]Alfred Weber Institute for Economics, University of Heidelberg, 69115 Heidelberg, Germany; and [e]Centre for Climate Economics and Policy, Australian National University, Canberra, ACT 0200, Australia

Edited* by Simon A. Levin, Princeton University, Princeton, NJ, and approved May 24, 2011 (received for review February 17, 2011)



Experimental approaches: Survey experiments

- Fighting Climate Change: International Attitudes toward Climate Policies (Dechezlepretre et al. 2023)
- Online survey experiment in 20 countries with N=40000 to examine how climate information affects policy support

Background of respondent

Socio-economic characteristics, political views, energy use, consumption habits

Video information treatment

Control group	Climate impacts	Climate policies	Both treatments
No video information provided	 Local impacts of climate change	 • Ban on combustion-engine cars • Carbon tax w/ cash transfers • Green infrastructure program	Climate impacts + climate policies  

Knowledge and understanding of climate change

- Climate change is real, anthropogenic, climate dynamics
- Factors causing climate change: gases, activities
- Impacts of climate change, prospects for the future

Views on climate policies

- **Three main policies**: ban on combustion-engine cars, green infrastructure program, carbon tax with cash transfers:
  - Policies' effectiveness: will the policies reduce emissions/pollution?
  - Distributional impacts: which groups will win or lose?
  - Self-interest concerns: will your household win or lose?
  - Perceived fairness
  - Support for policy (and variations of it)
- **Support for a range of other climate policies:** carbon taxes, emission standards, subsidies, mandatory insulation of buildings, policies to reduce beef consumption, global policies
- **Real-stake questions**: willingness to donate to reforestation cause, willingness to sign a petition for climate action

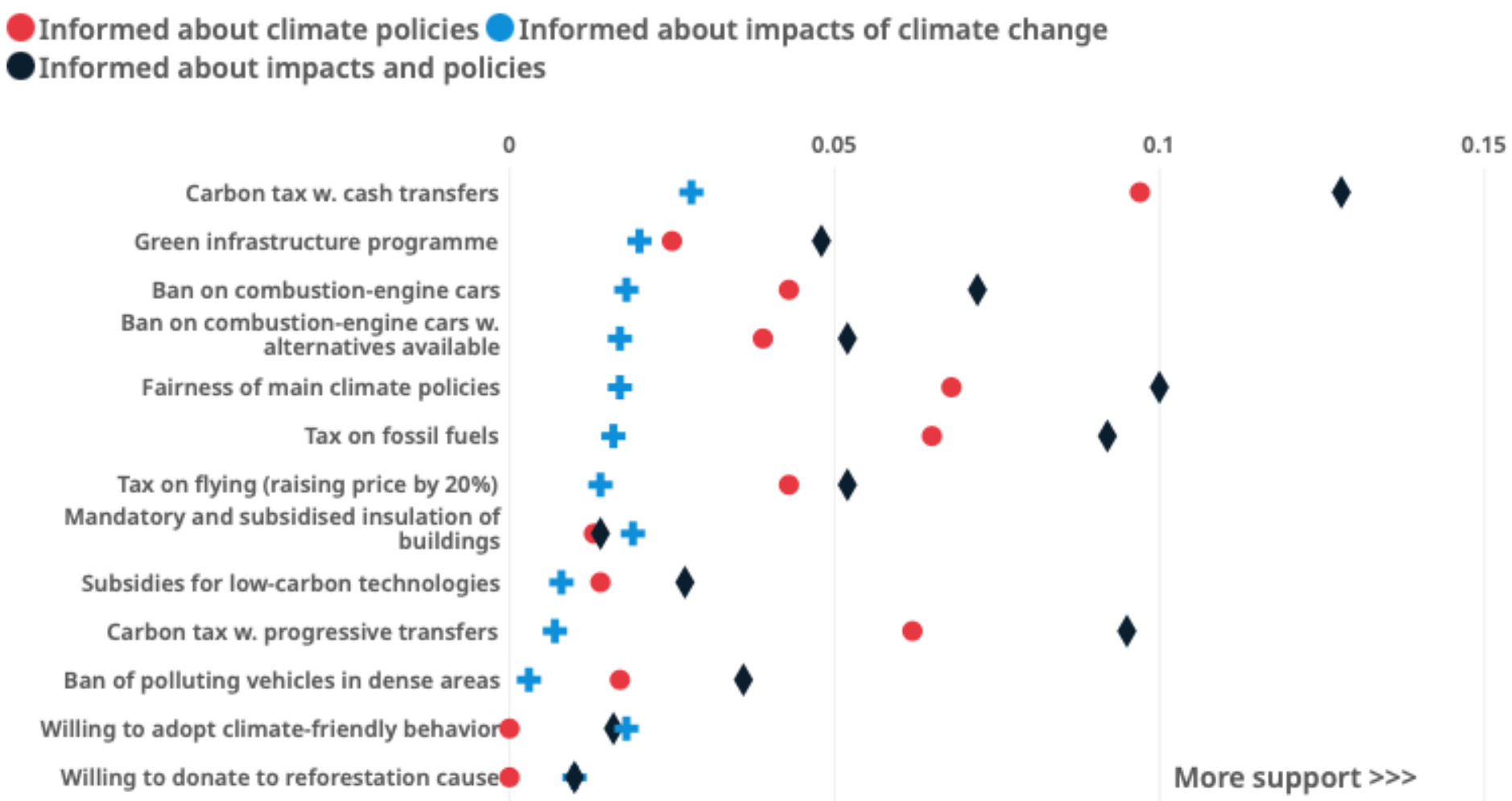
Experimental approaches: Survey experiments

- Fighting Climate Change: International Attitudes toward Climate Policies (Dechezlepretre et al. 2023)
- Online survey experiment in 20 countries with N=40000 to examine how climate information affects policy support
  - Climate impacts: https://lse.eu.qualtrics.com/WRQualtricsControlPanel/File.php?F=F_bj8yT5eiDpZCR82
  - Climate policies: https://lse.eu.qualtrics.com/WRQualtricsControlPanel/File.php?F=F_bg5w9RRYbGtMrwa

How does informing citizens affect support for climate change?

Change in level of support

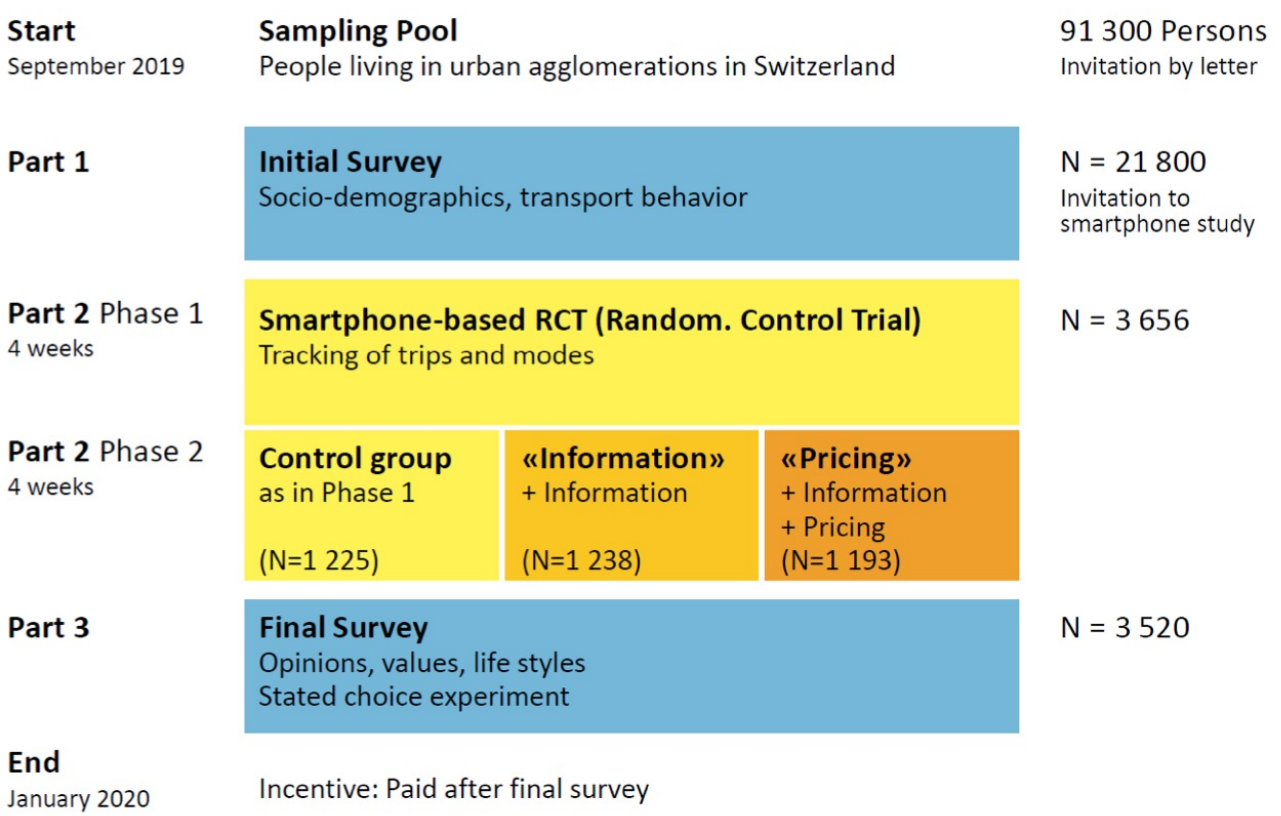
All | Private Behaviours | Support for Other Climate Polici | Support for Main Climate Policie



Experimental approaches: Field experiments

- Pigouvian Pricing in Practice (Hintermann et al. 2022 R&R JPE)
  - Large-scale field experiment in urban areas of Switzerland.
  - Pricing is varied across time, space and mode of transport.
  - One third of the participants is given a financial incentive to reduce their external costs of transport, whereas others are provided information only or served as a control group.

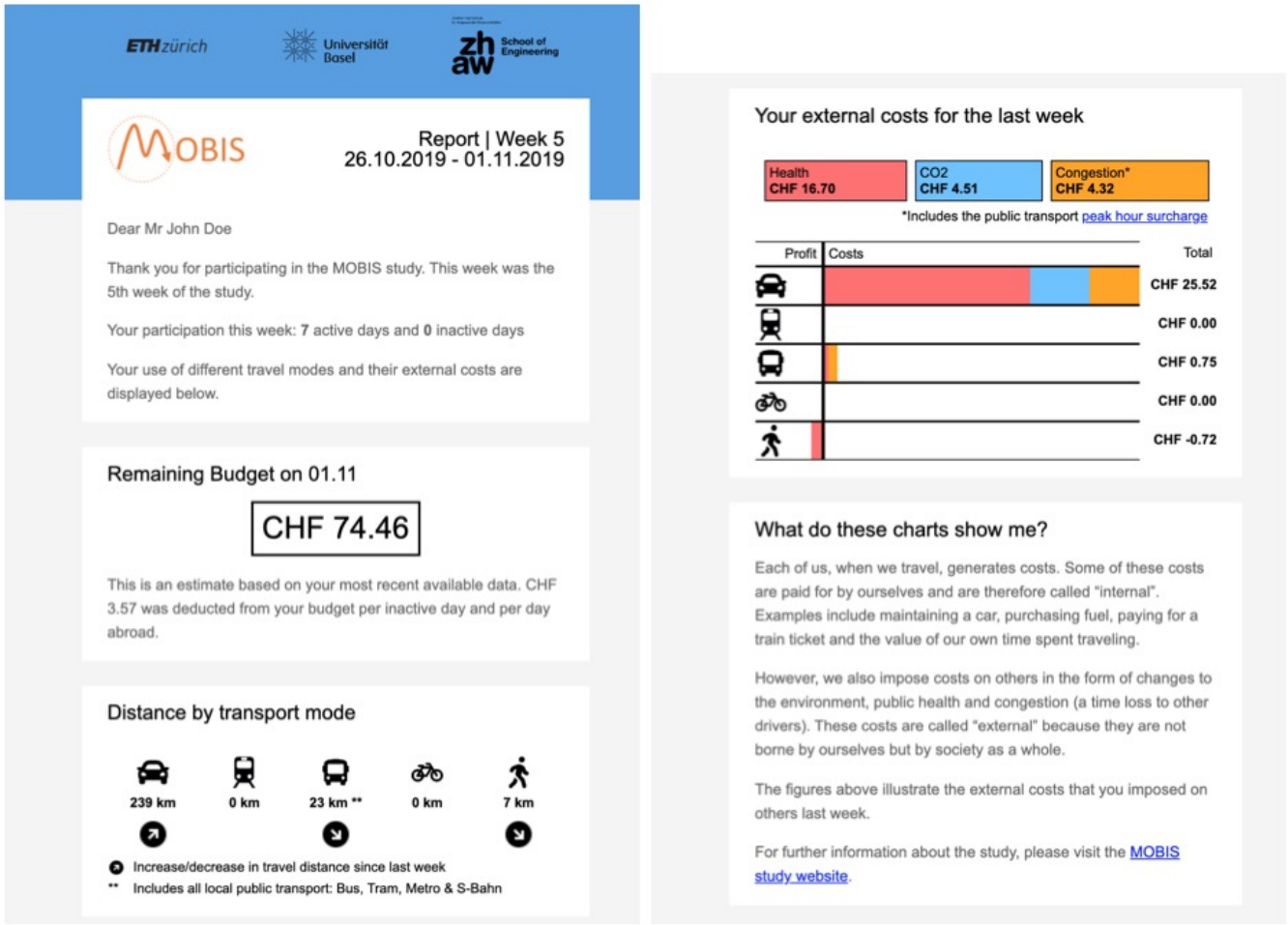
Figure 1: Design of the MOBIS experiment



Experimental approaches: Field experiments

- Pigouvian Pricing in Practice (Hintermann et al. 2022 R&R JPE)
  - Large-scale field experiment in urban areas of Switzerland.
  - Pricing is varied across time, space and mode of transport.
  - One third of the participants is given a financial incentive to reduce their external costs of transport, whereas others are provided information only or served as a control group.

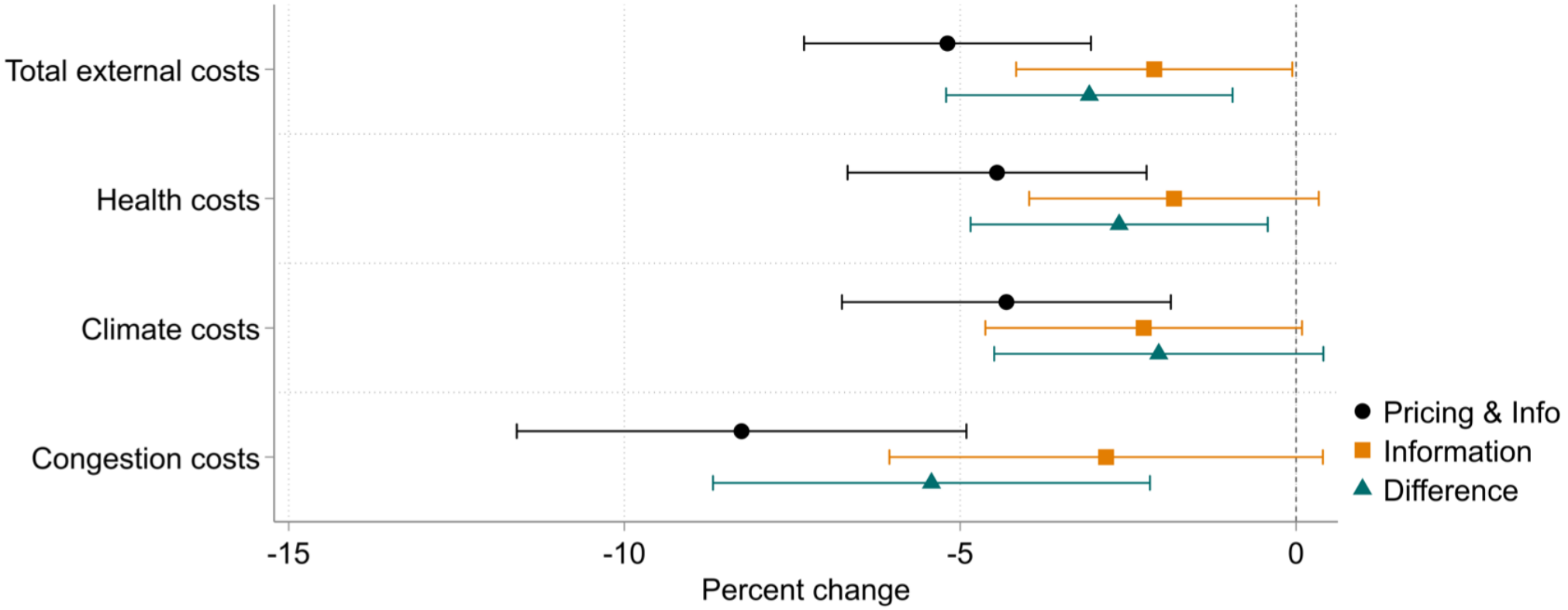
Figure 3: Weekly reports by e-mail



Experimental approaches: Field experiments

- Pigouvian Pricing in Practice (Hintermann et al. 2022 R&R JPE)

Figure 5: Treatment effect on the external costs of transport



Prescriptive analyses: Examples

- Pricing Carbon (Drupp et al. 2024 *AEJ*), see slides on GitHub

Quasi-experimental approaches: Examples

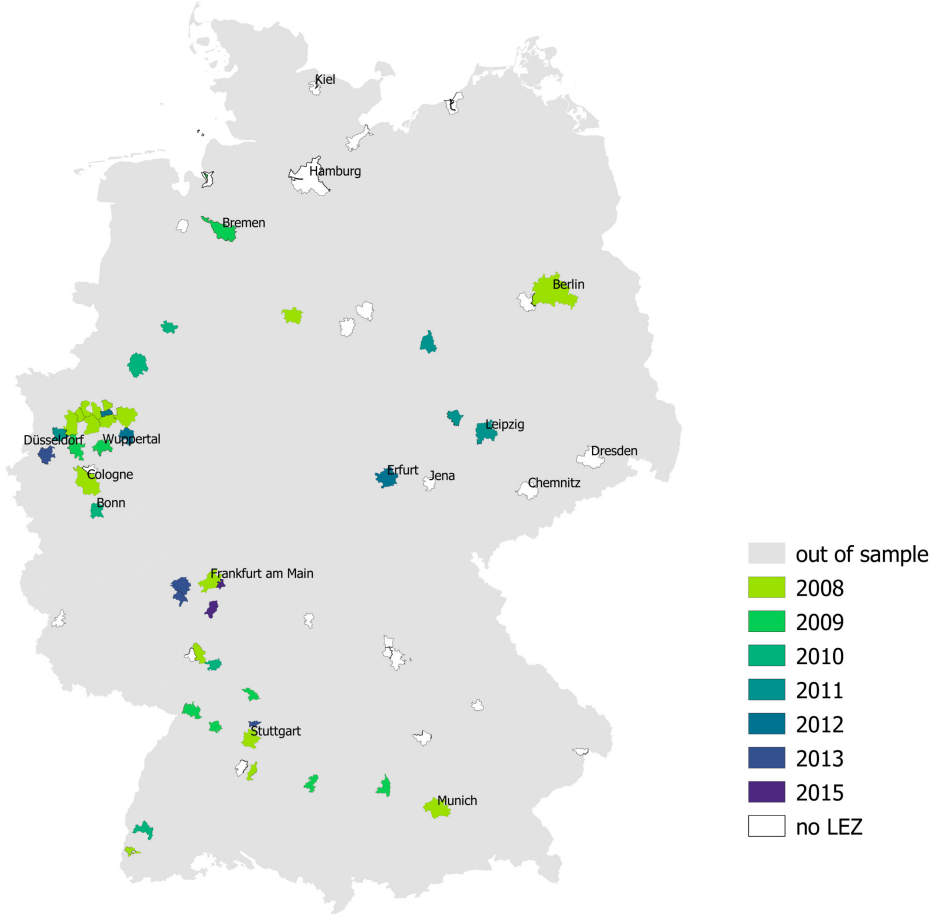
- Key issue: Treatment assignment is not random and thus may be correlated with unobserved determinants of an outcome under study.
    - Differences-in-differences (DID) method
    - Instrumental variables (IV)
    - Regression discontinuity design (RDD)
    - Synthetic control method (SCM)
    - …

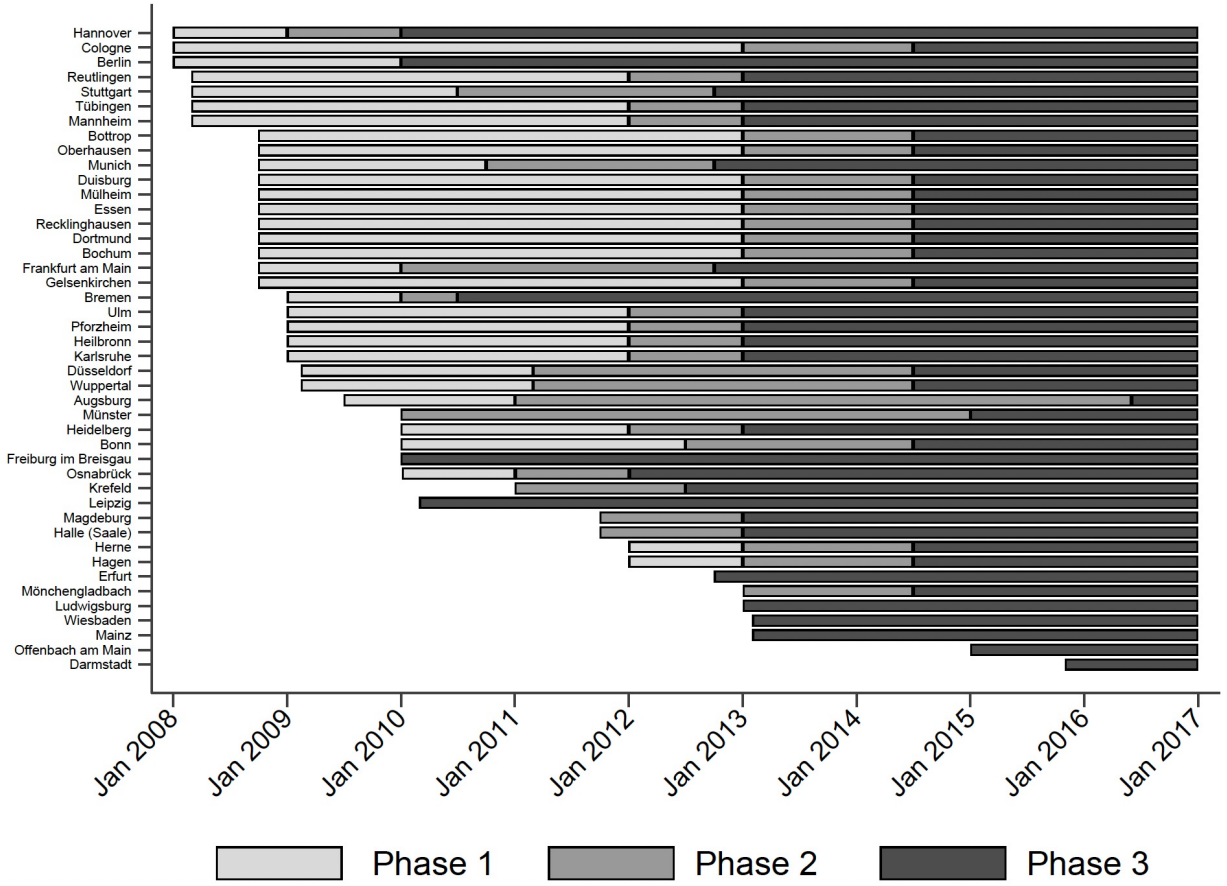
Quasi-experimental approaches: Examples

- Differences-in-differences (DID) method
  - If treatment and control units differ because of time-invariant unobserved characteristics, researchers assume common time trends in potential outcomes.
  - DID can be applied to settings in which some units experience a change in treatment status over time while other units do not. DID compares average change in outcomes between treated and control units over time, or average treatment effect (ATE)

Quasi-experimental approaches: Examples

- Low Emission Zones and Population Health (Margaryan 2021 *JHE*)





Quasi-experimental approaches: Examples

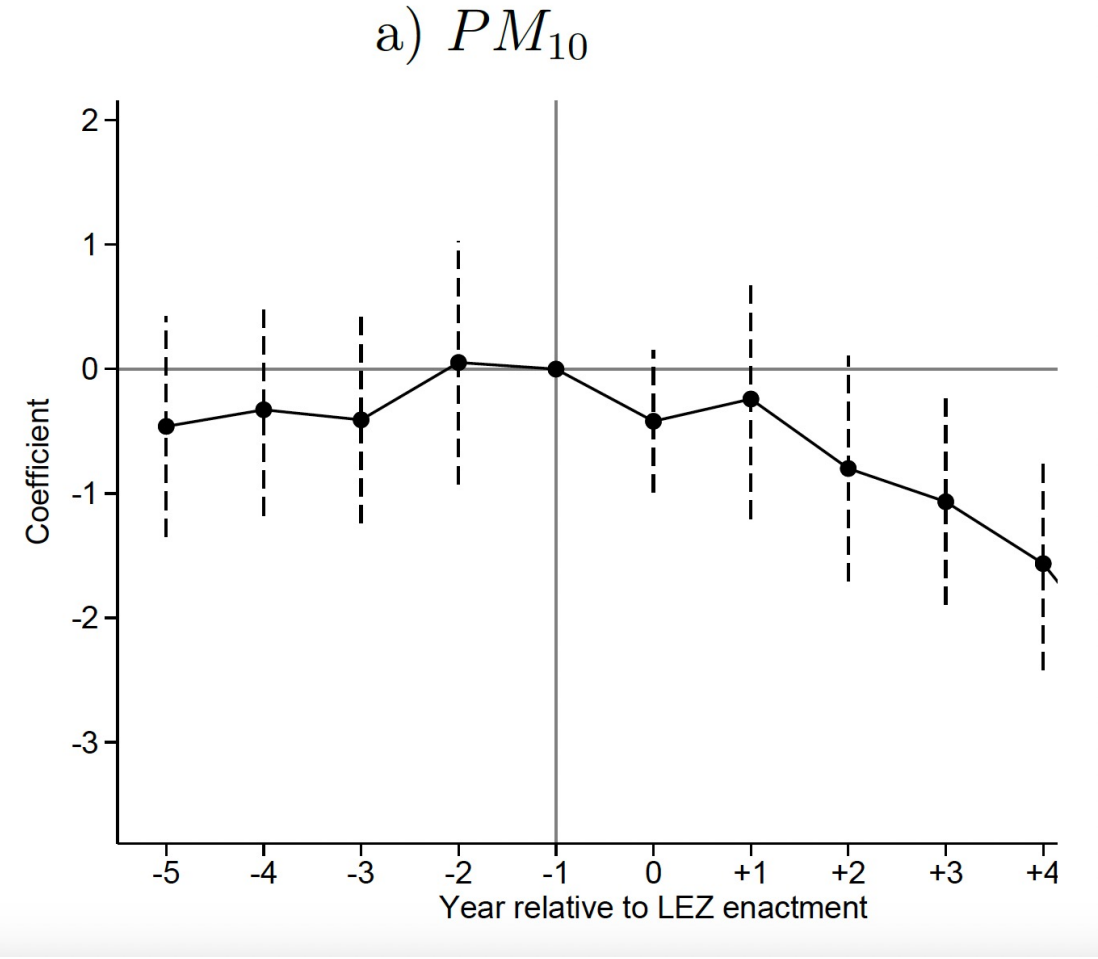
- Low Emission Zones and Population Health (Margaryan 2021 *JHE*)

$$y_{ict} = \alpha + \beta LEZ_{ict} + M_t + S_i + W_{ict} + \epsilon_{ict}$$

- y_{ict} is the monthly average concentration of PM_{10} at station i at time t in city c;
- LEZ_{ict} indicates whether a station i is located inside an LEZ at time t in city c;
- M_t and S_i are year-month and monitoring station fixed effects;
- the vector W_{ict} includes a set of weather controls.

Quasi-experimental approaches: Examples

- Low Emission Zones and Population Health (Margaryan 2021 *JHE*)



Quasi-experimental approaches: Examples

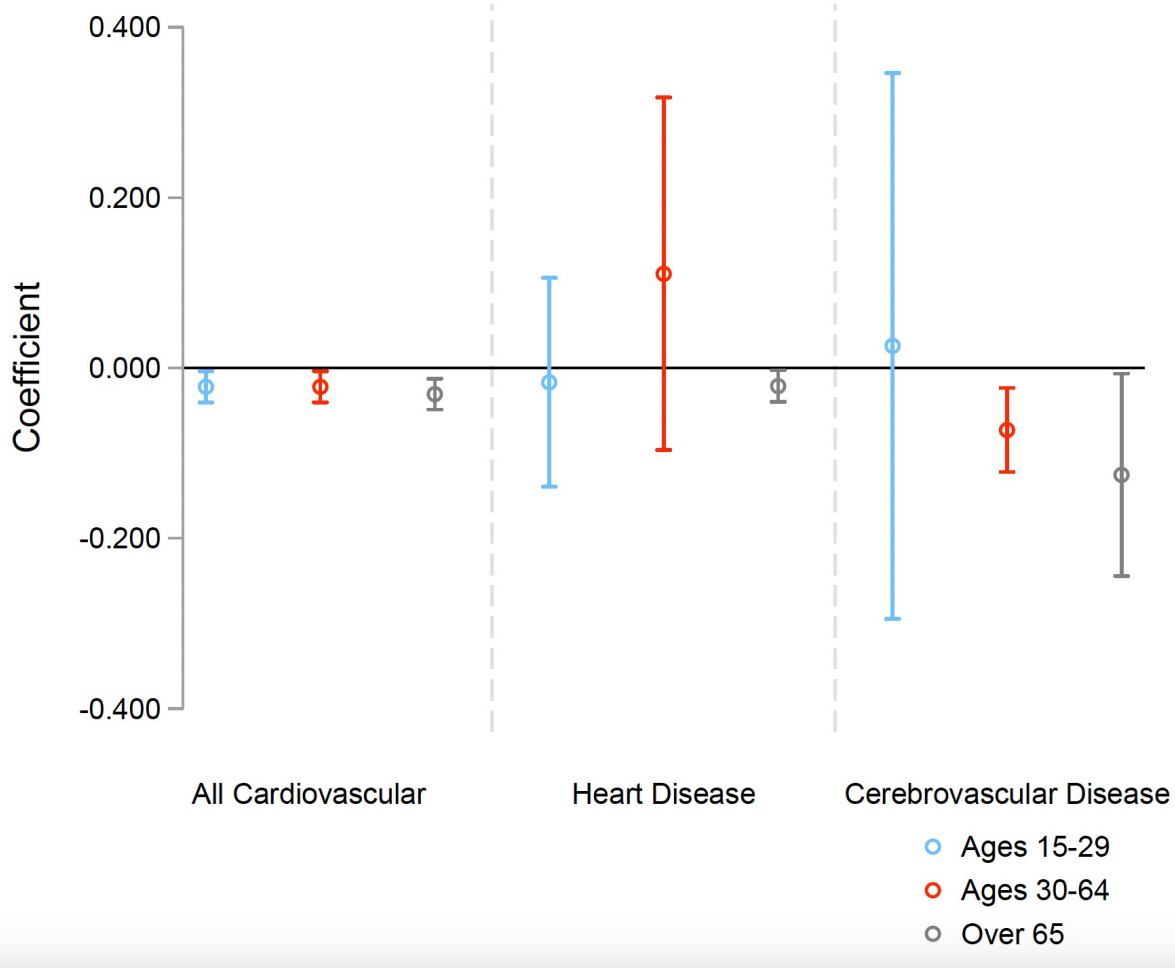
- Low Emission Zones and Population Health (Margaryan 2021 *JHE*)

$$log(y_{at}) = \alpha + \beta LEZ_{at} + transition_{at} + T_t + D_a + \epsilon_{at}$$

- y_{at} is the number of patients with the given diagnosis in log in area a in year t
- *transition* dummy is when an LEZ started in a year after January.
- LEZ_{at} indicates indicates whether the area a has LEZ in January of year t.
- T_t and D_a are year and area fixed effects.

Quasi-experimental approaches: Examples

- Low Emission Zones and Population Health (Margaryan 2021 *JHE*)



Quasi-experimental approaches: Examples

- Low Emission Zones and Population Health with DID

❖Threats and approaches

- Common trends assumption
  - Match cells on covariates (e.g. baseline pollution)
  - Use more recent advances in the DID literature to deal with staggered LEZ adoption
  - …
- Spill-overs contamination estimation of the treatment effect
  - Examine spill-overs on areas outside of LEZs, potentially outside of Germany, …
- …

Quasi-experimental approaches: Examples

- Instrumental variables (IV) method
  - IV attempts to isolate the exogenous component of treatment assignment to identify a causal effect. It makes use of a measurable relationship between the treatment of interest and an exogenous variable, or instrument.
  - Two requirements must be for the IV method to provide causal estimates.
    1. First, the instrument must be relevant in the sense that the relationship between the instrument and treatment variable, known as the first stage relationship, must be sufficiently strong and monotonic.
    2. Second, the instrument must be exogenous in the sense that it affects the outcome variable only through the endogenous treatment variable.
  - Under these conditions, the IV method estimates the local average treatment effect (LATE) for the subpopulation who experiences a change in treatment status as a result of the instrument.

Check out:
Sager, L. (2019). Estimating the effect of air pollution on road safety using atmospheric temperature inversions. *Journal of Environmental Economics and Management*, *98*, 102250.

Quasi-experimental approaches: Examples

- Regression discontinuity design (RD)
  - Treatment assignment may follow a discontinuous rule: units with values of a "forcing" variable above some threshold receive the treatment while those with values below the threshold do not.
  - A typical RD study compares the outcomes of units with values of the forcing variable that are "near" either sides of the threshold.
  - Key requirement: only the probability of receiving the treatment jumps discontinuously as the forcing variable crosses the threshold. All other factors that determine the outcome must be continuous around the threshold.
  - Under these conditions, the RD method estimates the local average treatment effect (LATE) for the subpopulation close to the threshold.

Check out:
Ito, K. (2015). Asymmetric Incentives in Subsidies: Evidence from a Large-Scale Electricity Rebate Program. *American Economic Journal: Economic Policy*, 7 (3): 209-37.

Quasi-experimental approaches: Examples

- Synthetic control method (SCM)
  → Basaglia et al. (2024), see slides on GitHub

Literature

- Carlsson, F., & Johansson-Stenman, O. (2012). Behavioral economics and environmental policy. *Annu. Rev. Resour. Econ.*, *4*(1), 75-99.
- List, J. A., & Price, M. K. (2016). The use of field experiments in environmental and resource economics. *Review of Environmental Economics and Policy*.
- Deschenes, O., & Meng, K. C. (2018). Quasi-experimental methods in environmental economics: Opportunities and challenges. *Handbook of environmental economics*, *4*, 285-332.
- …