# Evaluating efficiency-equality tradeoffs in health benefits analysis: Application to air toxics

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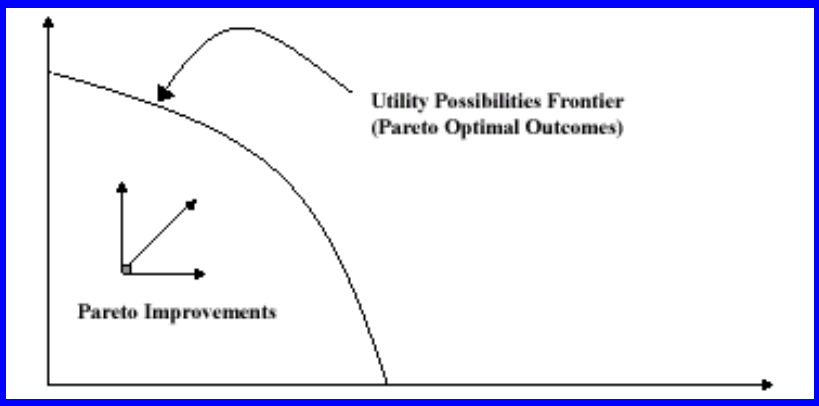
## Overview

- Brief introduction to our modeling framework for efficiency-equality tradeoff analysis
- Sample application (PM from power plants)
- Implications for HAPs

## Analytical challenge

- Risk analysts have developed simple, meaningful indicators that can capture the magnitude of the benefits of pollution control from a source or set of sources
  - Deaths, monetized benefits, QALYs, etc.
- Is there a simple, meaningful indicator that can capture the distribution of the benefits of pollution control from a source or set of sources?

**"Equality" = Distribution of Health Benefits**




**"Efficiency" =**
**Magnitude of Health Benefits**
**(or Net Benefits)**

## What does a meaningful inequality indicator look like?

- Numerous income inequality studies developed axiomatic approach to select indicators
- We modified the standard list of axioms and proposed additional axioms relevant to health benefits analysis (Levy et al., 2006)

## Highlights

- Many core axioms were similar for health and income, but not identical
  - Ex.: Scale invariance means something different for health and income
- Selected "additional" axioms:
  - Analyst must not impose a value judgment about the relative importance of transfers at different percentiles of the risk distribution
  - The welfare measure must be as close to a measure of health risk as possible
  - The inequality indicator should not be applied without consideration of baseline risk distributions
  - The inequality indicator should be derived for multiple competing policy alternatives

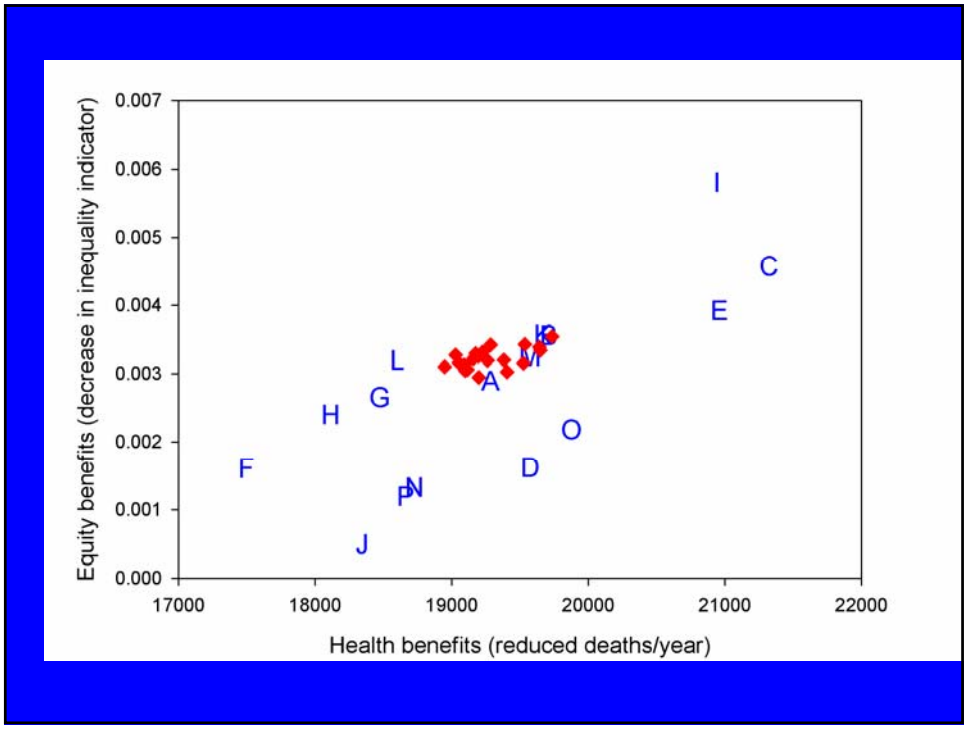
## Atkinson index

$$1-\left[\frac{1}{n}\sum_{i=1}^{n}\left[\frac{x_i}{\bar{x}}\right]^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}$$

- Member of generalized entropy family (derived specifically to be decomposable)
- Fulfills all major axioms
- Societal preferences about inequality incorporated through ε
  - Higher ε = more weight on transfers at low end

## Power plant case study (Levy et al., 2007)

- What do optimal reductions given a national cap on power plant emissions look like, considering efficiency and equality?
  - Developed logical (or illogical) approaches by which 75% reductions in NOx, $SO_2$, and $PM_{2.5}$ emissions could be achieved, to span efficiency/equality space
    - Meant to be illustrative rather than realistic


Equity benefits (decrease in inequality indicator)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
17000
18000
19000
20000
21000
22000
Health benefits (reduced deaths/year)
I
C
E
L
G
H
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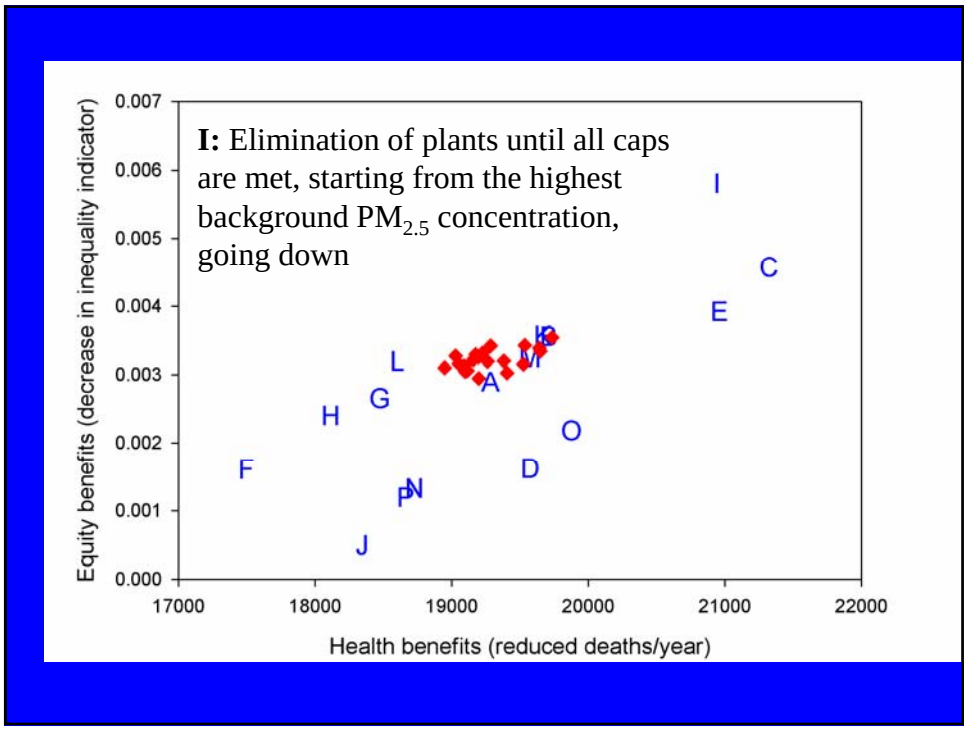
F
D
N
J


**I:** Elimination of plants until all caps are met, starting from the highest background $PM_{2.5}$ concentration, going down
Equity benefits (decrease in inequality indicator)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
17000
18000
19000
20000
21000
22000
Health benefits (reduced deaths/year)
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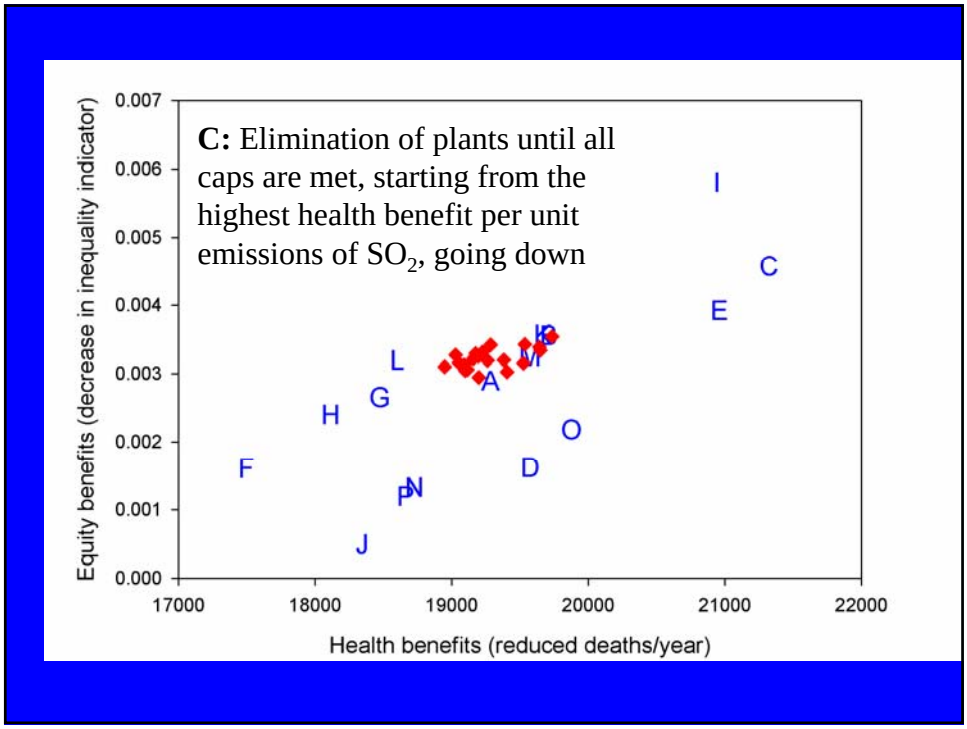
C: Elimination of plants until all caps are met, starting from the highest health benefit per unit emissions of $SO_2$, going down
Equity benefits (decrease in inequality indicator)
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0.000
17000
18000
19000
20000
21000
22000
Health benefits (reduced deaths/year)
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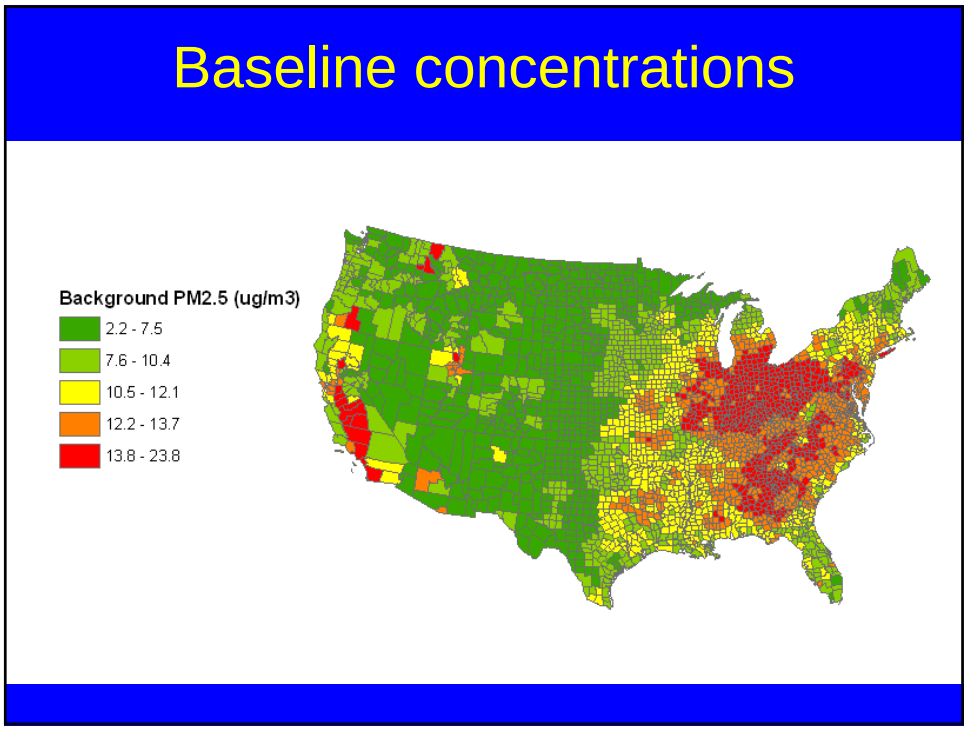
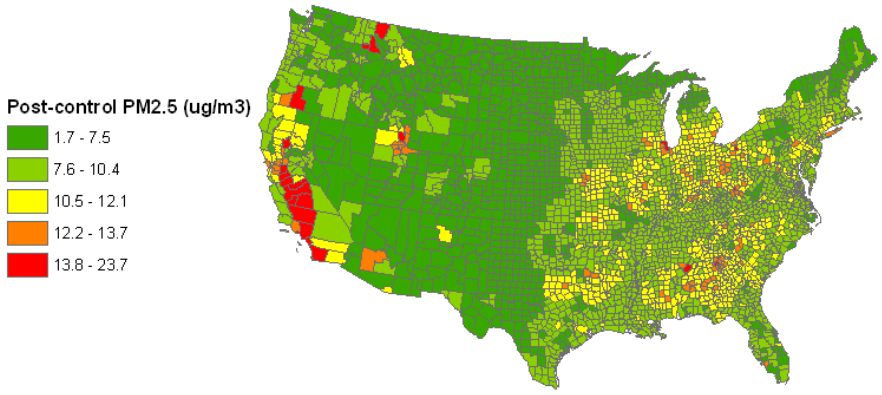

Baseline concentrations
Background PM2.5 (ug/m3)
2.2 - 7.5
7.6 - 10.4
10.5 - 12.1
12.2 - 13.7
13.8 - 23.8

## Post-control baseline concentrations

(High $SO_2$ health benefit per unit emissions)




## Application to air toxics

- Identical analytical framework could be applied to capture distribution of baseline risk from air toxics, distribution of risk post-control
  - Most useful with a variety of control strategies under consideration
  - Most applicable to cancer at present, but could be applied to non-cancer endpoints following “Science and Decisions” framework

## Important elements to include

- Distribution of risk, not just exposure
  - Incorporation of vulnerability for cancer, evaluating of background exposures/processes for non-cancer
  - Spatial variability in baseline mortality/morbidity rates can have significant impact (Levy et al., 2009)
- Inequality other than spatial inequality
  - Addressed through subgroup decomposability, potentially important for EJ considerations
- Incorporation of cost side (if desired)

## What would it take to make this useful?

- Well-defined and realistic control scenarios addressing multiple pollutants
- Reasonable sense that decision-makers and public perceive inequality in the manner implied by the indicator (Leibler et al., in press)
  - Also, need to communicate that equality of outcomes is not the same as equity of process
- Understanding of decision-maker willingness to trade off efficiency and equality, to choose among the subset of control strategies on the optimal frontier

## Conclusions

- Recent publications emphasize that health benefits analysis can move beyond efficiency to include inequality
- Application of these tools are feasible for air toxics
- If baseline exposures and vulnerability are appropriately characterized, there may be many situations where the most efficient strategy is also preferred from an equality perspective

## References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