

# Climate Change, Environmental Justice, and Public Policy

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Measurement and Evaluation of Stressors on Multiple Dimensions of Wellbeing

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**integral**  
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*Not for Third-Party Distribution*



# Quantifying EJ: Two Approaches

- Measuring the amount of inequality across in the distribution of outcomes across dimensions of wellbeing
- Aggregating individual wellbeing into an indicator of social wellbeing for policy-analysis

# Example: Urban Setting

People or Populations

| Achievment Matrix |    |     |     |     |
|-------------------|----|-----|-----|-----|
|                   | P  | H   | A   | M   |
| A                 | 36 | 310 | 180 | 37  |
| B                 | 1  | 280 | 100 | 90  |
| C                 | 3  | 270 | 75  | 15  |
| D                 | 30 | 270 | 225 | 33  |
| E                 | 50 | 350 | 330 | 30  |
| F                 | 20 | 340 | 330 | 150 |

Dimensions of Wellbeing

P: Acres of parks within 10 minutes

H: Annual days below 90 degrees F

A: Annual days with PM 2.5 below  $15 \mu\text{g}/\text{m}^3$

M: Annual income in thousands of US dollars

***How Should We Specify these Indicators?***

***How Should We Evaluate this Matrix?***

# Measuring Inequality

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# Axiomatic Approach to Measurement of Inequality and Welfare

- List desirable properties of a measure (axioms)
- What computational formula(s) satisfy these axioms?

# Logical/Operational Axioms

People or Populations

| Achievment Matrix |    |     |     |     |
|-------------------|----|-----|-----|-----|
|                   | P  | H   | A   | M   |
| A                 | 36 | 310 | 180 | 37  |
| B                 | 1  | 280 | 100 | 90  |
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| F                 | 20 | 340 | 330 | 150 |

Dimensions of Wellbeing

***Changing measurement scale doesn't alter assessment***

***Replicate the population, measure doesn't change***

***Small change in an achievement, measure doesn't jump***

***If A is better than B, then A+X is better than B+X***

# Analytical Axioms

People or Populations

| Achievment Matrix |    |     |     |     |
|-------------------|----|-----|-----|-----|
|                   | P  | H   | A   | M   |
| A                 | 36 | 310 | 180 | 37  |
| B                 | 1  | 280 | 100 | 90  |
| C                 | 3  | 270 | 75  | 15  |
| D                 | 30 | 270 | 225 | 33  |
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Dimensions of Wellbeing

***Measure can be disaggregated across people***  
*e.g. age, ethnicity, time periods, etc.*

***Measure can be disaggregated across dimensions***  
*e.g. social, infrastructure, health, under auspices of an agency*

# Ethical Axioms

People or  
Populations

| Achievment Matrix |    |     |     |     |
|-------------------|----|-----|-----|-----|
|                   | P  | H   | A   | M   |
| A                 | 36 | 310 | 180 | 37  |
| B                 | 1  | 280 | 100 | 90  |
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Dimensions of Wellbeing

## **Anonymity**

*Switch all positions between two persons,  
measure does not change*

## **Efficiency**

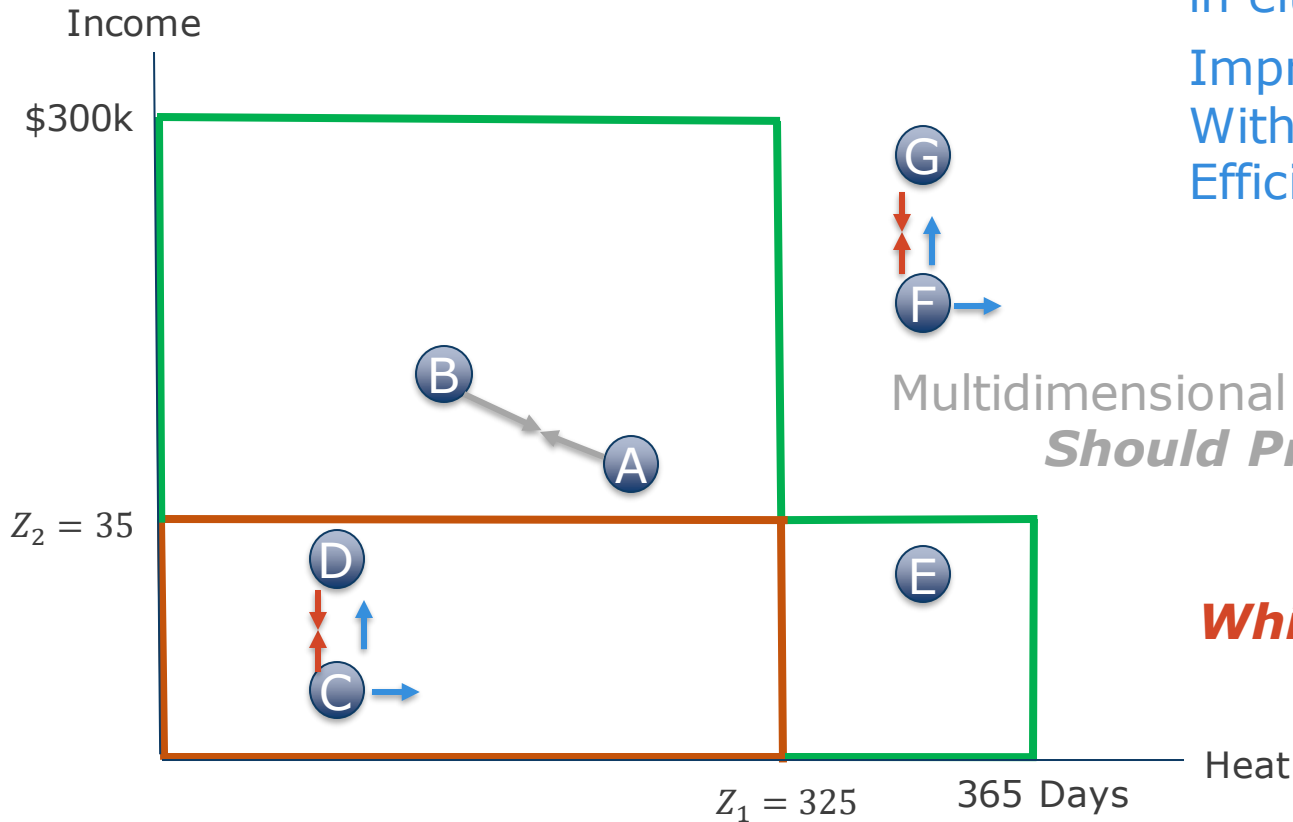
*Improve 1 person, all others no worse off, measure goes up*

## **Equity**

*Transfer from richer to poorer, measure goes up  
Correlation Increasing switch*



# How Should EJ Measure Respond?



Improve F and C  
in either dimension

Improving one or more  
With no one else harmed:  
Efficiency test

Multidimensional transfer from B to A  
***Should Preferences Matter?***

***Which transfer should  
count more?***

# Correlation Increasing Switch

Income      Low Heat Days



No Change in Either Distribution

Is A Better Off and B Worse Off Under Policy 2?

# Correlation Increasing Switch

- Depends on correlations across dimensions
  - Statistical analysis
- Depends on whether dimensions are complements or substitutes
  - Cumulative risk assessment
- May depend on preferences
  - People have the same preferences in poverty and inequality measures

# Environmental Welfare

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# Welfare-Based Approach

| Achievment Matrix |    |     |     |     |                     |
|-------------------|----|-----|-----|-----|---------------------|
|                   | P  | H   | A   | M   |                     |
| A                 | 36 | 310 | 180 | 37  | $U^A(\mathbf{x}_A)$ |
| B                 | 1  | 280 | 100 | 90  | $U^B(\mathbf{x}_B)$ |
| C                 | 3  | 270 | 75  | 15  | $U^C(\mathbf{x}_C)$ |
| D                 | 30 | 270 | 225 | 33  | $U^D(\mathbf{x}_D)$ |
| E                 | 50 | 350 | 330 | 30  | $U^E(\mathbf{x}_E)$ |
| F                 | 20 | 340 | 330 | 150 | $U^F(\mathbf{x}_F)$ |

- Look at each **row** of matrix
- Assign a well-being number  $U^i(\mathbf{x}_i)$ 
  - Aggregates across dimensions for each person
- Social Welfare Function  $W(U^1, U^2, \dots, U^N)$ 
  - Aggregates across people, accounting for inequality

# Welfare Approach

- Increase 1 person, everyone else unchanged, then welfare goes up (efficiency)
- Multi-dimensional transfers / correlation increasing switches included (equity)
- Can respect individual preferences about how persons view their own well-being (use wellbeing function  $U^i$ )
- Can deal with differences in preferences across populations

# Take Home Message

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# The Axiomatic Approach

- There exist **inequality** measures that meet all but efficiency
- Welfare measures can meet all axioms
  - Trade offs between equality and efficiency
- If invoke all the logical/operational axioms, plus anonymity, plus transfer, then inequality measure is
  - $I(x) = \frac{1}{\alpha(1-\alpha)N} [\sum_i^N [\frac{x_i}{m(x)}]^\alpha - 1]$  where  $\alpha$  governs sensitivity to inequality
  - $W(x) = m(x)[1 - I(X)]$