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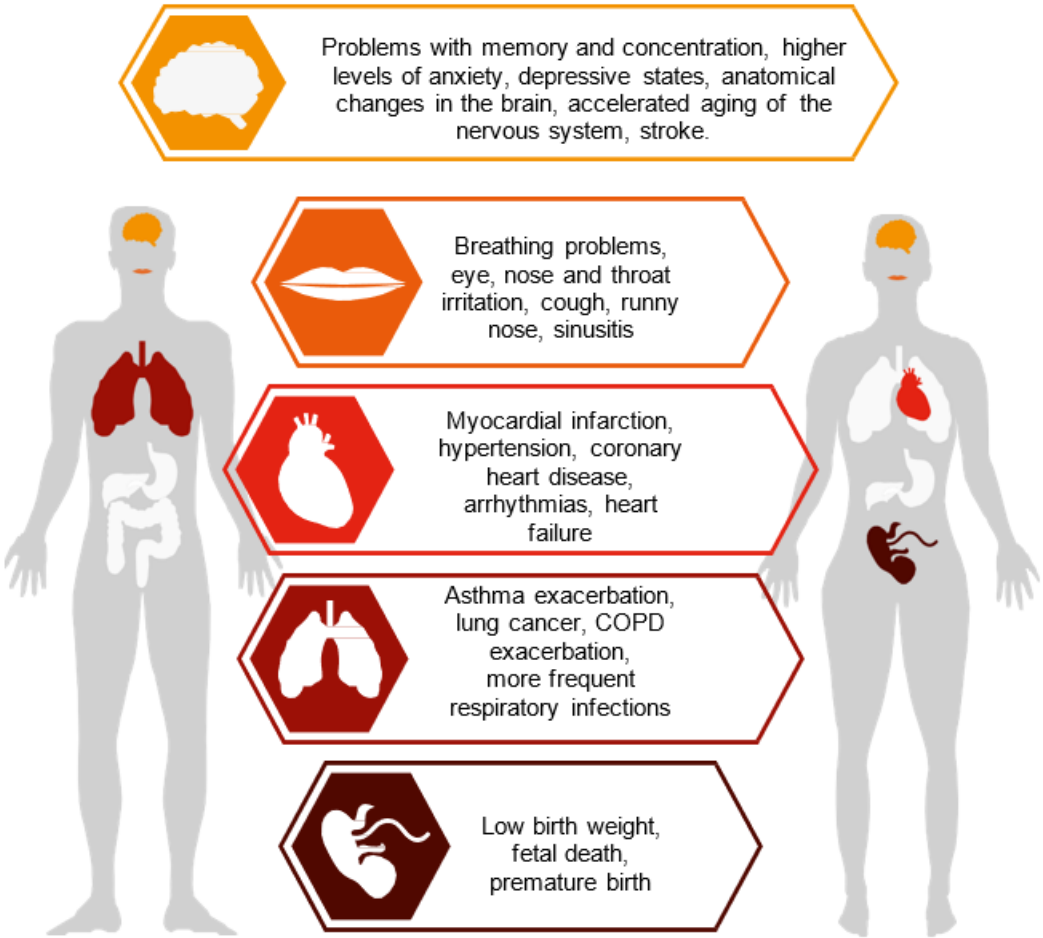
Distributive justice concerns when combating air pollution: the joint modelling of attitudes and preferences

Anna Bartczak, Wiktor Budziński, Ulf Liebe & Jurgen Meyerhoff

INTRODUCTION

- Ambient air pollution, especially particulate matter (PM), constitutes a significant environmental risk to human health.
- Studies conducted in many places worldwide suggest a significant increase in the risk of mortality and morbidity due to air pollution
- There is mounting evidence of non-fatal health effects resulting from exposure to PM air pollution, even at its very low concentrations.
- 97% of Europe's urban population is exposed to a concentration of PM above the health-based guideline level set by the WHO.



Source: Krakowski Alarm Smogowy

INTRODUCTION

- The United Nations (2030 Agenda for Sustainable Development) identifies air pollution as a global health priority;
- The EU's 2030 target is to reduce PM-related premature deaths by 55% compared to 2005 levels.

- Designing effective policies for public programs such as the improvement of air quality, requires exploring public preferences.
  - CBA to determine the impact of various policy actions on social welfare;
  - Non-market valuation methods to estimate the benefits in monetary terms;
  - Efficiency in terms of the use of scarce resources.

- The implementation of policy programs, however, depends not only on efficiency in using scarce resources but also on whether their funding is socially acceptable.
  - Societal concerns beyond efficiency may include aspects of distributive justice, i.e., the distribution of costs and benefits across socioeconomic groups.

OBJECTIVES

- We explore a novel approach by COMBINING TWO TYPES OF MULTIFACTORIAL SURVEY EXPERIMENTS to uncover the link between JUSTICE ATTITUDES and INDIVIDUALS' PREFERENCES.
- THE MAIN OBJECTIVE IS **TO EXAMINE HOW PEOPLE'S ATTITUDES TOWARDS DISTRIBUTIVE JUSTICE AFFECT THEIR PREFERENCES FOR PROGRAMS AIMED AT REDUCING AMBIENT AIR POLLUTION IN POLAND**
  - To elicit attitudes, we used a FACTORIAL SURVEY EXPERIMENT (FSE).
  - To elicit PREFERENCES and (willingness to pay) WTP, we applied a discrete CHOICE EXPERIMENT (CE).
  - FSE and CE were conducted separately on the same group of respondents.

FSE and CE

FSE

- is a type of multifactorial survey experiment that has become an important method in sociology for the study of justice attitudes and social norms, among others;
- In the FSE, respondents are presented with one or more descriptions of situations (vignettes) that differ from each other in a discrete number of factors; they are then asked to evaluate those situations according to criteria such as support, agreement, or perceived fairness;
- Based on the experimental variation in the situational attributes presented, an FSE can uncover the causal effects of single situational dimensions on the outcome being investigated.

CE

- is a non-market valuation method based on stated preferences;
- In a CE, respondents repeatedly choose a preferred option between at least two mutually exclusive alternatives varying in attribute levels;
- The observed choices subsequently enable making inferences about which attributes significantly influenced decisions and then deriving a marginal rate of substitution between those attributes.
- If one of the attributes is a price or a cost, then the marginal rate of substitution between a nonmonetary and a monetary attribute provides a marginal WTP for a nonmonetary attribute.

ADVANTAGES OF THE PROPOSED APPROACH

- Using a FSE instead of a single survey item or an unvalidated item battery to elicit attitudes.
  - FSE can separate the effects of different justice dimensions, such as participatory and distributive justice
  - As the situations described (the vignettes) vary in multiple aspects and respondents must make trade-offs in the FSE, socially desirable response behaviour is less likely

- The FSE and the CE were conducted among the same individuals but at separate points in time.
  - Previous research suggests that the order of the questions can affect the results if attitudes and preferences are measured in the same survey. Our two-wave approach thus avoids this issue and allows for stronger causal inferences

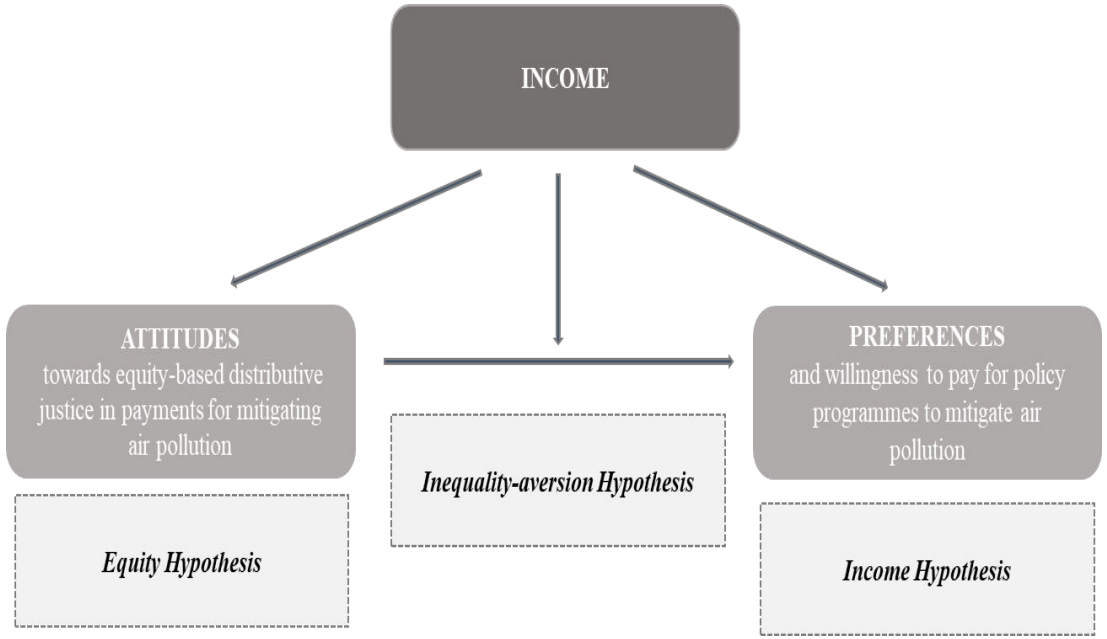
- Measurement of justice attitudes and stated preferences in the same general context, i.e., air pollution reduction, but not in relation to exactly the same environmental program.
  - Measuring attitudes and preferences at the same level of specificity – by referring to exactly the same environmental program, for example, and/or including it in the same experimental design such as CE – increases the strength of empirical correlations from a theoretical point of view; so more robust results are achieved by showing that environmental attitudes in one context explain preferences in another context

CONCEPTUAL FRAMEWORK

- Justice attitudes are expected to affect the behavioural intention i.e. WTP for environmental goods (see eg. Theory of Planned Behaviour by Ajzen, 1991).
- We focus on equity-based justice in bearing the costs of producing public environmental goods (see Schlosberg, 2007).
  - All socio-economic groups contribute equally financially to prevention programs according to their means.
- This aligns with an 'ability to pay' distributive justice principle (see Granqvist & Grover, 2016), implying that wealthier individuals should bear a greater proportion of the costs of preventing air pollution.
- Arguments:
  - From the society point of view: minimising the aggregate sacrifice in terms of decrease of utility (diminishing marginal utility of income).
  - At the margin, everyone should make an equal utility sacrifice => EQUITY

HYPOTHESES

- **Equity Hypothesis**: *On average, individuals, regardless of their income level, support an equity-based allocation of the costs of air pollution prevention compared with other cost allocations.*
- **Income Hypothesis**: *On average, higher-income individuals are willing to pay more for air pollution prevention than lower-income individuals.*
- **Inequality Aversion Hypothesis**: *The effect of equity-based distributive justice attitudes on average WTP for air pollution reduction increases with higher income.*



STUDY CONTEXT

(WHO 2019, EEA 2020, Eurostat 2023)

- About 46,000 premature deaths in Poland each year are linked to the extensive PM concentration (about 10% of all premature deaths);
- 25/50 most polluted cities in the EU are located in Poland;
- Low air quality in urban areas mainly related to low-stack emissions;
  - Not transport!
  - Burning fossil fuels for residential heating;
  - 80% of European households using coal are Polish;
  - The problem is exacerbated in autumn and winter.

SAMPLE & DATA COLLECTION

- Adult residents of 4 big (>500,000 inhabitants) cities in Poland:
  - 5-year average annual PM concentration < average (Gdańsk and Wrocław);
  - … > average (Katowice and Łódź).

- Professional polling agency, Dec 2021 - Jan 2022, CAWI;

- N=1139, representative (gender, age, education);

- Overrepresentation of those who suffer from chronic respiratory diseases:
  - Approx. 33% of respondents (usually 2-10%).

STUDY DESIGN

- FSE and CE were 2 separate surveys completed by the same respondents with a week-long break between them.
- The context of both surveys: the air pollution reduction programs.
  - FSE: old furnace replacement in private and communal houses => ATTITUDES
  - CE: WTP for mortality and morbidity reduction due to the air pollution changes => PREFERENCES
  - We focus on different aspects of the environmental programs concerning air pollution reduction to avoid a “spillover effect” in the FSE and CE.
- The analysis: a hybrid choice model (HCM).

FSE DESGIN

- An orthogonal design => 72 vignettes;
- Each respondent faced 6 vignettes;
- Perceived fairness => a 11-point Likert scale.

Attribute		Attribute levels
SHARE OF INVESTMENT COST – PRIVATE HOUSES	{average and high income group; low income group}	{100%; 100%}, {100%; 50%}, {100%; 0%}, {50%; 50%}, {50%; 0%}, {0%; 0%}
SHARE OF INVESTMENT COST – COMMUNAL HOUSES		100%, 50%, 0%
PERIOD		1 year, 3 years, 5 years
FINES	{average and high income group; low income group}	{1000 zł; 1000 zł}, {1000 zł; 500 zł}, {1000 zł; 0 zł}, {500 zł; 500 zł}, {500 zł; 0 zł}, {0 zł; 0 zł}
INFORMATION		no additional information, mobile phones, all tv information programs

FSE DESGIN

PRIVATE HOUSES

- *The cost of replacing the stoves will be in 50% financed by the **MUNICIPALITY from local taxes** and **in 50% by the HOUSE OWNERS** if their household income is on the **AVERAGE LEVEL** in Poland or **ABOVE.***
- *The cost of replacing the stoves will be in 100% financed by the **MUNICIPALITY from local taxes** if house owners household income is **LOWER** than the average in Poland.*

SOCIAL HOUSING

- *The cost of replacing the stoves will be in 50% financed by the **MUNICIPALITY from local taxes** and in 50% **by the HOUSE RESIDENTS.***

PERIOD

- *The stoves will be replaced **within** 5 years.*

FINES

- *If their household income is on the **AVERAGE LEVEL** in Poland or **ABOVE,** those who until the furnace replacement will use unappropriated fuel **will be fined** 1000 zł for each such event.*
- *People with **LOWER** household income than the average in Poland income will get a 500 zł **fine**.*

INFORMATION

- *Information about **SMOG** episodes in Poland will be **sent on** MOBILE PHONES.*

How FAIR or UNFAIR do you think this project would be in its current form?

Very unfair	□	□	□	□	□	□	□	□	□	□	□	*Very fair*
	0	1	2	3	4	5	6	7	8	9	10	

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CONSTRUCTION OF THE *EQUITY* VARIABLE („WEALTHIER SHOULD PAY MORE")

Variable: **EQUITY** (difference in contribution between HI and LI)	Contribution level for the investments in private houses depending on household income
0	100% (HI) – 100% (LI); 50% (HI) – 50% (LI); 0% (HI) – 0% (LI)
0.5	100% (HI) – 50% (LI); 50% (HI) – 0% (LI)
1	100% (HI) – 0% (LI)

Note: In our FSE design, the low-income group was always offered the same or a higher subsidy for the old furnace replacement compared with the average and high-income groups.

Attribute		Attribute levels
SHARE OF INVESTMENT COST – PRIVATE HOUSES	{average and high income group; low income group}	{100%; 100%}, {100%; 50%}, {100%; 0%}, {50%; 50%}, {50%; 0%}, {0%; 0%}
SHARE OF INVESTMENT COST – COMMUNAL HOUSES		100%, 50%, 0%
PERIOD		1 year, 3 years, 5 years
FINES	{average and high income group; low income group}	{1000 zł; 1000 zł}, {1000 zł; 500 zł}, {1000 zł; 0 zł}, {500 zł; 500 zł}, {500 zł; 0 zł}, {0 zł; 0 zł}
INFORMATION		no additional information, mobile phones, all tv information programs

DCE: DESIGN

- The D-efficiency design => 36 choice sets with 2 alternatives and a SQ option;
- 8 randomly drawn choice sets from the full design;
- The health risk framed as a public risk scenario (e.g., Carson and Mitchel 2006; Adamowicz et al. 2011);
- The design based on: Jin, Andersson and Zhang (2020);

Attribute	Description	Attribute levels
MORTALITY	Premature deaths prevented per year per 100,000 people	0 (SQ), 10, 20, 30, 40, 50
MORBIDITY	Non-fatal cases prevented per year per 100,000 people	0 (SQ), 100, 200, 300, 400, 500
PERIOD	Number of years before policy has an effect	0 (SQ), 1, 3, 5
COST	Annual cost of program per household in zł	0 (SQ), 25, 50, 100, 300, 500, 800

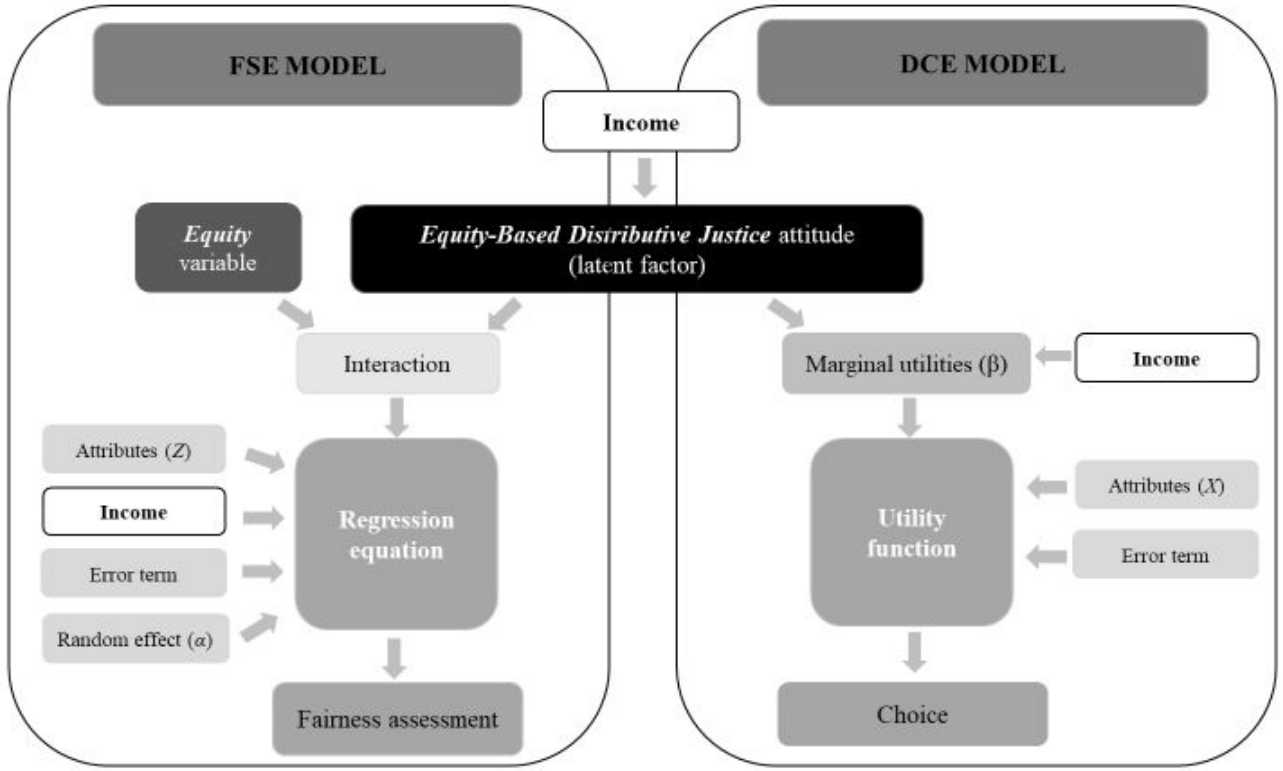
CE: CHOICE SET EXAMPLE

We will now present several choice sets describing different variants of the air quality program that could be undertaken in [CITY]. In each choice set, please select the best program option in your opinion.

	Option A	Option B	No program (status quo)
Prevented **PREMATURE DEATHS** per year in your city per 100,000 people	**5 deaths** less per 100,000 people	**10 deaths** less per 100,000 people	Same number of **deaths** as today
Prevented **NON-FATAL CASES** per year in your city per 100,000 people	**100 cases** less per 100,000 people	**50 cases** less per 100,000 people	The same number of **cases** as today
NUMBER OF YEARS before policy has an effect	**5** years	**3** years	-
ANNUAL COST per **household**	**50** zł	**300** zł	**0** zł
MY CHOICE	o	o	0

HYBRID CHOICE MODEL

- The FSE and CE parts of the model are linked by the common latent factor denoted as: *the Equity-Based Distributive Justice* attitude
- In the CE model, it enters through **the marginal utilities for each attribute**,
- In the FSE model, it enters as **an interaction with the *Equity* variable**.
- To evaluate hypotheses, we incorporated individuals' income into both parts of the model, as well as into the structural equation of the *Equity-Based Distributive Justice* attitude.



HYBRID CHOICE MODEL

- **CE component** (McFadden and Train 2000) – MXL

$$U_{ijt} = \mathbf{X}_{ijt}\boldsymbol{\beta}_i + \varepsilon_{ijt}$$

  - Integrated preference heterogeneity

$$\begin{cases} \beta_i^N = \mu_N + (\alpha_N + \pi_N Inc_i)LV_i + \gamma_N Inc_i + \sigma_N \xi_i^N \\ \beta_i^{LN} = exp\left(\mu_{LN} + (\alpha_{LN} + \pi_{LN} Inc_i)LV_i + \gamma_{LN} Inc_i + \sigma_{LN} \xi_i^{LN}\right) \end{cases}$$

- **FSE component**

$$F_{ik} = \alpha_{ik} + LV_i Equity_{ik} + \boldsymbol{\theta Z}_{ik} + \delta\eta_{ik}.$$

- LV is interacted with the $Equity_{ik}$ attribute and can be interpreted as individual-specific marginal effect for it.
- If the level of LV_i is high for the given individual, then the $Equity_{ik}$ of a given policy option strongly affects their fairness assessment.
- We assume that for a given level of income the latent variable follows a normal distribution in the population:

  $LV_i \sim N\left(\mu_{LV} + \alpha_{LV} Inc_i, \sigma_{LV}\right)$, with parameters μ_{LV}, α_{LV}, and σ_{LV} to be estimated.

RESULTS – FSE component

Equity Hypothesis: *On average, individuals, regardless of their income level, support an equity-based allocation of the costs of air pollution prevention compared with other cost allocations*

- The average *Equity-Based Distributive Justice* attitude level for an individual with the lowest income = 0.4 => significantly higher than zero (p-value of the Wald test: 0.0001).

Dependent variable: *Equity-Based Distributive Justice* attitude	Means		
var.	coef.		st.err.
Income/4k	0.039	***	0.019

Equity Hypothesis: VERIFIED POSITIVELY

Dependent variable: Fairness assessment	Means			Standard deviations		
var.	coef.		st.err.	coef.		st.err.
Constant (random effect)	4.508	***	0.143	1.689	***	0.046
Period	0.002		0.020	-		-
Contribution: Private housing_HI (50%)	0.289	***	0.089	-		-
Contribution: Private housing_HI (100%)	-0.657	***	0.083	-		-
Contribution: Communal housing	-0.903	***	0.077	-		-
Fines (HI = 500zł, LI = 0zł)	0.221	*	0.118	-		-
Fines (HI = 500zł, LI = 500zł)	0.806	***	0.104	-		-
Fines (HI = 1000zł, LI = 0zł)	0.098		0.107	-		-
Fines (HI = 1000zł, LI = 500zł)	0.681	***	0.103	-		-
Fines (HI = 1000zł, LI = 1000zł)	0.968	***	0.101	-		-
Smog information (TV)	0.352	***	0.076	-		-
Smog information (mobile phone)	0.317	***	0.074	-		-
Income in zł/4k	0.176	***	0.028			
	Equity-Based Distributive Justice attitude					
Equity	0.475	***	0.101	0.985	***	0.134

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RESULTS – CE component

- Majority of respondents wanted the air quality improvements to be implemented.
- Respondents derived higher utility from higher mortality and morbidity risk reduction due to air pollution.
- They preferred to have a program implemented earlier rather than later.

		μ		σ	
var.	dist.	coef.	st. err.	coef.	st. err.
SQ_ASC	n	-7.415 ***	0.470	5.271 ***	0.370
Mortality/10	ln	-1.653 ***	0.154	1.534 ***	0.103
Morbidity/100	ln	-1.646 ***	0.183	1.019 ***	0.119
Period	n	-0.147 ***	0.028	0.241 ***	0.025
-Cost/100	ln	-0.102	0.103	1.890 ***	0.058

	Median WTP	Conf. Interval	
Mortality (1 person per 100,000)	2.72	2.19	3.34
Morbidity (1 person per 100,000)	0.31	0.24	0.39
Period	9.26	6.57	12.23

RESULTS: linking the attitudinal (FSE) and the preference (CE) component

Income Hypothesis: *On average, higher-income individuals are willing to pay more for air pollution prevention than lower-income individuals.*

Income Hypothesis: VERIFIED NEGATIVELY

Note: on average, wealthier individuals generally favour paying for programs to reduce air pollution.

LV Equity-Based Distributive Justice

	Direct effect			Interaction with *Income*		
var.	coef.		st. err.	coef.		st.err.
SQ_ASC	-0.852	*	0.445	0.890	**	0.421
Mortality/10	-0.006		0.151	0.222	**	0.099
Morbidity/100	0.246	*	0.143	0.324	***	0.104
Period	-0.025		0.032	0.049	**	0.025
-Cost/100	-0.518	***	0.117	-0.056		0.058

Income

	Direct effect		
var.	coef.		st. err.
SQ_ASC	-0.904	***	0.293
Mortality/10	-0.057		0.084
Morbidity/100	-0.129		0.113
Period	-0.027	*	0.015
-Cost/100	-0.034		0.044

RESULTS: linking the attitudinal (FSE) and the preference (CE) component

Inequality Aversion Hypothesis: *The effect of Equity-based distributive justice attitudes on average WTP for air pollution prevention increases with higher income.*

Inequality Aversion Hypothesis: VERIFIED POSITIVELY

- The WTP increases with the *Equity-Based Distributive Justice* attitude; however, this relationship appears stronger for *Mortality* than for *Morbidity*.
- The increase in WTP is much greater for high-income individuals than for low-income individuals.
- This effect is mainly driven by differences in preferences for the attributes of *Mortality* and *Morbidity* instead of differences in the cost-sensitivities across individuals with lower and higher incomes

LV Equity-Based Distributive Justice

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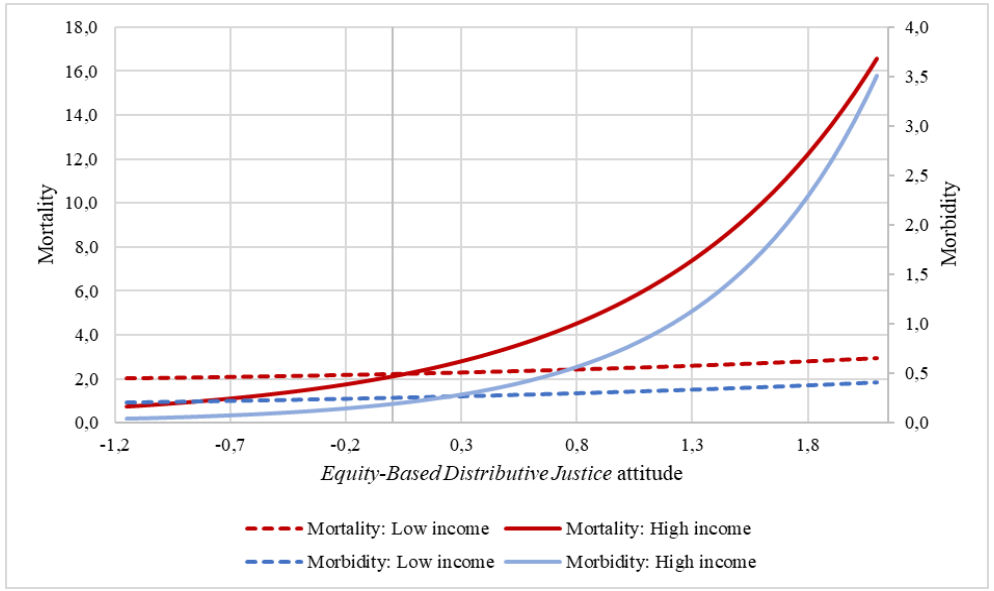

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CONCLUSIONS & SUMMARY

- By using a FSE for attitude measurement and stated preference analysis (a CE) for economic analysis, we were able to comprehensively examine distributive justice considerations that affect the acceptance of environmental policies.
- Our findings indicate that people strongly support an equity-based cost distribution.
- Those with a stronger equity-based distributive justice attitude were more willing to pay for air quality improvement programs.
- We propose a novel approach that can be applied to investigate the effects of other attitudes, beliefs, or normative judgments on people's preferences, not just in the environmental context.

ACKNOWLEDGMENT:

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Anna Bartczak
bartczak@wne.uw.edu.pl