DEPARTMENT OF FOOD AND RESOURCE ECONOMICS
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IFRO Working Paper

Preferences for distributional impacts of climate policy

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2017 / 10

IFRO Working Paper 2017 / 10

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JEL-classification: D30, H41, Q51, Q54

Published: November 2017

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October 12, 2017

ABSTRACT

What role do people think distributional aspects should play in design of climate policy? The literature assessing climate policies has shown that assumptions regarding peoples' distributional preferences for climate change policy impacts are central for policy assessment, but empirical evidence for such preferences is lacking.

We design a discrete choice experiment that varies how climate policies affect the income of people living in the future in three geographical regions. The experiment is implemented on a representative sample of the Danish population and preferences are modelled in a latent class model. Our results show that i) a small majority of Danes expresses preferences for climate policies consistent with inequity aversion, ii) a group expresses preferences resembling simple warm glow, while iii) a small group prefers not to support additional climate policies. Finally a somewhat larger group expresses some form of distributional preferences, but shows positive preferences for costs, suggesting that responses could be influenced by strategic behaviour and over-signalling of commitment. Our results provide support for the inclusion of social preferences regarding distributional effects of climate change policies in policy assessments, and hence for the significant impact on policy this inclusion have.

Keywords: choice experiment, social preferences, inequity aversion, warm glow, altruism, climate change impacts, latent class, social cost of carbon

JEL codes: D30, H41, Q51, Q54

INTRODUCTION

Climate change remains a daunting challenge facing the global community. Since the emergence of the first IPCC reports, a fast growing body of research has focused on modelling and predicting the future consequences of climate change for human societies. A key finding is that the future impacts of climate change are likely to be felt unevenly around the globe. Societies and people in developing countries may be more susceptible to negative impacts of climate change, due to both geographical and climatic contexts as well as adaptive capacity (IPCC 2014). Governments around the world are ratifying the Paris Agreement (UNFCC 2016[1]) and are reporting national goals for their respective emission levels. In that process, the question of whether and how to account for global impacts of policies, herein the impact CO_2 emissions can have on others, becomes pertinent for designing national climate policies (Anthoff and Tol 2010). The answer will affect the costs a nation would be willing to carry to reduce CO_2 emissions.

The utility effect of a specific absolute loss of income will in general not be the same to a poor person as to a rich. Integrated assessment models used to assess the marginal social costs of carbon emissions (SCC) often handle this aspect using equity weights of some form. This implies weighing together the monetized welfare (income) losses from climate change across regions of disparate incomes, under the assumption of a supranational social planner (Fankhauser et al. 1997, Pearce 2003, Johansson-Stenman 2005, Anthoff et al. 2009). But in the absence of this supranational planner, how should national policy makers account for climate change impacts in other countries? One could argue that this should depend on local, national preferences over global impacts.

Importantly, as pointed out by Anthoff and Tol (2010), it is unusual in national policy assessments in general to take into account the impacts a national policy may have on citizens of other countries. Anthoff and Tol (2010) develop a handful of alternative models for how a national government may account - or not - for welfare losses in other countries resulting from national policies. They show that varying assumptions about the concern for others have significant impact on what costs a national government would be willing to carry.

[1] http://unfccc.int/paris_agreement/items/9444.php

Our paper addresses the question whether people's preferences over climate policy alternatives vary according to how the policy affects the income of people of disparate wealth living in the future. There is a substantial body of evidence in the behavioral economics literature that people exhibit varying degrees of other-regarding/social preferences when placed in different experimental contexts (Andreoni 1990, Fehr and Schmidt 1999, Bardsley and Sugden 2006, Fehr and Schmidt 2006, Andreoni and Harbaugh 2007, Fischbacher and Gachter 2010), but none that have investigated if such preferences are relevant in the intergenerational context of climate policy design.

The core contribution of this paper is an experiment designed to enable explicit evaluation of hypotheses about the presence of intergenerational social preferences for distributive impacts in the context of climate policy. Building on Anthoff and Tol (2010), we formulate and evaluate two different hypothesis regarding preferences over climate policy impacts. Specially, we investigate for the presence of preferences consistent with the idea that climate policy design should take into account inequity aversion, and we call this type 'Inequity Averse Altruists'. We also investigate for preferences corresponding to individuals preferring climate policies that reduce *aggregate* impacts on future generations' income, but with no attention to who experience these impacts. We call this type simply 'Altruists'. We note that preferences of many other forms may exist and indeed co-exist in any population.

We implemented the experiment on a representative sample of the Danish population (N = 813) and modelled preferences in a latent class model. We find that a small majority (60 %) of Danes expresses preferences for climate policies consistent with the type Inequity Averse Altruists. We find that a small group (17 %) expresses preferences resembling simple Warm Glow (Andreoni 1990), while another small group (6 %) prefers not to support additional climate policy initiatives. Finally a somewhat larger group (17 %) expresses preferences that reflect some concerns over the future impact of policies. However a positive parameter for the costs of a policy suggests that at least some responses from this group could be influenced by the hypothetical setting and could be seen as acting strategic, e.g. over-signalling of commitment to act on climate policies.

The remainder of this article is structured as follows. The next section reviews the related literature and Section 3 introduces a formal utility framework that can be linked to our econometric specification. Section 4 describes the methods and materials and Section 5 presents the results. Section 6 discusses and concludes.

RELATED LITERATURE

The literature on modeling the economic impact of climate change has for many years debated the use of equity weights, which essentially account for the distributional impacts of climate change (Fankhauser et al. 1997, Pearce 2003, Johansson-Stenman 2005, Anthoff et al. 2009, Anthoff and Tol 2010). One of the critical assumptions in this literature is the presence of a global social planner. As an extension to this literature, Anthoff and Tol (2010) introduced the notion that national policymakers could design policies in accordance with the degree of concern for climate change impacts in other countries in the population of their country. They investigated how different forms of such other-regarding preferences would influence the optimal level of climate policy in different countries[2]. They find that when a nation is concerned about impacts in other countries and regions, this influences how much they would be willing to pay for emissions reductions, with varying effect across the countries and regions they include in their analysis. Thus, the role of social preferences over distributive impacts does not appear to be trivial from neither a theoretical nor policy point of view.

The relevance of social preferences over distributive outcomes can both be established as a normative criterion for behavior (Grubb 1995, Konow 2001, Ikeme 2003) as well as a description of actual behavior, as found in the behavioral and experimental economics literature. Here, several papers and models have been developed to explain the other-regarding/altruistic behavior of agents, e.g. that agents often do exhibit varying degrees of social preferences, and are willing to sacrifice some of their own payoff to the benefit of others (Andreoni 1990, Fehr and Schmidt 1999, Bardsley and Sugden 2006, Fehr and Schmidt 2006, Andreoni and Harbaugh 2007, Fischbacher and Gachter 2010). An important aspect from this literature is that several different forms of social

[2] Anthoff and Tol (2010) did not explicitly label their categorization as social preferences, but as different attitudes towards equity and justice. They introduced different concerns regarding the distributional impacts in other regions; which they called 'sovereignty', 'altruism', 'good-neighbour' and 'compensation'.

preferences might be relevant and present in any given context (Engelmann and Strobel 2004, Burlando and Guala 2005, Cappelen et al. 2007, Clément et al. 2015).

We are not the first to study social preferences in relation to climate change and climate change policies as such. Previous examples include the investigation of the preferences of negotiators involved in the international negotiations on climate change (Lange et al. 2007, Dannenberg et al. 2010), people's preferences over the distribution of the costs of CO2 mitigation (Cai et al. 2010, Carlsson et al. 2012), as well as theoretical papers on the use of equity weights and general inequity aversion models (Pearce 2003, Anthoff et al. 2009, Anthoff and Tol 2010, Kverndokk et al. 2014) and the role of social norms for climate policy preferences (Alló and Loureiro 2014). Note that none of these studies explicitly address the aspect of intergenerational equity concerns in climate policy preferences.

A fundamental feature in the literature on climate policy preferences is what constitutes the outcome provided by a climate policy. In this study, we have opted for an aggregation of impact into income measures in different regions. In the literature, preventing changes in temperature and accompanying changes to ecosystems etc. have been used as attributes (Johnson and Nemet 2010). Another dimension is the physical placement of the policy outcome where both local (Berk and Fovell 1999, Layton and Brown 2000, Viscusi and Zeckhauser 2006) and global expected climate change impacts (Carlsson et al. 2012) have been used as climate policy outcomes for which to elicit WTP. Thus a large diversity exists in the approaches to eliciting WTP for climate policies and their outcomes, and our choice derives from our focus on equity aspects.

Climate mitigation policies often generate local co-benefits[3], and this aspect is included in the experimental design as well. Co-benefits may affect peoples' willingness to support climate policies, as it has been found in several studies (MacKerron et al. 2009, Longo et al. 2012, Rodríguez-Entrena et al. 2014, Torres et al. 2015). We include a regional co-benefit for current generations of implementing climate mitigation policies in the region and this allow us to investigate, as a side issue, whether people express social preferences for the physical placement of the mitigation policy and hence associated regional co-benefits.

[3] Examples could be cleaner or safer energy, resulting in improved health outcomes, or it may be changed land uses reducing erosion issues or biodiversity losses.

THEORY

In this section we develop a theoretical framework for our two social preference types; Inequity Averse Altruists and Altruists and derive a foundation for our empirical model. The model we construct is based on the premise of an agent living today (we call this period 1) who can choose to invest in climate policies that will have an effect both in the agents' own life time (period 1) and for future generations (we call this period 2).

We interpret the overall problem faced by respondents in our study as an income allocation problem. By a simplifying assumption, respondents decide how much income to allocate to different climate policies[4]. The income that an agent will allocate to a given climate change policies is a function of; 1) the utility resulting from co-benefits generated by climate policies which influence present generations and 2) the utility associated with the resulting income-changes for future generations affected by climate change. This implies that we consider the utility, U, of a representative agent to be composed of two additive sub-utility functions; U_1which captures the utility generated by period 1 co-benefits and U_2 which captures utility from period 2 income effects. We assume two non-overlapping time periods and that the representative agent lives in time period 1, but gains utility from both period 1 and 2 outcomes.

In our model a representative consumer allocates a given level of income to climate change policies in period 1 which is labeled y_1. Assume that the income allocated to climate policy will influence three specific regions; Western Europe (WE), Southeast Asia (SEA) and Sub-Saharan Africa (SSA). By allocating income to climate policy, the expected loss in income for future generations resulting from climate change in these three regions will be reduced and co-benefits will be generated for the present generation in the region where mitigation policies are implemented. Therefore we can implicitly model the problem of allocating income to the climate change policy as a problem of allocating income to influence climate policy outcomes in the three specified regions[5]. More

[4] We acknowledge that this is a narrow definition of the general income allocation problem that agents face. The general allocation of income between different goods could be handled in a two-stage budgeting model which can handle that agents have a range of different goods they wish to allocate their overall income on. However, as we wish to develop a model of preferences in relation to climate policy, we abstract from the general, underlying income allocation problem and focus directly on the income allocated to climate policy, thus assuming that the general allocation of income to different goods (among here climate policy) has already taken place.

[5] This is also the case for co-benefits since they are assumed to be improvements in air quality, resulting in fewer cases of respiratory diseases in the region which will result in income increase.

specifically, we let IL_i^2 for $i = WE, SEA, SSA$ denote the period 2 loss in income resulting from climate change in WE, SEA and SSA, COB_i^1 for $i = WE, SEA, SSA$ denote the period 1 co-benefit in either WE, SEA or SSA, and let y_i^1 be the income allocated to policies affecting each region in time period 1. The income allocated to policies affecting each region is a function of the income loss and co-benefit of the specific policy, implying that $y_i(IL_i, COB_i)$.

In our study the representative agent is asked to imagine that their household will pay a price, in the form of additional incomes taxes, for any increase in climate policy efforts. We assume that the income allocation represents real market behavior, so the representative consumer cannot allocate more income than y_1. This implies that the following budget restriction must be satisfied

$$y_1 = y_{WE}^1\left(IL_{WE}^2, COB_{WE}^1\right) + y_{SEA}^1\left(IL_{SEA}^2, COB_{SEA}^1\right) + y_{SSA}^1\left(IL_{SSA}^2, COB_{SSA}^1\right) \tag{1}$$

Thus, the sum of allocated income to policies affecting the three regions cannot exceed the total income to be allocated to climate policies.

As mentioned we assume the overall utility function for a representative agent to be composed of two additive, separable sub-utility functions, capturing that income allocated to climate policy now has immediate effect in the form of co-benefits (captured by U_1) and a future effect on the expected income loss from climate change (captured by U_2):

$$U = U_1 + U_2 \Longrightarrow U = U_1(y_{WE}^1(IL_{WE}^2, COB_{WE}^1), y_{SEA}^1(IL_{SEA}^2, COB_{SEA}^1), y_{SSA}^1(IL_{SSA}^2, COB_{SSA}^1) + U_2(y_{WE}^1(IL_{WE}^2, COB_{WE}^1), y_{SEA}^1(IL_{SEA}^2, COB_{SEA}^1), y_{SSA}^1(IL_{SSA}^2, COB_{SSA}^1) \tag{2}$$

For an agent that derive utility from the provision of co-benefits in period 1 for herself or others, we assume $\frac{\partial U_1}{\partial y_i^1}\frac{\partial y_i^1}{\partial COB_i^1} > 0$, and similarly for an agent that derive utility from reducing the income loss arising for future generations in her own or other regions , we assume $\frac{\partial U_2}{\partial y_i^1}\frac{\partial y_i^1}{\partial IL_i^2} < 0$ for $i = WE, SEA, SSA$.

The maximization problem is solved using the Lagrange function in eq. (3),

$$L = U_1(y_{WE}^1(IL_{WE}^2, COB_{WE}^1), y_{SEA}^1(IL_{SEA}^2, COB_{SEA}^1), y_{SSA}^1(IL_{SSA}^2, COB_{SSA}^1) +$$

$$U_2(y_{WE}^1(IL_{WE}^2, COB_{WE}^1), y_{SEA}^1(IL_{SEA}^2, COB_{SEA}^1), y_{SSA}^1(IL_{SSA}^2, COB_{SSA}^1) + \lambda(y_1 -$$

$$y_{WE}^1(IL_{WE}^2, COB_{WE}^1) - y_{SEA}^1(IL_{SEA}^2, COB_{SEA}^1) - y_{SSA}^1(IL_{SSA}^2, COB_{SSA}^1))$$

(3)

Here the multiplier λ can be interpreted as the marginal utility of income. Using COB_{WE}^1, COB_{SEA}^1 and COB_{SSA}^1 as control variables for period 1 utility U_1 and IL_{WE}, IL_{SEA} and IL_{SSA} as control variables for period 2 utility, U_2, yield the following first-order conditions:

$$\frac{\partial U_1}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial COB_{WE}^1} - \lambda\frac{\partial y_{WE}^1}{\partial COB_{WE}^1} = 0 \quad (4)$$

$$\frac{\partial U_1}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial COB_{SEA}^1} - \lambda\frac{\partial y_{SEA}^1}{\partial COB_{SEA}^1} = 0 \quad (5)$$

$$\frac{\partial U_1}{\partial y_{SSA}^1}\frac{\partial y_{SSA}^1}{\partial COB_{SSA}^1} - \lambda\frac{\partial y_{SSA}^1}{\partial COB_{SSA}^1} = 0 \quad (6)$$

$$\frac{\partial U_2}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial IL_{WE}^2} - \lambda\frac{\partial y_{WE}^1}{\partial IL_{WE}^2} = 0 \quad (7)$$

$$\frac{\partial U_2}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial IL_{SEA}^2} - \lambda\frac{\partial y_{SEA}^1}{\partial IL_{SEA}^2} = 0 \quad (8)$$

$$\frac{\partial U_2}{\partial y_{SSA}^1}\frac{\partial y_{SSA}^1}{\partial IL_{SSA}^2} - \lambda\frac{\partial y_{SSA}^1}{\partial IL_{SSA}^2} = 0 \quad (9)$$

The first term on the left-hand side of each of the six first order conditions captures the marginal utility for the agent from experiencing a marginal increase in income loss or co-benefits in the different regions. The second term captures the marginal utility of income (λ) times the marginal change in income allocated to supporting (buying) a policy in a region depending on the marginal change in the outcome variable of that policy in the region.

The first-order conditions in (4) – (9) can be reduced to yield six equations of the form:

$$\frac{\partial U_j}{\partial y_i^1} - \lambda = 0 \quad (10)$$

Here *i* again denote the three different regions, and *j* is an index for the period. This reduced first order condition states that in optimum the marginal utility of a marginal allocation of income to buying a marginal amount more of any of the two policy elements (reduced income loss, co-benefits) must equal the marginal utility of income, λ.

The two social preference types, Inequity Averse Altruists and Altruists, can now be formulated within this framework.

Inequity Averse Altruists

In economic analysis it is common to separate efficiency and distributional concerns as the Altruist type will do, but we propose that agents might have preferences for distributional outcomes of climate policies and prefer climate polices that takes this into account. The Inequity Averse Altruist cares about distributional outcomes and is concerned with who benefits from a reduced income loss. He/she observes the principle of declining marginal utility of income and hence that a marginal reduction in income loss may be worth more to the poor that to the rich. An agent conforming to the Inequity Averse Altruist type will derive higher utility from a marginal reduction in income loss for those among future generations that are less well of, than for those that are better off. Similarly, the Inequity Averse Altruist may prefer a marginal increase in co-benefits be provided to the less well-off than the well-off regions. This implies the following two restrictions on the form of the utility function:

$$\frac{\partial U_2}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial IL_{WE}^2} < \frac{\partial U_2}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial IL_{SEA}^2} < \frac{\partial U_2}{\partial y_{SSA}^1}\frac{\partial y_{SSA}^1}{\partial IL_{SSA}^2}$$

and

$$\frac{\partial U_1}{\partial y_{WE}^1}\frac{\partial y_i^1}{\partial COB_{WE}^1} < \frac{\partial U_1}{\partial y_{SEA}^1}\frac{\partial y_i^1}{\partial COB_{SEA}^1} < \frac{\partial U_1}{\partial y_{SSA}^1}\frac{\partial y_i^1}{\partial COB_{SSA}^1} \qquad (11)$$

These conditions imply that an Inequity Averse Altruist agent will allocate more income to (buying) climate policies that favor SSA over SEA and WE. This holds for both period 1 and 2 utility.

Altruists

We define the simpler Altruist type as an individual concerned with securing the highest aggregate future income across the three regions, through his/hers allocation of income to climate policy. This means that this type does not distinguish between who receives the reductions in income loss through the climate policy – his/hers concern is to achieve the overall largest reduction in income loss, and hence the largest aggregate income. Likewise, the Altruist is agnostic about who receives the co-benefit, but derives utility from the co-benefit being delivered. This implies the following restriction on the form of the utility function:

$$\frac{\partial U_2}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial IL_{WE}^2} -= \frac{\partial U_2}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial IL_{SEA}^2} -= \frac{\partial U_2}{\partial y_{SSA}^1}\frac{\partial y_{SSA}^1}{\partial IL_{SSA}^2}$$

and

$$\frac{\partial U_1}{\partial y_{WE}^1}\frac{\partial y_i^1}{\partial COB_{WE}^1} = \frac{\partial U_1}{\partial y_{SEA}^1}\frac{\partial y_i^1}{\partial COB_{SEA}^1} = \frac{\partial U_1}{\partial y_{SSA}^1}\frac{\partial y_i^1}{\partial COB_{SSA}^1} \tag{12}$$

An Empirical Specification

This subsection integrates the general model in the empirical model. We assume a functional form for our utility functions in eq. (2) U_1 and U_2, identical to that used in our econometric model. Specifically, the utility of a climate change policy is assumed to be a simple linear additive function of the marginal change in any of the six variables affected by climate policy; co-benefits and income losses arising in the three regions:

$$U = \frac{\partial U_1}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial COB_{WE}^1} * COB_{WE}^1 + \frac{\partial U_1}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial COB_{SEA}^1} * COB_{SEA}^1 + \frac{\partial U_1}{\partial y_{SSA}^1} * \frac{\partial y_{SSA}^1}{\partial IL_{SSA}^1} COB_{SSA}^1 + \frac{\partial U_2}{\partial y_{WE}^1}\frac{\partial y_{WE}^1}{\partial IL_{WE}^2} * IL_{WE}^2 + \frac{\partial U_2}{\partial y_{SEA}^1}\frac{\partial y_{SEA}^1}{\partial IL_{SEA}^2} * IL_{SEA}^2 + \frac{\partial U_2}{\partial y_{SSA}^1}\frac{\partial y_{SSA}^1}{\partial IL_{SSA}^2} * IL_{SSA}^2 + \lambda * cost \tag{13}$$

Note that with this specification the marginal rate of substitution between an improvement in any of the six variables and income allocated for the consumption of any other good can be obtained, as exemplified by $\frac{\partial U_1}{\partial y_i^1}\frac{\partial y_i^1}{\partial COB_i^1}/\lambda$. From (10) we get $\frac{\partial U_1}{\partial y_i^1}\frac{\partial y_i^1}{\partial COB_i^1}/\lambda = \frac{\partial U_1}{\partial y_i^1}\frac{\partial y_i^1}{\partial COB_i^1}\Big/\frac{\partial U_1}{\partial y_i^1} = \frac{\partial y_i^1}{\partial COB_i^1}$. This last term can be interpreted as the individual's willingness to pay (WTP) for a marginal increase in co-benefits in region *i*.

Define for each region *i* two variables:

$$\frac{\partial U_1}{\partial y_i^1}\frac{\partial y_i^1}{\partial COB_i^1} = \delta_i \text{ and } \frac{\partial U_2}{\partial y_i^1}\frac{\partial y_i^1}{\partial IL_i^2} = \beta_i \tag{14}$$

Which can be inserted into eq. (13)

$$U = \delta_{WE} * COB^1_{WE} + \delta_{SEA} * COB^1_{SEA} + \delta_{SSA} * COB^1_{SSA} + \beta_{WE} * IL^2_{WE} + \beta_{SEA} * IL^2_{SEA} + \beta_{SSA} * IL^2_{SSA} + \lambda * cost \tag{15}$$

The two social preference types can now be identified through the following tests on the empirical data, suggesting that both types can be identified based on either the coefficients for future income effects (β) or the coefficients for present co-benefits (δ)

Inequity Averse Altruists: $|\beta_{WE}| < |\beta_{SEA}| < |\beta_{SSA}$ and $\delta_{WE} < \delta_{SEA} < \delta_{SSA}$ (16)

Altruists: $\beta_{WE} = \beta_{SEA} = \beta_{SSA}$ and $\delta_{WE} = \delta_{SEA} = \delta_{SSA}$ (17)

In eq. (16) it is the absolute values of the coefficients that are compared. This is because the (β)'s measures sensitivity to income loss, and by the implications of inequity aversion, an income loss in SSA compared to SEA should have a stronger impact on utility, thus the absolute value of β_{SSA} should be larger than β_{SEA}.

In our model we have assumed a strict distinction between period 1 and 2 effects, but it is not given that agents perceive the problem like this. Bequest values and, for younger people in particular, considerations about the effect on own life time income from additional climate policy efforts now, could potentially influence the coefficients obtained for WE, since the data is collected on a sample of respondents currently living in WE. These concerns suggest that the hypotheses formulated in eq. (16)-(17) should be revised to omit the WE-variables. We therefor propose the following hypotheses for Inequity Averse Altruists and Altruists

Hypothesis 1

Inequity Averse Altruists: $\delta_{SEA} < \delta_{SSA}$ and $|\beta_{SEA}| < |\beta_{SSA}|$ (18)

For one unit increase in the income loss or co-benefit attribute for each region, the marginal utility of an Inequity Averse Altruist is statistically significantly more impacted by income losses and co-benefits in a poorer region (SSA), as compared to a richer region (SEA)

Hypothesis 2

Altruists: $\delta_{SEA} = \delta_{SSA}$ and $\beta_{SEA} = \beta_{SSA}$ (19)

For one unit increase in the income loss or co-benefit attribute for each region, the marginal utility of an Altruists is not statistical significantly different across income losses and co-benefits occurring in different regions.

Since the main purpose of this paper is to investigate social preferences in relation to the future distributive impacts of climate change, the main focus will be on identifying the Inequity Averse Altruists and Altruists as reflected in the coefficients for the income effects.

MATERIALS AND METHOD

The case study and survey design

Due to the stock pollutant nature of carbon in the atmosphere and the slow adjustment of numerous physical mechanisms and ecological processes, it is common in the scientific literature to discuss the consequences of climate change, and hence climate change policies, over quite long time horizons. Often the year 2100 is a measure milestone (IPCC 2014) and we adopt this practice in our study, as we describe the effects of current climate policies for the income of people living in year 2100. In addition to the future impacts we also include present benefits of climate policy in the form of co-benefits, generated from mitigation effort.

The study focuses on three different regions of the world, Western Europe, Southeast Asia and Sub-Saharan Africa, as depicted in Figure1.

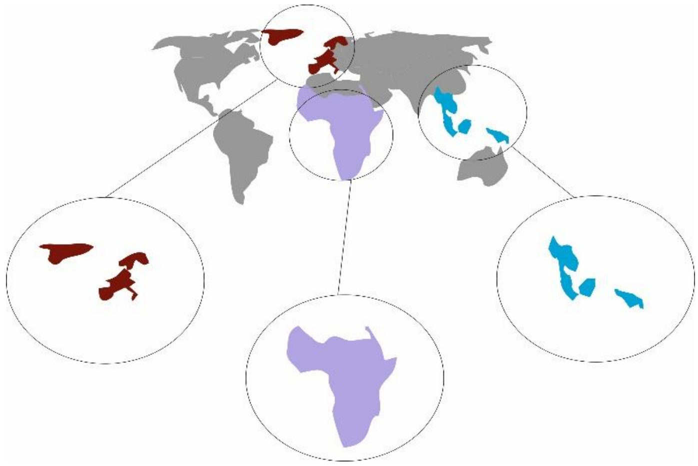

Figure 1. Visual representation of the three regions, as it was displayed to respondents in the survey

These three regions are selected to be aligned with typical regions used in the literature, including the model in Anthoff and Tol (2010).

The attribute levels for the income loss effects in the three regions are determined using the online-appendix to Anthoff & Tol (2010), which provides estimates of regional growth in income, along with expected degree of economic impact of climate change in the various regions investigated. This data were used in further calculations to arrive at plausible ranges for the income effect in year 2100 in each region (See Table 1). Respondents were informed that without further climate policy action, the average income of people living in 2100 is expected to drop by 5% by 2100, as a result of climate change[6]. The effect of the climate change policies was presented as lowering the average expected income loss across the three regions, to a varying extent (0, 1, 2 or 4 %).

The mitigation effort was described as a set of policies targeting reduced fuel consumption through changes in combustion-technology in the energy and transportation sector, or in households. This level of detail was included in order to justify the existence of a co-benefit from the mitigation effort, which was described qualitatively as fewer cases of respiratory diseases in the region implemented (See Table 1). In the attribute description, the mitigation part of the policy could take place in only

[6] An inherent challenge is that overall income is expected to rise towards 2100 by a non-trivial amount. This means that people now, across the three regions selected, are on average poorer than we predict people living in the same regions in 2100 to be. This could affect their choices even if they hold social preferences. In the survey, respondents were informed about this fact in the attribute-explanation section, and total per capita income for each region was displayed in each alternative in all choice sets.

one region within each policy alternative, allowing for trade-offs across the regions with regards to this more immediate local public good.

Furthermore, it was explained that adaption effort would always be present and vary across decision alternatives and regions. It was described in general terms as varying in intensity across-and within regions, and examples such as building dikes and changed crop management was mentioned.

Finally, respondents were informed that the additional climate policies would have a cost in terms of an increase in their annual household income tax (See Table 1). They were also informed that the Danish Government is committed to reducing CO_2 emissions further, with national as well as international instruments, to enhance climate adaptation and support developing countries in adapting. We further informed respondents that the Danish government already contributes from the government budget to programs run by the EU, UN or the World Bank towards these objectives, and that these contributions could increase in the future. Lastly, respondents were informed that the results of the survey would be publicized and made available for policy makers, this was done in order to enhance perceived consequentiality (Carson and Groves 2007).

The respondents faced a demanding, highly complex choice-task, spanning effects in both time and space. For this reason the survey was tested thoroughly over the course of 6 months, with respect to understanding, wording and presentation of the case study. Testing included three focus-groups and two pilot data collections, one on students and researchers with elaborate feedback and one on the panel used for the main experiment, which all provided valuable inputs to the survey design, as well as providing priors for the technical design. Two researchers were present under focus group sessions, in order to capture all relevant points, take notes and ensure sufficient flow. Discussions in focus groups tested and improved both the presentation of the co-benefit and income attributes, the latter developed to include graphics, text and numbers in order to support as many perception preferences as possible.

Table 1. Attributes and attribute levels

	Levels								Status Quo
Co-benefit	Fewer cases of respiratory diseases (Western Europe) Fewer cases of respiratory diseases (Southeast Asia) Fewer cases of respiratory diseases (Sub-Saharan Africa) No effect								No effect
Income-effect									
- Western Europe	42.000		33.600		16.800		8.400		42.000
- Southeast Asia	21.000		16.800		8.400		4.200		21.000
- Sub-Saharan Africa	10.500		8.400		4.200		2.100		10.500
Price, DKK	0	100	200	400	600	900	1200	2000	0

Experimental Design

The survey consisted of three sections. The first section contained information on the case study, along with warm-up questions on attitudes and beliefs about climate change and elements of the presented case study. In the second section, respondents were asked to make choices in 8 choice sets between three different climate policy options, of which one was always “No additional climate policy”, corresponding to the status quo level of climate policy (See Figure 2 for an example of a choice card). The third and last section contained follow-up and attitude questions as well as questions eliciting socio-demographic information.

Thus, the experimental design consisted of 8 choice-tasks, each with 3 alternatives. The choice -tasks were distributed into 2 blocks, resulting in 16 different designs of the choice cards. The technical design was optimized according to D-efficiency in the program Ngene (ChoiceMetrics 2012), using a main-effects dummy-coded MNL model and the final design had a D-error of 0.3063.

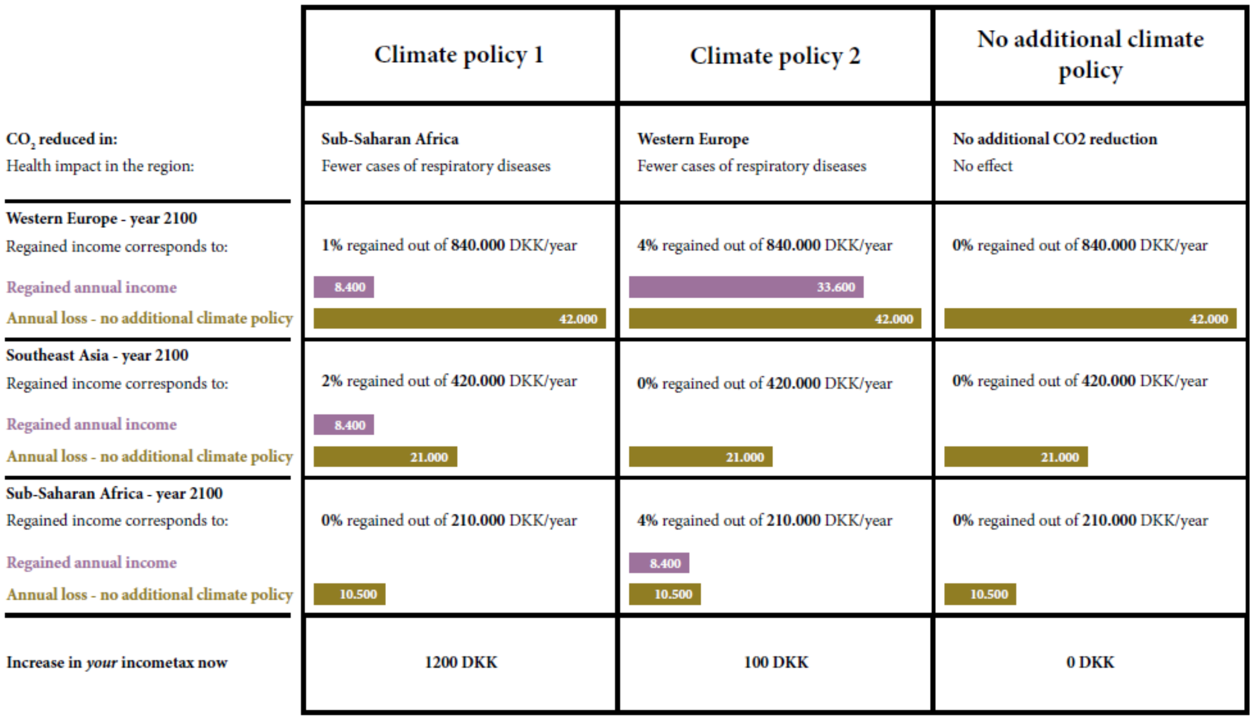

Figure 2. Example of choice card

Data collection

The data collection was handled by means of an online panel, Userneeds, including more than 95,000 members of the general Danish public. The survey was conducted on 813 respondents[7]. The average response time was approx. 20 minutes. The sampling was designed to be representative in regards to age, gender and income. From Table 2 it can be seen that the sample matched the general population fairly well for gender, age and income with the sample being slightly older than the general population. Furthermore, although the educational levels are similar, and compared to the general population, there seems to be an overrepresentation of respondents with a vocational education, and an underrepresentation of respondents with a primary education only.

[7] The survey included two splits, of which only one is used in this paper. Across both splits a total of 14,831 respondents were invited to the survey, of which 1,634 had completed the survey. The survey was closed once a minimum population of representative respondents had replied, thus a standard response rate cannot be estimated.

Table 2. Socio-demographic characteristics of the sample and the population of Denmark

	Sample n = 813	Population of Denmark
Female	0.50	0.50
Age	44.90	41.1
Income[a]	250,000 – 274,999	261,323
Education - tertiary	0.25	0.27
Education - secondary	0.13	0.09
Education – vocational	0.52	0.30
Education - primary	0.09	0.27

Education levels are provided for the population aged above 15 years
[a]: Mean interval- income per respondent, in DKK, for the sample.

The Latent Class Model

We use a latent class model to explore the possible preference heterogeneity that we a priori have formed hypotheses about. The latent class model assumes that there exists discrete heterogeneity in segments of the population, but that individuals in each class are homogenous in their preferences (Greene and Hensher 2003).

The underlying theoretical framework used to analyse the respondents' preferences is the Random Utility framework (McFadden 1973) along with Lancasters' characteristics of demand theory (Lancaster 1966). Following the Random Utility framework, the utility of agent *i* for alternative *j* can be described by an observable part $x_{i,j}$ and an unobservable part ε_{ij}, which is the individual stochastic error term. This allows the utility of agent *i* to be formulated as follows:

$$U_{ij} = \beta x_{i,j} + \varepsilon_{ij} \quad (20)$$

Here $x_{i,j}$ may contain both individual characteristics and the characteristics of the alternatives, while β is a vector containing parameter coefficients to be estimated. This econometric formulation directly relates to the empirical specification of the theoretical model developed in eq. (15), which forms the basis for developing the social preference hypotheses in eq. (18) and (19).

Assuming that the error term in eq. (20) is type I extreme value distributed and that agent, *n*, chooses the alternative which gives her/him the highest utility, facing a sequence of choices, T, and that she/he belongs to class s, the joint probability of observing a given sequence of choices can be formulated as a multinomial logit model:

$$P_{n,s} = \prod_t^T \left[\frac{\exp(\beta_s x_{nit})}{\sum_{j=1}^{J_i} exp(\beta_s x_{njt})}\right] \quad , \qquad s = 1, \dots., S \tag{21}$$

Where β_s is a vector of parameter estimates connected to the explanatory variables x_{nit}, specific for class *s*. The probability that a given individual belongs to class s is described by the class membership function:

$$P_{n,s} = \frac{exp\theta_s Z_n}{\sum_{s=1}^{S} exp\theta_s Z_n} \quad , \quad s = 1, \dots \dots, S \tag{22}$$

Where θ_s is the parameter estimate connected to the observed characteristics or attitudes of individual Z_n. In estimation of (22), the parameter estimates in one of the classes is set to zero, for identification purposes.

Under the assumption of independence, the combination of the probability of a given sequence of choices given membership of class s (eq. 21), and the probability of being in class s (eq. 22), one can describe the probability of observing a sequence of choices for a random individual *n* as:

$$P_n = \sum_{s=1}^{S} \left[\frac{exp\theta_s Z_n}{\sum_{s=1}^{S} exp\theta_s Z_n}\right] \left[\frac{\exp(\beta_s x_{nit})}{\sum_{j=1}^{J_i} exp(\beta_s x_{njt})}\right] \quad , \quad s = 1, \dots\dots, S \tag{23}$$

Now re-formulate (20) with respect to the empirical specification of our model from eq. (15) to yield:

$$U_{ij} = \alpha ASC_j - \rho p_j + \delta_{WE} COB_{WE,j} + \delta_{SEA} COB_{SEA,j} + \delta_{SSA} COB_{SSA,j} + \beta_{WE} IL_{WE,j} +$$

$$\beta_{SEA} IL_{SEA,j} + \beta_{SSA} IL_{SSA,j} + \varepsilon_{ij}$$

(24)

Where α is the parameter coefficient for the alternative specific constant, ρ is the parameter coefficient for the cost attribute p_j measuring the marginal utility of income and ε_{ij} represents the random error term. The remaining parameters correspond to those defined for eq. (15) above.

RESULTS

In latent class analysis it is left to the researchers' discretion to choose the number of classes. This can either be based on theoretical arguments or guided through selection criteria such as the Bayesian Information Criteria (BIC) or Akaike Information Criteria (AIC). Table 3 shows the BIC and AIC selection criterions, as well as the log-likelihood for 1-10 classes. As can be seen, the different criteria do not suggest the same number as classes and furthermore, we see that the optimal number of classes, according to these criterions is rather high. This can result in classes of very small size and several insignificant parameters (Scarpa and Thiene 2005).

Table 3. Performance of selection criterions for models with 2-10 classes, n = 813

Number of classes	Parameters	Log-Likelihood	BIC	AIC
2	8	-5798.27	11650.15	11612.55
3	17	-4845.25	9804.40	9724.49
4	26	-4618.69	9411.60	9289.39
5	35	-4486.48	9207.48	9042.95
6	44	-4388.43	9071.68	8864.85
7	53	-4348.20	9051.54	8802.40
8	62	-4307.11	9029.67	8738.23
9	71	-4285.32	9046.39	8712.64
10	80	-4267.44	9070.95	8694.89

Given that our hypotheses are predicted each to cover a class, we base our choice of number of classes on the theory that we wish to test for, and additionally allow for two free classes, which resulted in reasonable class sizes.

Table 4 and Figure 3 present the results of a latent class model with 4 classes. The estimation of the latent class model was implemented using Latent Gold 5.1 (Vermunt and Magidson 2015). The log likelihood of the model is -4432 and the R-squared 0.43, the latter suggesting a relatively good fit of the model.

Figure 3 illustrates the size of the four classes in the data. We have chosen to label each class according to the main behavioural characteristics of each class; the Inequity Averse Altruists class which captures 60 % of observed behaviour, the Warm Glow class which captures 17 %, the Do No More class capturing 6 % and the Strategic class which captures 17 % of observed behaviour. We will now interpret and expand on each of the four classes.

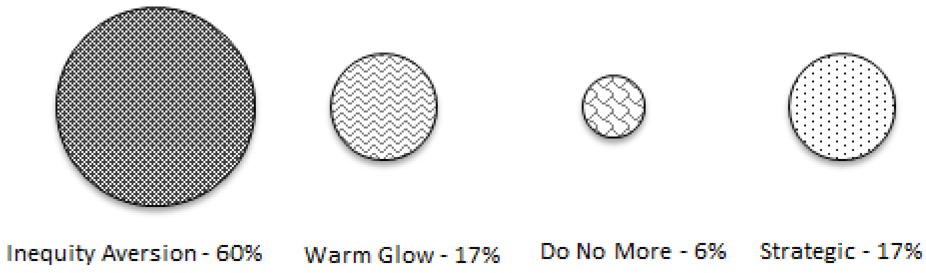

Figure 3. The Four Preference Classes - % captures class-share in data

The Inequity Averse Altruist Class

We label the first class as the Inequity Averse Altruist class. Coefficients for the income effects are all negative and significant and we note that the hypothesis of Inequity Averse Altruists for the income effect coefficients cannot be rejected, as $\beta_{SEA} < \beta_{SSA}$, (Wald test of equality between coefficients, z value = 6.53). Co-benefits in all the three regions have a positive and statistically significant effect on utility. An increase in the price of climate policy has a negative and significant impact on utility. The ASC is negative and highly significant, suggesting that this class of respondents strongly prefer to engage in additional climate policy action. The Inequity Averse class is by far the largest class in the data capturing around 60 % of the respondents.

The Warm Glow Class

We label the second class Warm Glow. The coefficients on the income effects in the three regions (WE, SEA & SSA) are all statistically insignificant, but the ASC is negative and significant, indicating that respondents captured by this class had a positive utility gain from just choosing a climate policy as opposed to the status quo. We suggest that the Warm Glow class could capture the behaviour of respondents who are getting a “warm glow” from the mere act of choosing and indicating a positive

WTP for additional climate policy (Andreoni 1990), and thus not are concerned with the distributive impacts of climate policy on others.

An increase in the price of climate policy has a negative and significant impact on their utility, and co-benefits in WE has a significant and positive impact on utility whereas co-benefits in the other two regions are insignificant. This further strengthens the argument that respondents in this class are not concerned with outcomes for others, rather they prefer to secure outcomes for themselves in the form of co-benefits. The Warm Glow class captures around 17 % of the respondents.

Table 4. Four Class Latent Class Model, std. errors in parenthesis

	Inequity Averse Altruists		Warm Glow		Do No More		Strategic	
Class size	0.60		0.17		0.06		0.17	
Explanatory variables	Coef	z	Coef	Z	Coef	z	Coef	z
ASC	-3.397	8.769	-0.893	4.819	2.780	3.339	-0.981	2.270
	(0.387)		(0.185)		(0.833)		(0.432)	
Income effect: *WE*	-0.029	11.210	-0.006	1.344	0.026	0.672	-0.039	5.254
	(0.003)		(0.005)		(0.039)		(0.007)	
Income effect: *SEA*	-0.021	5.287	-0.015	1.778	0.048	1.060	-0.016	1.431
	(0.004)		(0.008)		(0.045)		(0.011)	
Income effect: *SSA*	-0.077	9.555	0.001	0.054	0.015	0.171	0.026	1.033
	(0.008)		(0.017)		(0.087)		(0.025)	
Co-benefit: *WE*	1.768	16.533	0.552	3.278	0.312	0.364	0.758	3.238
	(0.107)		(0.168)		(0.859)		(0.234)	
Co-benefit: *SEA*	1.025	13.542	-0.023	0.161	-1.316	1.188	0.522	2.829
	(0.076)		(0.145)		(1.108)		(0.185)	
Co-benefit: *SSA*	1.173	12.311	-0.011	0.062	-0.226	0.024	-0.076	0.308
	(0.095)		(0.168)		(0.925)		(0.246)	
Price	-0.545	7.993	-2.046	10.564	-0.128	0.230	1.508	6.548
	(0.068)		(0.194)		(0.554)		(0.230)	
Model Statistics								
Number of individuals	813							
Choice task pr person	8							
LL	-4432							
BIC	9099							
R-squared	0.432							

The Do No More Class

The third class is labelled as the Do No More class. Only the coefficient on the ASC is statistically significant and positive, thus we interpret this class as capturing respondents with an affinity for the status quo, e.g. respondents who did not want to invest in additional climate policy. We find no effect of price, presumably because respondents in this class chose the status quo option often, thereby not generating a sufficient amount of observations for an estimated effect of price.
This class captures 6 % of the respondents.

The Strategic Class

In the last class, denoted the Strategic class, only the coefficient for income effects in WE is significant, implying that for respondents in this class, only future losses in income in their own region significantly impact their utility. The influence of co-benefits is mixed, but statistically significant in two regions, WE and SEA. Receiving co-benefits in the respondents own region (WE) and in SEA has a positive impact on utility, whereas generating co-benefits in SSA influence the respondents' utility negatively, although the coefficient is statistically insignificant.

Furthermore, the price coefficient is positive and significant, which suggests that respondents grouped in this class gain a positive utility impact from increasing the price of climate policy. We will discuss these patterns in more detail in Section 6. Approximately 17 % of the respondents can be described by this class.

Robustness of Specification

In addition to the main model above, we have investigated several different specifications of our model to see how robust the results are. Table 6 shows a summary of the robustness checks we have performed and below we further expand on each check in more detail.

Table 5. Robustness Checks and Their Influence on Model Interpretation[8]

Robustness Check	Inequity Averse Altruists Identified	Altruists Identified	Strategic class Identified	Warm Glow Identified	Do No More Identified	Inequity Averse Altruists Identified as Largest Class
Hypotheses imposed as technical restrictions	**X**		**X**	**X**	**X**	**X**
LC model with class membership function	**X**		**X**	**X**	**X**	**X**
Subsample of data	**X**		**X**			**X**
LC model with RPL specification for four attributes	**X**		**X**		**X**	

Hypotheses imposed as technical restrictions

How does the main conclusions from Table 4 change when two specific classes are imposed as technical restrictions on the estimated utility coefficients, with the technical restrictions conforming to the Altruists hypothesis and to the pattern of Warm Glow? Table 7 in the Appendix presents the results of this specification.

Comparing these results with those from Table 4, the LL increases insignificantly (Likelihood Ratio test, chi-square value = 3.86, df = 5) from an unrestricted (-4432) to a restricted model (-4434).

Imposing the Warm Glow restriction does not change the interpretation of the Warm Glow class from Table 4, and the number of respondents that fall into this class remains unchanged.

The implemented Altruist restriction for class two, only specified that the coefficients on the income effect in all three regions should be identical. The estimated model fulfils this restriction, but all

[8] The conclusions with respect to Inequity Aversion being the largest class in the data also hold when testing models with 1-5 classes.

three coefficients are statistically insignificant. Only the coefficient on the ASC is significant and positive, suggesting that this class, with the Altruists restriction imposed, now captures the Do No More class, with a class size of 6 %. The Strategic class still emerges on its own, capturing the same amount of respondents (17 %) as in Table 4. The Inequity Averse also class emerges on its own, with the same interpretation as in Table 4, capturing 60 % of respondents' behaviour.

The main finding of this robustness check is that imposing technical restrictions does not alter the conclusion with respect to Inequity Aversion being the hypotheses that captures the largest class in the data.

Latent Class model with class membership function

The survey contained a battery of follow-up questions and embedded in this battery were questions designed to capture each of the two hypotheses (see Table 6 in the Appendix). In this model specification we test how these attitude questions perform in the class membership function[9]. The attitude questions clearly measures concerns over various distributional aspects, which again relate to the individuals personal preferences for said factor. Thus, it can be argued that there is a risk of a technical endogeneity between the respondents' answers to attitude questions and their choices in choice sets, as both could be influenced by an unobserved latent type (Hess et al. 2013).

Table 8 in the Appendix presents the results of this specification. Overall the LL improves from -4432 (model with no class membership function) to -4366 (model with class membership function), a significant drop in likelihood units (Likelihood Ratio test, chi-square value = 133.35, df = 15).

We find that the estimated parameter coefficients and class size are almost identical across the two models. Inequity Averse Altruists again falls out as the largest class in the data. This suggests that technical endogeneity is not a problem for our preferred model and the conclusions drawn from it, if we wish to use attitude questions to predict membership of the 4 classes.

Turning to the coefficients of the class membership function, we observe the following patterns.

Agreeing with the Altruist attitude question positively predicts membership of both the Strategic and Inequity Averse Altruist classes, whereas it predicts negative for the Do No More class.

[9] See the paper by Beck et al. (2013) who also apply attitude questions in the class membership function.

The Inequity Averse Altruist attitude question positively predicts membership of the Strategic and Inequity Averse Altruist classes, whereas it predicts negatively for the Do No More class.

Agreeing to the Own Income attitude question negatively predicts membership of the Strategic class, but predicts positively for membership of the Warm Glow class. Bequest concerned respondents are more likely to be Strategic, but not likely to belong to the Warm Glow class. The Warm Glow attitude question positively and significantly predicts membership of the Strategic class, but answering that one agree with this attitude question also significantly predicts negative probability of belonging to the Warm Glow class. This could suggest that the phrasing of the Warm Glow question which was *" I did not pay that much attention to the size of the income effect, because I think the most important thing is just to do something"* instead captured the signaling, do-good behavior captured by the Strategic class.

Subsample of data

The choice task was arguably complex for respondents and one could suspect that perhaps all respondents were not able to read the choice card in the intended way. In an attempt to evaluate this concern, we included a follow-up question aimed at measuring whether or not a respondent was able to read the choice card correctly[10]. According to the results of this test, 63% of the respondents were able to read the choice-cards in the way we had intended[11]. Table 9 in the Appendix presents the results of a 4 class latent class model on this subsample of data. The results show indications of Inequity Averse Altruists as the largest class in the subsample (58 %), followed by the Strategic class (23 %), with no significant change in parameter coefficients and interpretation. Neither of the Do No More or the Warm Glow class emerges. Instead the results indicate a class who would like to invest in additional climate policy (negative and significant ASC) that secures income effects for Western Europe and Southeast Asia, and a class where both the provision of co-benefits in Southeast Asia and increases in price generate significant disutility for respondents allocated to this class.

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[10] The question showed the same type of choice card that the respondents had just answered, and asked the following question: "Which of the climate policies secures the largest gain in income in Sub-Saharan Africa".

[11] This is a rather bold statement, as we actually have no way of controlling for the respondents perception of the choice task, and one could imagine that for some portion of respondents who answered correctly, it might not necessarily reflect that they understood the task. Nevertheless we would argue that the test is at least an attempt to control for choice complexity.

The main finding of this robustness check is that the conclusions from the main model are robust to being estimated on a subsample of respondents, with Inequity Averse Altruists still remaining the largest class in the data.

Latent Class model with RPL specification for four attributes

Another way of testing the two hypotheses is a Latent Class model with random parameters for the co-benefits and price attributes fixed across the four classes. Allowing only the variation in the income effect attributes to distinguish the four classes from each other facilitates a more restrictive test of the two behavioural hypotheses. In such a model, we thus exclude the discrete, between-class variation in preferences regarding co-benefits and price and assume that the four classes have the same mean preference (normally distributed) for each of the three co-benefits and the price.

Table 10 in the Appendix presents the results of such a model. The LL significantly improves from -4432 to -4389 (Likelihood Ratio test, chi-square value = 85.09, df = 8). Looking at the interpretation of the classes solely based on the parameter coefficients for the income effects and the ASC, the results indicate a class of Inequity Averse Altruists (21 %) and a somewhat larger class (56 %) where the test on the coefficients for income effects in SEA and SSA indicate Inequity Averse Altruists, but the coefficient on income effects in SEA is not statistically significant. The Do No More class emerges, with only the ASC being positive and significant and explains 5 % of our data. The remaining class is labelled as “Own Income Effect”, to capture that only the income effect in Western Europe is negative and significant, suggesting that this group (18 %) choose climate policies based only on the income effect that is expected in the respondents own region.

The coefficients on co-benefits and price are all significant. This implies that across all four classes, respondents are influenced positively by the presence of co-benefits, whereas an increase in the price influences their utility negatively, as expected.

This robustness check highlights the importance of allowing flexibility in model specification, as we in a free four class model (Table 4) identify a class of strategic signallers (The Strategic Class) who has a positive coefficient on price. Choosing an RPL specification for both price and co-benefits masks this behavioural pattern and could potentially lead to misleading conclusions with respect to the importance of either of our two social preference types.

CONCLUDING DISCUSSION

Preferences for distributional impacts of climate policy

This paper presents empirical results that support the inclusion of distributional social preferences when designing and evaluating climate policy. Including such distributional concerns has important and significant impacts on the design and evaluation of such policies (Anthoff and Tol 2010).

Formulating two distinct social preference hypotheses, we were able to find behavioural patterns in the data which conform to our hypothesis of Inequity Averse Altruists, which is also the prominent class in our sample, capturing around 55% of the observed behaviour in the sample. Subjecting this finding to several robustness checks does not alter the conclusion that the behavioural pattern of Inequity Averse Altruists is relevant for describing a significant part of our respondents' choice of climate policy. Only in one robustness check do we find that Inequity Averse Altruists is not the largest behavioural class in the data, but instead the second largest.

We were not able to find patterns of behaviour that were consistent with the hypothesis of Altruists, which suggests that people in our sample not only value the outcomes of climate policy, but also assign value to how these outcomes are distributed.

The second largest class of behaviour in the data was the Strategic class. This class did show concern for future distributional impacts in their own region, but also showed a positive preference for costs, which is in contrast to the expectations from standard theory.

We found that 17% of our sample conformed to the Warm Glow hypothesis and about 7% could be described as people that did not want additional climate policy (Do No More). Both of these classes show no sensitivity to the distributional impacts of climate policy, leaving about 77 % of our sample with concerns over the distributional impacts of climate change.

We thus find convincing indications that distributional preferences are relevant in describing the choice of climate policy, for a non-trivial share of a representative sample of the Danish population and that the majority of respondents in our sample prefer climate policies to secure lower impacts from climate change, for people who are already enduring economic hardship.

Preferences for co-benefits

The two social preference types were developed theoretically to encompass both the income effect attributes and the co-benefit attributes. So far the present discussion has mainly focused on the hypotheses with respect to the income loss attribute, given the main objective of this paper was to explore the empirical foundation for the use of social preferences in the Social Cost of Carbon. In all four classes a clear tendency of respondents to prefer to secure co-benefits in their own region, Western Europe, is observed and for the Inequity Averse Altruist class we find no indication of inequity aversion between Southeast Asia and Sub-Saharan Africa with respect to the co-benefits (Wald test of equality between coefficients, z value = 1.90). One could argue that attempting to confirm social preferences from both period 1 and 2 utility using the same set of assumptions is challenging, since the two periods are not entirely comparable. In period 1, the agent making the choice to allocate money to climate policy stands to gain a co-benefit himself, whereas the other component of climate policy, the future income losses, is not directly relevant for the agent making the choice now, since he/she will not be alive to experience this effect. So in the context of social preferences in period 2, social preferences are expressed on behalf of other, future individuals, whereas social preferences in period 1, contain a clear component of self-interest and self-involvement since the social preferences span a context where the decision-maker her/himself can gain something. It is therefore perhaps not too surprising that we find a clear tendency for respondents to favour co-benefits in the respondents' own region, Western Europe.

Caveats and future work

The reduced, strict social preferences typology introduced and tested is of course a subset of many possible social preferences relating to distributive impacts of climate change. Furthermore, it is also plausible that different social preferences might co-exist, and that people possess several different forms of social preferences in a given context, which we are not able to capture in our experimental design.

Another caveat is the complex context and hypothetical nature of the study and although great efforts were made to simplify and reduce the presentation, we cannot exclude that this might influence the behavioral patterns in our data. Indeed the proportion of respondents who appeared to have difficulties interpreting the choice sets was not negligible. While excluding these does not affect overall findings, it is not possible to say conclusively if their expression of preferences would be affected by a better understanding of the context and choices.

Our findings rely on a hypothetical Stated Preference technique, which limits the degree to which we can say that preferences are robust enough to carry over into the corresponding non-hypothetical context. Such a context is not easily produced, though, as policy motions affecting household taxes are never voted about directly in Denmark. Thus, any revealed preference attempts will have to pick a different and likely less attractive payment vehicle, e.g. donation.

Finally, our sample is restricted to a representative sample of the Danish population and we cannot know whether the preference patterns we identify are descriptive for other nationalities too. This of course is an important question to consider for the results to be broadly relevant for policy assessments. On that note it could be especially interesting to sample several different nationalities to investigate the possible differences in the valuation of distributional impacts from climate policy. Secondly, before such a practice is instigated, more work on the actual metric used to weigh distributional concerns is needed, since our study also indicated that these distributional concerns are likely to be heterogeneous in nature.

Policy relevance

Acknowledging the above limitations of the study, the policy relevance of our study is obvious. We find empirical support for the hypothesis that people, in our case Danes, care about and express preferences concerning the distributional impacts of climate policies affecting future generations in regions of disparate wealth. While limited to Danes, we expect that future studies inspired by this may confirm similar preference structures in other nations and countries.

The results thus lend empirical and context specific support to the practice of including equity weights or related adjustments for distributional impact of policies in the literature and research on climate policy design and evaluation. As this literature documents (Fankhauser, Tol et al. 1997, Pearce 2003, Johansson-Stenman 2005, Anthoff, Hepburn et al. 2009; Anthoff and Tol 2010) the policy consequences of this practice, relative to ignoring distributional impacts, are signficant notably in the developed world.

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Appendix – Supplementary Tables

Table 6. Descriptive statistics for attitude questions, percentage

Attitude questions	Agree	Partly agree	Partly disagree	Disagree
Warm Glow ” I did not pay that much attention to the size of the income effect, because I think the most important thing is just to do something”	21.89	43.67	25.22	9.23
Altruists ”When I made my choice, my objective was to support climate policies that secured the largest income gain, irrespective of which region this effect befell.”	17.34	39.85	28.17	14.64
Inequity Averse Altruists ”I often selected the climate policy that secured the highest income gain for the poor regions”	10.82	39.98	34.44	14.76
Own Income ”When making my choices, I assumed that I would also improve my own income during my lifetime, through supporting climate policies”	7.26	34.07	35.18	23.49
Bequest Value ”I made my choices thinking about my (future) grandchildren”	24.60	40.96	16.61	17.84

Table 7. Latent Class Model with imposed Warm Glow and Altruists restrictions

	Warm Glow		Do No More		Inequity Averse Altruists		Strategic	
Class size	0.17		0.06		0.60		0.17	
Explanatory variables	Coef	z	Coef	z	Coef	z	Coef	z
ASC	-1.022 (0.135)	-7.548	2.770 (0.817)	3.822	-3.438 (0.398)	8.638	-1.074 (0.435)	2.467
Income effect: *WE*	0.000 .	.	0.034 (0.028)	1.221	-0.029 (0.003)	11.232	-0.038 (0.007)	5.298
Income effect: *SEA*	0.000 .	.	0.034 (0.028)	1.221	-0.022 (0.004)	5.325	-0.017 (0.011)	1.495
Income effect: *SSA*	0.000 .	.	0.034 (0.028)	1.221	-0.078 (0.008)	9.521	0.024 (0.025)	0.955
Co-benefit: *WE*	0.599 (0.159)	3.765	0.274 (0.806)	0.340	1.771 (0.107)	16.515	0.779 (0.230)	3.387
Co-benefit: *SEA*	0.007 (0.141)	0.051	-1.325 (1.103)	1.200	1.024 (0.076)	13.524	0.531 (0.183)	2.905
Co-benefit: *SSA*	0.092 (0.158)	0.579	-0.275 (0.912)	0.031	1.173 (0.096)	12.264	-0.067 (0.245)	0.273
Price	-1.908 (0.159)	11.975	-0.101 (0.521)	0.195	-0.557 (0.070)	7.934	1.485 (0.229)	6.484
Model Statistics								
Number of individuals		813						
Choice task pr person		8						
LL		-4434						
BIC		9070						
R-squared		0.43						

Tabel 8. Latent Class Model with class membership function

	Inequity Averse Altruists		Strategic		Warm Glow		Do No More	
Class size	0.59		0.18		0.17		0.06	
Explanatory variables	Coef	z	Coef	z	Coef	z	Coef	z
ASC	-3.440 (0.445)	7.725	-1.130 (0.446)	2.536	-0.873 (0.202)	4.319	2.998 (0.824)	3.637
Income effect: *WE*	-0.029 (0.003)	10.746	-0.041 (0.008)	4.846	-0.005 (0.005)	1.157	0.016 (0.042)	0.384
Income effect: *SEA*	-0.021 (0.004)	5.081	-0.019 (0.011)	1.793	-0.013 (0.009)	1.578	0.046 (0.044)	1.042
Income effect: *SSA*	-0.078 (0.008)	9.460	0.020 (0.024)	0.850	-0.001 (0.017)	0.052	0.005 (0.084)	0.056
Co-benefit: *WE*	1.821 (0.107)	16.989	0.636 (0.231)	2.759	0.570 (0.166)	3.442	0.616 (0.984)	0.626
Co-benefit: *SEA*	1.042 (0.077)	13.521	0.517 (0.183)	2.818	-0.001 (0.149)	0.008	-0.973 (1.034)	-0.940
Co-benefit: *SSA*	1.190 (0.097)	12.311	-0.019 (0.243)	0.077	0.041 (0.178)	0.232	0.001 (0.831)	0.001
Price	-0.581 (0.073)	7.973	1.418 (0.218)	6.516	-1.959 (0.191)	10.236	-0.219 (0.549)	0.398
Class Membership Function								
Altruists	0.514 (0.158)	3.260	0.846 (0.234)	3.618	-0.335 (0.203)	1.648	-1.025 (0.290)	3.534
Own Income	-0.139 (0.143)	0.967	-0.448 (0.204)	2.201	0.664 (0.183)	3.637	-0.078 (0.256)	0.303
Bequest	0.253 (0.145)	1.742	0.495 (0.217)	2.277	-0.515 (0.190)	2.716	-0.233 (0.258)	0.903
Warm Glow	-0.097 (0.154)	0.633	0.980 (0.274)	3.580	-0.672 (0.193)	3.487	-0.211 (0.258)	0.816
Inequity Averse Altruists	0.293 (0.147)	1.996	0.664 (0.205)	3.236	-0.300 (0.200)	1.502	-0.657 (0.281)	2.337
Model Statistics								
Number of individuals	813							
Choice task pr person	8							
LL	-4366							
BIC	9067							
R-squared	0.43							

Table 9. Latent Class Model on subsample of respondent who answered the follow-up question correctly

	Inequity Averse Altruists		Strategic		Pro Climate Policy		Co-benefit in SEA	
Class size	0.58		0.24		0.09		0.09	
Explanatory variables	Coef	z	Coef	z	Coef	z	Coef	z
ASC	-3.985 (0.705)	5.653	-1.474 (0.419)	3.514	-1.883 (0.490)	3.841	0.573 (0.330)	1.737
Income effect: *WE*	-0.034 (0.004)	9.166	-0.031 (0.006)	4.904	-0.036 (0.012)	2.982	0.013 (0.009)	1.365
Income effect: *SEA*	-0.028 (0.006)	4.831	-0.011 (0.011)	0.990	-0.058 (0.020)	2.888	-0.007 (0.017)	0.437
Income effect: *SSA*	-0.098 (0.012)	8.293	0.038 (0.026)	1.458	0.006 (0.050)	0.116	0.042 (0.035)	1.189
Co-benefit: *WE*	1.939 (0.142)	13.620	0.988 (0.235)	4.198	0.633 (0.508)	1.245	0.502 (0.296)	1.698
Co-benefit: *SEA*	1.048 (0.103)	10.180	0.758 (0.191)	3.971	-0.259 (0.380)	0.775	-0.944 (0.351)	2.688
Co-benefit: *SSA*	1.315 (0.133)	9.868	0.323 (0.242)	1.335	-0.699 (0.419)	1.670	-0.335 (0.306)	1.096
Price	-0.652 (0.084)	7.740	1.136 (0.186)	6.094	-4.469 (0.692)	6.460	-1.094 (0.274)	3.995

Model Statistics	
Number of individuals	518
Choice task pr person	8
LL	-2651
BIC	5522
R-squared	0.47

Table 10. Latent Class Model with RPL specification for the co-benefits and price attributes

	Pro Climate Policy		Inequity Averse Altruists		Own Income Effect		Do No More	
Class size	0.56		0.21		0.18		0.05	
Explanatory variables	Coef	z	Coef	z	Coef	z	Coef	z
ASC	-3.602 (0.454)	7.937	-2.862 (2.609)	1.097	-0.302 (0.197)	1.539	4.722 (0.878)	5.378
Income effect: *WE*	-0.024 (0.003)	7.086	-0.105 (0.014)	7.734	-0.012 (0.005)	2.486	0.077 (0.091)	0.844
Income effect: *SEA*	-0.006 (0.005)	1.118	-0.076 (0.013)	5.933	-0.006 (0.008)	0.670	0.004 (0.079)	0.051
Income effect: *SSA*	-0.029 (0.011)	2.698	-0.330 (0.058)	5.686	0.008 (0.017)	0.452	-0.013 (0.133)	0.099
RPL – across all classes								
Co-benefit: *WE (mean)*	1.315 (0.074)	17.725						
Co-benefit: *WE (sigma)*	0.067 (0.135)	0.496						
Co-benefit: *SEA (mean)*	0.826 (0.058)	14.362						
Co-benefit: *SEA (sigma)*	0.234 (0.104)	2.251						
Co-benefit: *SSA (mean)*	0.776 (0.071)	10.912						
Co-benefit: *SSA (sigma)*	0.070 (0.125)	0.560						
Price (mean)	-0.494 (0.080)	-6.142						
Price (sigma)	1.345 (0.077)	17.595						
Model Statistics								
Number of individuals		813						
Choice task pr person		8						
LL		-4389						
BIC		8960						
R-squared		0.51						