Voting Between Social Justice and Rewarding Pro-environmental Behaviour - An Experimental Framework

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1 Introduction

Tackling climate change requires a drastic reduction in greenhouse gas emissions. The transport sector is the first emitting sector in France in 2023 and the second in the European Union in 2022 (Baude et al., 2024). To reduce these emissions, a shift in behaviour is needed: more efficient use of private vehicles (such as car-pooling) or more environmentally friendly means of transport (such as public transport). To encourage this shift, carbon pricing is an effective tool and may even be essential (Stiglitz et al., 2017). Carbon taxation, with a cap-and-trade system, is the main policy option when considering carbon pricing. However, a carbon taxation policy can play a crucial role in reducing greenhouse gas emissions where the EU ETS does not apply, such as private car transport.

However, public acceptance is key to this type of policy, as new tax implementation can face rejection, and environmental taxation such as the carbon taxes are no exception to this. These considerations are particularly striking in France, where public opposition led to the failure of a carbon tax (Douenne and Fabre, 2022; Fabre et al., 2023). Our work focuses on carbon taxation policy, and in particular, in the context of urban commuting.

Various studies have been conducted to identify the factors that explain opposition to carbon taxes. We present here a non-exhaustive list of these factors. The mere label "tax" exposes these mechanisms to tax aversion (Kessler and Norton, 2016). Taxes suffer from misperception at various levels. For example, carbon taxes aim to reduce greenhouse gas emissions, but their environmental effectiveness is often not well perceived (Carattini et al., 2018). Citizens also tend to misperceive the monetary impact of carbon taxes, overestimating the negative impact on their purchasing power (Douenne and Fabre, 2022). This overestimated impact comes with a perceived risk of exacerbating poverty (Dresner et al., 2006), a risk that is not necessarily false: carbon taxes can be regressive (Owen and Barrett, 2020; Wang et al., 2016). Mistrust in the political institution also has a negative impact on tax acceptance, since acceptance also requires trust that the government will use tax revenues appropriately (Baranzini and Carattini, 2017; Barrez, 2024). It goes hand in hand with the misperception of efficiency mentioned above: carbon pricing is often seen as a way to increase the general budget of the government, rather than as a way to reduce greenhouse gas emissions (Dresner et al., 2006; Sommer et al., 2022). The fear of a mechanism that exacerbates poverty is a factor that can increase the perceived unfairness of carbon taxes. Fairness encompasses more than the issue of social justice, but if a policy is perceived as unfair, for whatever reason, it can also hinder public acceptance (Sommer et al., 2022; Ewald et al., 2022; Dechezleprêtre et al., 2025). To avoid this, various institutions agree on a just transition, even if its application is not clearly defined (Galanis et al., 2025).

There are different frameworks for addressing justice in the environmental transition, which differ in the different aspects of justice defined. The distributive aspect of justice seems to always be a major dimension of a just transition (McCauley and Heffron, 2018; Krüger, 2022; Jose Carlos Cañizares and Doorn, 2024). Distributive justice relate to justice in the distribution of outcomes (Cook and Hegtvedt, 1983; Paavola and Adger, 2002). In the case of a carbon taxes, outcomes are both the environmental and monetary outputs. In the following we will focus on the tax monetary output. We will explore whether or not different revenue recycling procedure aimed at providing a just redistribution of outcome can enhance public acceptability for a carbon tax.

It the classic economy theory, states' taxation and spending are only to be considered through cost-effectiveness. The classic use of tax revenue is therefore to allocate it to the general government budget, as it allows for their flexible use among competing purposes (Musgrave and Musgrave, 1989). In this matter, other revenue usage can be consider as sub-optimal. However, in order to tackle public acceptance, other revenue usage should be explored.

Revenue recycling is usually divided in three main mechanisms : earmarking, tax reform and redistribution (Barrez, 2024; Carattini et al., 2018; Maurice et al., 2013; Rouaix et al., 2015). The fourth tax usage being an inclusion to the general budget, as classically prescribed. These categories are aggregated, and can be developed in further detail (Mohammadzadeh Valencia et al., 2024; Barrez, 2024).

Earmarking correspond to a pre-commitment to use tax revenue towards specific purposes. In the case of environmental earmarking, tax revenue is directed for environmental usage: new infrastructures, low-carbon technologies, environmental damage remediation, etc. The interest of earmarking is solving two issues: mistrust in institutions and underestimation of carbon tax's environmental efficiency. Revenue usage is public, showing that it is not misused and making the environmental benefits more salient(Carattini et al., 2018). Through many studies, environmental earmarking show positive effect on acceptance (Barrez, 2024; Carattini et al., 2018; Mohammadzadeh Valencia et al., 2024). However, earmarking may be more popular with a section of the population that is already more supportive of carbon taxes, running the risk of polarizing the social support (Sommer et al., 2022; Tatham and Peters, 2023). Additionally, environmental earmarking are less perceived has a way to reduce the tax regressivity, leading advocates of earmarking to support lower tax levels to prevent too much fiscal pressure on poorer households (Sommer et al., 2022). Nevertheless, environmental earmarking appears to be one of the favourite revenue recycling options to increase public acceptance of carbon taxes (Maestre-Andrés et al., 2021; Sommer et al., 2022; Barrez, 2024).

An other tax revenue recycling option is to conduct a tax reform. The principle is to have tax reduction equivalent to the new carbon taxes: the overall tax level is maintained but with a shift from labour, capital and consumption to activities harmful for the environment. This shift aims at reducing GHG emissions while introducing a positive effect on the economy: it is the double dividend hypothesis (Freire-González and Ho, 2018). However, this hypothesis is not well known, or sceptically perceived and therefore have small to no effect on public acceptability (Dresner et al., 2006). This revenue recycling option is usually less supported than earmarking and tax revenue redistribution (Sommer et al., 2022; Barrez, 2024).

The last considered revenue recycling option is tax revenue redistribution. The idea is to used tax revenue to reduce the impact of the carbon tax on the lower income household. Fairness is an important concern when considering carbon taxes (Carattini et al., 2018; Dechezleprêtre et al., 2022), and mechanisms that allocate a higher burden to higher income households and a lower burden to lower income households are usually preferred (Barrez, 2024). Tax carbon literature tackle two different redistribution methods: social cushioning and lump-sum transfer. Social cushioning address the potential regressive nature of carbon taxes by reallocating tax revenue to low income household. Even if social fairness is often stated as a main concern (Ewald et al., 2022; Carattini et al., 2018), positive social cushioning often fails to show significant effect on acceptance (Sælen and Kallbekken, 2011; Hammerle et al., 2021; Sommer et al., 2022). However, some studies still find a positive effect of social cushioning on tax acceptability (Carattini et al., 2017; Maestre-Andrés et al., 2021; Dechezleprêtre et al., 2022). Lump-sum transfer corresponds to a uniform redistribution of tax revenues, and can in some cases reduce or eliminate the regressivity of carbon taxes (Carattini et al., 2018). This revenue recycling option shows mixed effect: with either positive effect (Carattini et al., 2017; Nowlin et al., 2020; Maestre-Andrés et al., 2021) or no effect (Sommer et al., 2022; Ewald et al., 2022; Dechezleprêtre et al., 2022). Maestre-Andrés et al. (2021) shows that a lump-sum redistribution can show higher effect on perceived fairness than social cushioning. The authors establish a link between perceived fairness and perceived personal gain, suggesting that an important element of the perceived fairness of a policy is that individuals see it as fair to themselves. Overall redistribution mechanism seems to perform better than a general budget inclusion and a tax reform, but worse than environmental earmarking (Barrez, 2024). In this article, we will examine the effects of these different redistribution schemes.

This literature is mainly built on stated preference methodology, with a large part of them relying on survey data Barrez (2024). As explained in Cherry et al. (2012) these methods "might not effectively disentangle material interests from possible behavioural influences". We propose a laboratory experiment to elicit the redistribution effect on acceptability. The monetary incentives enable a control for material interests and subsequently to identify the impact of redistribution schemes on acceptability.

Our experiment follow a design similar to the one developed in Kallbekken et al. (2011) and in a forthcoming experiment (the pre-registration is available on the AEA RCT Registry website [1]). Participants engage in a repeated mode choice game; each round they are asked to choose between using a low cost private vehicle or a higher cost public transport. Private cars are the source of two externalities: congestion borne by the driver and pollution borne by everyone. Our participants are divided into two categories with different travel costs, creating inequity. The travel costs and externalities are such that the Nash equilibrium deviates from the social optimum. A Pigouvian tax is introduced to solve this social dilemma. We propose three different mechanisms to redistribute the tax revenue. In addition to social cushioning and lump-sum redistribution, we also consider a redistribution treatment that favours environmentally friendly behaviour. This last treatment is a midway point between redistribution and environmental earmarking: it isn't earmarked for environmental purposes, but is given directly to the household, and it isn't conditional on income, but is given to the less polluting households. This environmental redistribution lack in regard to social justice but should enhance the saliency of the environmental effect of the taxes. Participants' support for each mechanism is elicited before and after its implementation. Participants have access to feedback information in each round. Our experiment is designed to assess the initial preference for a mechanism and whether it's implementation causes a revision in preference.

In their experiment, Kallbekken et al. (2011) propose a market experiment with heterogeneous resale values and pollution externalities. They implement a Pigouvian tax with either lump-sum redistribution or redistribution to either polluters or victims. They find preferences for group-based redistributions, which are also a mechanism for reducing inequality. However, participants were assigned a role in pollution (polluter and/or victim) and couldn't switch between them. We are interested in behaviour change from carbon intensive transport to low carbon transport. Our design will not directly create group identification in externality production. Therefore we may have a finer explanation of the preference

[1] `https://www.socialscienceregistry.org/trials/13408`

for group-based redistributions described in Kallbekken et al. (2011): group identification is related to high or low travel costs, which in our calibration are independent of polluting behaviour. But we may still observe preferences of some respondents depending on their mode choice (i.e. polluting behaviour). Many other experiment were built upon Kallbekken et al. (2011) designs (Cherry et al., 2012, 2014, 2017; Heres et al., 2017; Janusch et al., 2021; Huang and Xiao, 2021; Andreassen et al., 2024; Dupoux and Ouvrard, 2023). These other studies focuses on different dimension of social acceptability of market regulation and in particular taxation: comparison of different settings including subsidies or quantity regulations, part of revenue redistributed through lump-sum mechanism, group communication and peer pressure, etc. However none of these other studies are aimed at assessing acceptability for different tax revenue recycling options.

The originality of our experiment is to bridge the gap between the laboratory experiment literature and the revenue recycling literature. We provide a factorial design that allows us to explore the relationship between transport cost inequalities and different options for recycling carbon tax revenues. We have shown in a forthcoming experiment that tax implementation has an effect on acceptance only the first time, even if the tax is different. We want to see whether this result can be applied to redistribution mechanisms. We also ought to see whether pro-social preferences can lead to greater acceptance of mechanisms with lower expected payoffs if they favour the less advantaged. Finally, we want to identify the determinant of preferences for the three different mechanisms.

The following work highlights the outline of a future experiment. In section 2 we describe the theoretical framework behind the experiment. Section 3 covers the design of the experiment: the procedure, the calibration, and the predicted bids and usages. The theoretical hypothesis we will test is presented in section 4.

2 Theoretical background

2.1 The externality game

2.1.1 Notations, definitions and assumptions

We consider two populations r and p with different transportation cost.

- $C_{V,r}$: transportation costs arising from private vehicle use for the population r,
- $C_{V,p}$: transportation costs arising from private vehicle use for the population p,
- $C_{T,r}$: transportation costs arising from the use of public transport for the population r,
- $C_{T,p}$: transportation costs arising from the use of public transport for the population p,
- q_r, q_p : PV traffic for the population r and for the population p respectively,
- n_r, n_p : total number of transport users for the population r and for the population p respectively,
- $t_{V,r}$, $t_{V,p}$: temporal cost cost to a user of using a PV for the population r and for the population p respectively,
- $t_{T,r}$, $t_{T,p}$: temporal cost (constant) of using public transport for the population r and for the population p respectively,
- α_r, α_p : private fixed cost of private vehicle use for the population r and for the population p respectively,

- β : marginal cost of congestion externality linked to PV traffic,
- γ : marginal cost of pollution externality linked to PV traffic,
- ρ : share of the common path between the two populations.

The users' choice is between a private vehicle, for which the total cost per user is c_B, and public transport, for which the cost is c_H.

Three hypothesis have been formulated :

1. the cost of local pollution and global warming is borne by transport users, regardless of their mode of transportation;
2. the cost of traffic congestion is borne only by private vehicle users (option 1), and there is no congestion on public transport (option 2);
3. in each population users are homogeneous, and the technologies used to produce external effects are identical.

The temporal (private) costs of using these modes are, for each population :

$$t_{V,r} = \alpha_r + \beta(1-\rho)q_r + \beta\rho(q_r + q_p) \tag{1}$$
$$t_{V,p} = \alpha_p + \beta(1-\rho)q_p + \beta\rho(q_r + q_p) \tag{2}$$
$$t_{T,r} = T_r \tag{3}$$
$$t_{T,p} = T_p \tag{4}$$

The individual cost functions for private vehicle use for each population, including private and external costs, are as follows :

$$C_{V,r} = \alpha_r + \beta(1-\rho)q_r + \beta\rho(q_r + q_p) + \gamma(q_r + q_p) \tag{5}$$
$$C_{V,p} = \alpha_p + \beta(1-\rho)q_p + \beta\rho(q_r + q_p) + \gamma(q_r + q_p) \tag{6}$$

The individual cost functions for public transport use, including private and external costs for each population, are :

$$C_{T,r} = T_r + \gamma_r * (q_r + q_p) \tag{7}$$
$$C_{T,p} = T_p + \gamma_p * (q_r + q_p) \tag{8}$$

2.1.2 Balance without taxes

Following Hartman (2012) reasoning, at traffic equilibrium, transport costs must be equalized internally across all population (Wardrop-Nash equilibrium). This principle gives :

$$\alpha_r + \beta(1-\rho)q_r + \beta\rho(q_r + q_p) + \gamma * (q_r + q_p) = T_r + \gamma * (q_r + q_p) \tag{9}$$
$$\alpha_p + \beta(1-\rho)q_p + \beta\rho(q_r + q_p) + \gamma * (q_r + q_p) = T_p + \gamma * (q_r + q_p) \tag{10}$$

Using Equations 9 and 10, we obtain the equilibrium for private vehicle traffic for population r and p respectively :

$$\widehat{q_r} = \frac{1}{(1-\rho^2)\beta}(T_r - \alpha_r - \rho(T_p - \alpha_p)) \tag{11}$$

$$\widehat{q_p} = \frac{1}{(1-\rho^2)\beta}(T_p - \alpha_p - \rho(T_r - \alpha_r)) \tag{12}$$

2.1.3 The optimal allocation of traffic

A carbon tax policy aim is to minimize the sum of travel cost, given by:

$$\begin{aligned} CTT \; = \; & q_r(\alpha_r + \beta(1-\rho)q_r + \beta\rho(q_r + q_p) + \gamma * (q_r + q_p)) + \\ & q_p(\alpha_p + \beta(1-\rho)q_p + \beta\rho(q_r + q_p) + \gamma * (q_r + q_p)) + \\ & (n_r - q_r) * (T_r + \gamma * (q_r + q_p)) + \\ & (n_p - q_p) * (T_p + \gamma * (q_r + q_p)) \end{aligned} \tag{13}$$

The first partial derivatives with respect to the PV uses q_r and q_p are :

$$\frac{\partial CTT}{\partial q_r} = 2\beta(q_r + \rho q_p) + \alpha_r - T_r + (n_r + n_p)\gamma \tag{14}$$

$$\frac{\partial CTT}{\partial q_p} = 2\beta(q_p + \rho q_r) + \alpha_p - T_p + (n_r + n_p)\gamma \tag{15}$$

The second derivative being positive (β), the roots of the derivatives give us the sum of total costs minima. We obtain the optimal private car usage value for each population:

$$q_r^* = \frac{T_r - \alpha_r - (n_r + n_p)\gamma(1-\rho) - \rho(T_p - \alpha_p)}{2\beta(1-\rho^2)} \tag{16}$$

$$q_p^* = \frac{T_p - \alpha_p - (n_r + n_p)\gamma(1-\rho) - \rho(T_r - \alpha_r)}{2\beta(1-\rho^2)} \tag{17}$$

2.1.4 Pigouvian Taxes

(a) Lump-sum and social cushioning

In both the lump-sum and social cushioning cases, the redistribution value does not change whether the participant chooses public transport or the private car. Therefore, the redistribution scheme has no impact on the optimal tax value. The different redistribution terms are given in Appendix 8.

To determine the optimal tax level, we equalise the total cost of private car use at the optimal traffic level, including the taxes, and the total cost of public transport use at the optimal traffic level. We consider one tax level by population:

$$\alpha_r + \beta q_r^* + \beta\rho q_p^* + \gamma(q_r^* + q_p^*) + p_r = T_r + \gamma(q_r^* + q_p^*) \tag{18}$$

$$\alpha_p + \beta q_p^* + \beta\rho q_r^* + \gamma(q_r^* + q_p^*) + p_p = T_p + \gamma(q_r^* + q_p^*) \tag{19}$$

Using Equations 16 and 17 we obtain the pigouvian taxes:

$$p_r = \frac{T_r - \alpha_r + (n_r + n_p)\gamma}{2} \tag{20}$$

$$p_p = \frac{T_p - \alpha_p + (n_r + n_p)\gamma}{2} \tag{21}$$

$$\tag{22}$$

(b) Environmental redistribution

In the calibration scheme, the redistributed revenue is directed at public transport users. Therefore we need to include the redistributed revenue in the equation at optimum:

$$\alpha_r + \beta q_r^* + \beta\rho q_p^* + \gamma(q_r^* + q_p^*) + p\_env_r = T_r + \gamma(q_r^* + q_p^*) - \frac{p\_env_r * q_r^* + p\_env_p * q_p^*}{n_r + n_p - (q_r^* + q_p^*)} \tag{23}$$

$$\alpha_p + \beta q_p^* + \beta\rho q_r^* + \gamma(q_r^* + q_p^*) + p\_env_p = T_p + \gamma(q_r^* + q_p^*) - \frac{p\_env_r * q_r^* + p\_env_p * q_p^*}{n_r + n_p - (q_r^* + q_p^*)} \tag{24}$$

Using Equations 16 and 17 we obtain the pigouvian taxes:

$$p\_env_r = \frac{(T_r - \alpha_r + (n_r + n_p)\gamma) * (n_r + n_p - (q_r^* + q_p^*)) + q_p^*(T_r - T_p - \alpha_r + \alpha_p)}{2(n_r + n_p)} \tag{25}$$

$$p\_env_p = \frac{(T_p - \alpha_p + (n_r + n_p)\gamma) * (n_r + n_p - (q_r^* + q_p^*)) + q_r^*(T_p - T_r - \alpha_p + \alpha_r)}{2(n_r + n_p)} \tag{26}$$

2.2 The referendum game

In order to elicit support for the different distribution mechanisms, we will use the voting procedure presented by Horowitz (2006) and described in detail by Messer et al. (2010). This procedure enable for a continuous expression of willingness to pay which provide a finer measure of acceptance than the binary voting procedure used in Kallbekken et al. (2011); Cherry et al. (2012, 2014, 2017); Janusch et al. (2021); Heres et al. (2017); Huang and Xiao (2021); Andreassen et al. (2024); Dupoux and Ouvrard (2023). This voting procedure called group format elicitation procedure (Denant-Boemont et al., 2021) or random price voting mechanism (Messer et al., 2010), follow the procedure:

1. Each participant are given an initial endowment E. From that amount they decide a bid $b \in [0, E]$, that express their support for a policy, in our case a tax with a redistribution mechanism.

2. A number R is randomly drawn in $]0, E[$. If the median bid is greater than this randomly drawn value, then the policy is accepted. In that case each participant pays R and win $E - R$. If the median value is lower than the drawn value, then the policy is rejected and participants win E.

Figure 1 show the bid mechanism principle. If the randomly drawn value $R \in]0, E[$ fall in $]0, Med_{sup}[$, then at least half the bid are higher and the policy is accepted, otherwise less than half the bid are higher and the policy is rejected.

As shown in Messer et al. (2010), this procedure is incentive-compatible. In our experiment, each voting step is divided into three different referendum games: one for each redistribution mechanism. The voting step is repeated three times, once after each stage. To determine the policy implemented in the final stage (stage 4), we randomly draw one referendum game out of the nine played and implement its result.

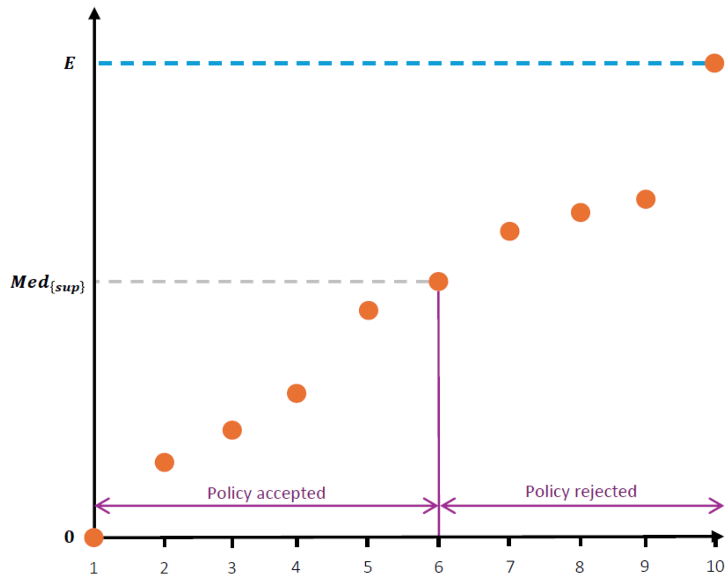

Figure 1: Bid mechanism

3 Design, experimental treatments, calibration

Our experimental sessions are randomly divided into two categories: one half of the participants will experience social cushioning, and the other half will experience environmental redistribution. An experimental session is divided in four steps: the main game, elicitation of inequity aversion, psycho-social questionnaires and an ex-post experimental questionnaire. During the main game, participants will be randomly divided into two groups of equal size. Participants will only interact with other participants of the same group. Participants first play an externality game consisting of repeated transport mode choices. Then, in a referendum game, they express their preferences for the different redistribution mechanisms.

3.1 The initial effort task

Drawing on Brent et al. (2019) experiment, we introduce an effort task to divide participants into two subgroups with different travel costs: a group with advantageous travel cost and one with disadvantageous ones. We use an encryption similar as the one used in Erkal et al. (2011) and Brent et al. (2019). Participants have 5 minutes to translate a text in number helped by a correspondence table associating letters to number. The task is not monetised to prevent wealth effect, but participants are informed that their performance will affect their future payoffs. At this point no information is given about the next games to prevent any unwanted effect, such a selection bias. The best performers in the task are assigned to the low travel cost group (population r) and the worst performers are assigned to the high cost group (population p).

The rest of the main game is inspired by the two-step design of Janusch et al. (2021).

3.2 The experimental sequence

The sequence follows a different setting depending if the session is a "social cushioning session" or an "environmental redistribution sequence". In both cases, the experiment is divided into three different policy implementations, called stages:

1. A no tax policy, corresponding to a business-as-usual situation,
2. A Pigouvian tax implementation with lump-sum redistribution,
3. A Pigouvian tax implementation with either social cushioning or environmental redistribution, depending on the session.

The game always starts with a situation without tax, but to control for possible order effects, the two situations with tax are played in one order for half of the participants and the other for the other half. To help participants understand how the experiment works, we include two trial periods before the no tax stage. Figure 2 corresponds to one possible sequence for both session settings.

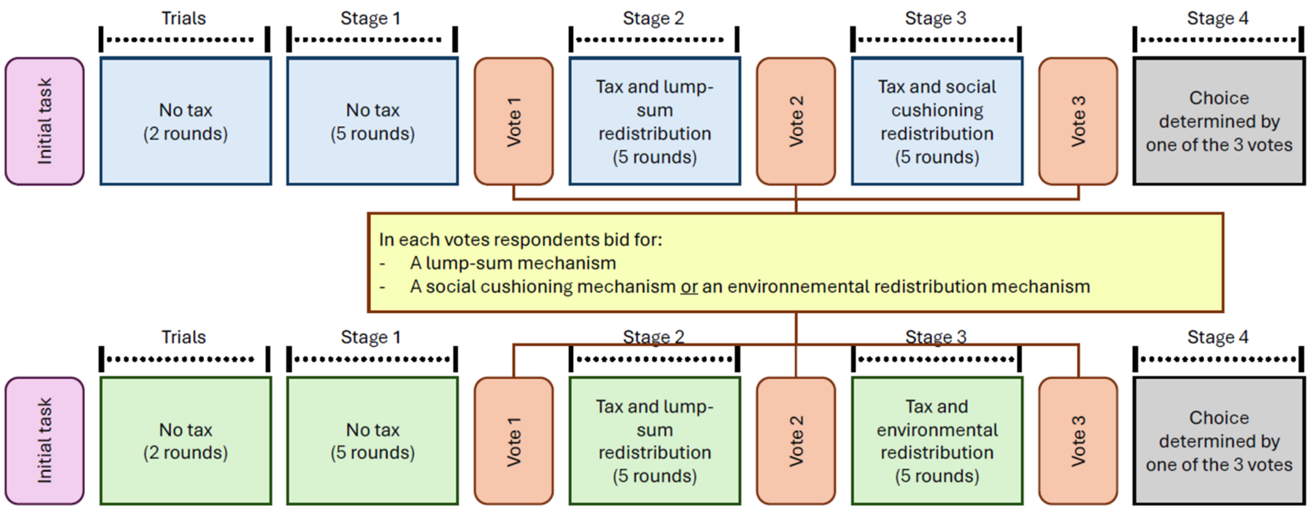

Figure 2: The two experimental sequences for one possible order

3.3 The referendum game

During the voting procedure, participants play three different referendum game games, one for each possible policy. For each referendum game, participants are given 20 Experimental Currency Units (ECUs) to bid for the proposed policy. Each policy correspond to a full policy: the tax and the redistribution mechanism. In case of rejection no policy is applied, which correspond to the no tax treatment. The three referendum game are displayed in random order to control any order effect.

3.4 Calibration and Theoretical Predictions

3.4.1 Calibration and externality game prediction

To prevent cognitive burden on participants, calibration should be simple and easily understandable. We determine a set of parameter using the theoretical model describe above. We opt for a calibration with equal taxation level between the two population. The proposed set of parameter is given in the following Table 1:

$n_r = n_p$	T_r	T_p	α_r	α_p	β	γ	ρ	$\widehat{q_r} = \widehat{q_p}$	$q_r^* = q_p^*$	$p_r = p_p$	$p\_env_r = p\_env_p$
5	**35**	**45**	**10**	**20**	**4**	**0.5**	**0.25**	**5**	**2**	**15**	**9**

Table 1: Calibration of experimental parameters

3.4.2 Calibration and referendum game prediction

With our calibration, we can calculate the travel cost in the different treatment and for the different population. Participants start each round with an initial endowment of 60 points, from which are deducted their travel costs to find their profit. Table 3.4.2 gives the predicted cos and profit at equilibrium:

Treatment	No Tax	Tax and lump-sum redistribution	Tax and social cushioning	Tax and environmental redistribution
Cost at equilibrium (population r)	40	31	36	31
Cost at equilibrium (population p)	50	41	36	41
Profit at equilibrium (population r)	20	29	24	29
Profit at equilibrium (population p)	10	19	24	19

Table 2: Theoretical predicted equilibrium for the different tax treatments

The difference in payoffs between the no-tax treatment and the different redistribution treatments gives the expected gain from implementing the treatment. In the referendum game, participants bid to implement the different treatment. In doing so, they express their willingness to pay for the different redistribution mechanisms. By appropriately selecting the conversion rate of both the points earned in the externality game and the Ecus from the referendum game, the theoretical willingness to pay (in Ecus) for a treatment corresponds to the expected gain for that treatment. The different theoretical bid are given in Table 3.4.2

Treatment	Tax and lump-sum redistribution	Tax and social cushioning	Tax and environmental redistribution
Predicted bid (population r)	9	4	9
Predicted bid (population p)	9	14	9

Table 3: Theoretical predicted equilibrium for the different tax treatments

4 Behavioral conjectures and hypothesis tested

4.1 Support for specific tax revenue redistribution

First we suggest three set of hypothesis regarding redistribution mechanism:

- **Hypothesis 0 - Policy efficiency**:

  a. The private vehicle usage is lower when a tax is implemented, than when none are.

- **Hypothesis 1 - Tax implementation effect**:

  a. The acceptance of the lump-sum mechanism will increase after the first redistribution mechanism implementation.
  b. The acceptance of the social cushioning mechanism will increase after the first redistribution mechanism implementation.
  c. The acceptance of the environmental redistribution mechanism will increase after the first redistribution mechanism implementation.

- **Hypothesis 2 - Profit maximization**:

  a. Participant in population p will have higher acceptance for the cushioning mechanism.
  b. Participant in population r will have lower acceptance for the cushioning mechanism.
  c. The lump-sum and environmental redistribution treatments will have same level acceptance.

4.2 Inequity aversion mechanism

Our experiment introduces heterogeneous payoffs between participants. Moreover, the different redistribution mechanism may grant heterogeneous redistributed values. These two levels of heterogeneity can lead to the perception of inequity. Participants' sensitivity to payoff inequities has been well studied, in particular in bargaining situations(Bellemare et al., 2008). To investigate this effect, we estimate inequity aversion using the methodology explained in Blanco et al. (2011). In this method participant pass both an ultimatum bargaining game and a dictator game to estimate the coefficient in the utility function with inequality aversion base on Fehr and Schmidt (1999) model:

$$U_i\left(x_i, x_j\right) = \begin{cases} x_i - \alpha_i(x_j - x_i), & \text{if } x_i \leq x_j, \\ x_i - \beta_i(x_i - x_j), & \text{if } x_i > x_j \end{cases} \tag{27}$$

where $U(x_i, x_j)$ is the utility of player i for a monetary payoff x_i and for the other player j payoff x_j. α_i is the coefficient of disadvantageous inequality aversion whereas β_i is the coefficient of advantageous inequality aversion.

We follow Blanco et al. (2011) procedure: participants first play a dictator game with a randomly drawn partner. They then take part in an ultimatum bargaining game in which each participant proposes a way to divide a monetary endowment between themselves and a potential partner. Each participant also decides whether to accept each possible sharing rule. Participants are then randomly paired, one as the offerer and the other as the receiver. If the sharing rule proposed by the offerer is one of the rules accepted by the receiver, then it is implemented, otherwise both participants receive no payoff.

We are interested in the influence of inequity aversion on respondents' acceptance of social cushioning. We propose the following:

- **Hypothesis 3 - Social cushioning**:
  a. Participant in population r with high disadvantageous inequality (α_i), will have lower acceptance for social cushioning.
  b. Participant in population r with high advantageous inequality (β_i), will have higher acceptance for social cushioning.
  c. Participant in population p with high disadvantageous inequality (α_i), will have higher acceptance for social cushioning.

4.3 Psychological construct

To the previous hypotheses, we will add a set of hypotheses corresponding to the effects of psychosocial characteristics on bids.

- **Hypothesis 4 - Effect on bidding for taxes**:
  a. Participants with high levels of perceived legitimacy of redistribution mechanisms and environmental concern show greater support for environmental taxes, regardless of the redistribution mechanism.

- **Hypothesis 5 - Specific effect:** :
  a. Participants with low levels of system justification and subjective social status show a higher level of bidding for social redistribution.
  b. Participants with high levels of environmental concern show greater support for environmental redistribution.

5 Statistical method and power analysis

5.1 Statistical analysis

All the hypothesis, other from hypothesis 0, focus on the effect of treatments and participants characteristics on policy support. Policy support is assessed through participants' bids for policy implementation.

5.1.1 Hypothesis 0 - Policy efficiency

Hypothesis 0 require testing the evolution share of private vehicle user after tax implementation. This will be done using a one-sided Wilcoxon signed-rank test.

5.1.2 Hypothesis 1 - Tax implementation effect

Hypothesis 1 requires testing participants' bids before a policy implementation against the bids after the policy implementation. This "within" design create matched data sample. We will therefore rely on one-sided Wilcoxon signed-rank tests to determine the policy effect.

5.1.3 Hypothesis 2 - Profit maximisation

Hypothesis 2 requires testing participants' bids in one population against the other. Since we don't give participants feedback on other participants' bids after the referendum game, they can't adjust their voting strategy to other real bids. Participants can only bid based on their hypothesis of what others will bid. Therefore, it is not absurd to consider that each participant bids are independent from other participants bids.

Under this assumption, we will rely on Wilcoxon rank-sum test to test this hypothesis.

5.1.4 Other hypothesis

Hypotheses 3 to 5 examine the impact of individual characteristics on their bidding behaviour. These characteristics are measured as pseudo-continuous variables. To test these hypotheses, we consider a modelling framework. To account for bid limits and the panel nature of our data, we propose a random effects Tobit model.

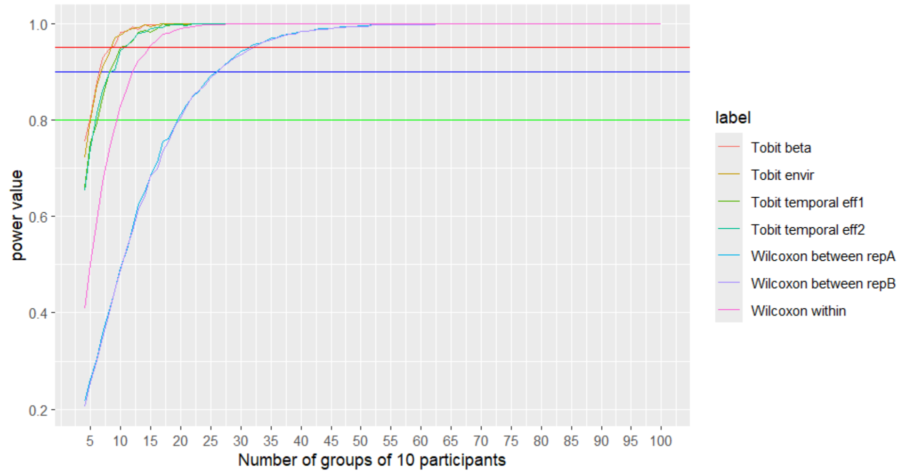

Figure 3: Caption

From this Tobit model we test whether the marginal effect of the model parameter is significantly different from 0.

5.2 Power analysis

Our hypothesis requires the analysis of two outcomes: the share of private vehicle use and participants' bid for redistribution mechanisms. Our previous experiment [2] rely on similar analysis. We will rely on this first experiment to conduct our power analysis.

The first experiment rely on a biding between 0 and 10 ECUs for policy support, where this current experiment allow a biding between 0 and 20. To simplify the use of the first experiment data for policy support testing, we will conduct our power analysis on a 0 to 10 scales with a Smallest Effect Size Of Interest (SESOI) divided by two.

First, we define the smallest effect size of interest for both outcomes. For policy support we consider a SESOI, of 10% of the maximum bids, which correspond to a two ECUs marginal effect. Therefore in our power analysis we will use a one ECU marginal effect, to account for the 0 to 10 scale used in the power analysis. For private vehicle use, we consider the effect of one change in transport mode per person, which equates to two changes in transport mode choice per group.

We rely on the previous experiment to simulate realist outcomes, from which we compute the power analysis using a Monte Carlo method. Data are simulated using the previously defined smallest effect size of interest.

We consider a value of $\alpha = 0.05$ as a first error risk (ie : maximum p-value to reject H0). To account for the different tests, we use a Bonferroni correction in our analysis.

Figure 3 illustrate the variation of the estimated power of our tests depending on the number of groups of ten participants.

Twenty groups should give us a power above the 0.8 threshold for all tests. Therefore, we will consider twenty groups for each of our two treatments, making a total of forty groups of ten people.

However, we have not considered the required power for Hypothesis 0 here. Our previous experimental data showed a very significant effect of taxes on car usage. Therefore, with a reasonable effect

[2] Pre-registration available on the AEA RCT Registry website `https://www.socialscienceregistry.org/trials/13408`

size of one car variation, a power threshold of 0.8 is obtained with very few groups.

6 Conclusion

A carbon tax could be a necessary instrument to decarbonise the transport sector. But it's also one that is likely to be rejected by the public. Among the many reasons that may explain this resistance, two important dimensions are the underestimation of the environmental effectiveness of a carbon tax and the perceived unfairness of this type of tax. One possible solution to increase acceptance is revenue recycling. The literature on this topic relies mainly on survey methodology. We contribute to the literature by proposing a laboratory experiment to investigate the impact of revenue recycling on the acceptability of a carbon tax. Our experiment builds on the design of Janusch et al. (2021) and Hartman (2012) in a setting with heterogeneous travel costs and multiple redistribution mechanisms. In their article, Janusch et al. (2021) develop a route choice laboratory experiment with congestion externalities and Pigouvian taxes. Similarly, we consider a mode choice laboratory experiment with a congestion externality borne by private car users and add a pollution externality affecting all participants. We introduce three redistribution options: lump-sum redistribution, social cushioning, which addresses social fairness, and environmental redistribution, which addresses perceptions of environmental efficiency.

Albeit the "pure" economic model tells us that only the expected payoff should influence bids for the redistribution mechanism, we might find different results. In fact, prospect theory (Kahneman and Tversky, 1979), suggests that preferences are dynamically constructed depending on the decision context. Therefore, we might observe an influence on the way the redistribution mechanism works on preferences and not only an influence on payoffs.

We hope that this experiment will enable us to make recommendations to policymakers on some of the determinants of carbon tax acceptability. Tax revenue recycling Recycling of tax revenues is an often discussed issue, especially in the context of achieving a just transition. This future laboratory experiment may shed more light on how to design these taxes to maximise the chances of their acceptance.

The redistribution patterns considered are rooted in the distributive aspect of justice, but other aspects are highlighted when considering environmental policies, such as restorative or procedural justice (Galanis et al., 2025; Krüger, 2022). Procedural justice is based on the decision-making process (Rawls, 1999). In this context, citizens' perception of the fairness of the decision-making process is crucial for the perceived fairness of the policy as a whole. The issue of procedural justice is therefore closely related to democratic considerations, as citizen involvement in the decision-making process can increase perceived fairness (Krüger, 2022; Carman, 2010). The issue of democratic process may also influence the perceived legitimacy of the policy decision and political institutions (Cohen, 1997; Carman, 2010). In the next chapter, we propose a discrete choice experiment to assess preferences for democratic innovation in the implementation of a Low Emission Zone.

References

Andreassen, G. L., Kallbekken, S., and Rosendahl, K. E. (2024). Can policy packaging help overcome pigouvian tax aversion? a lab experiment on combining taxes and subsidies. *Journal of Environmental Economics and Management*, page 103010.

Baranzini, A. and Carattini, S. (2017). Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data. *Environmental Economics and Policy Studies*, 19:197–227.

Barrez, J. (2024). Public acceptability of carbon pricing: unravelling the impact of revenue recycling. *Climate Policy*, 24(10):1323–1345.

Baude, M., Herry, M., Mesqui, B., and Richaud, I. (2024). Chiffres clés du climat. france, europe et monde. Technical report, Commissariat Général au Développement Durable / Service des données et études statistiques.

Bellemare, C., Kröger, S., and Van Soest, A. (2008). Measuring inequity aversion in a heterogeneous population using experimental decisions and subjective probabilities. *Econometrica*, 76(4):815–839.

Blanco, M., Engelmann, D., and Normann, H. T. (2011). A within-subject analysis of other-regarding preferences. *Games and Economic Behavior*, 72(2):321–338.

Brent, D. A., Gangadharan, L., Mihut, A., and Villeval, M. C. (2019). Taxation, redistribution, and observability in social dilemmas. *Journal of Public Economic Theory*, 21(5):826–846.

Carattini, S., Baranzinia, A., Thalmann, P., Varone, F., and Vöhringer, F. (2017). Green taxes in a post-paris world: Are millions of nays inevitable? *Environmental and Resource Economics*, 68:97–128.

Carattini, S., Carvalho, M., and Fankhauser, S. (2018). Overcoming public resistance to carbon taxes. *Wiley Interdisciplinary Reviews: Climate Change*, 9(5):e531.

Carman, C. (2010). The process is the reality: Perceptions of procedural fairness and participatory democracy. *Political Studies*, 58(4):731–751.

Cherry, T. L., Kallbekken, S., and Kroll, S. (2012). The acceptability of efficiency-enhancing environmental taxes, subsidies and regulation: An experimental investigation. *Environmental Science & Policy*, 16:90–96.

Cherry, T. L., Kallbekken, S., and Kroll, S. (2014). The impact of trial runs on the acceptability of environmental taxes: Experimental evidence. *Resource and Energy Economics*, 38:84–95.

Cherry, T. L., Kallbekken, S., and Kroll, S. (2017). Accepting market failure: Cultural worldviews and the opposition to corrective environmental policies. *Journal of Environmental Economics and Management*, 85:193–204.

Cohen, J. (1997). Deliberation and democratic legitimacy. In *Deliberative Democracy: Essays on Reason and Politics*. The MIT Press.

Cook, K. and Hegtvedt, K. (1983). Distributive justice, equity, and equality. *Annual Review of Sociology - ANNU REV SOCIOL*, 9:217–241.

Dechezleprêtre, A., Fabre, A., Kruse, T., Planterose, B., Chico, A. S., and Stantcheva, S. (2022). Fighting climate change: International attitudes toward climate policies. Working papers, OECD Publishing.

Dechezleprêtre, A., Fabre, A., Kruse, T., Planterose, B., Sanchez Chico, A., and Stantcheva, S. (2025). Fighting climate change: International attitudes toward climate policies. *American Economic Review*, 115(4):1258–1300.

Denant-Boemont, L., Faulin, J., Hammiche, S., and Serrano-Hernandez, A. (2021). Valuations of transport nuisances and cognitive biases: a survey laboratory experiment in the pyrenees region. *Environmental Modeling & Assessment*, pages 1–16.

Douenne, T. and Fabre, A. (2022). Yellow vests, pessimistic beliefs, and carbon tax aversion. *American Economic Journal: Economic Policy*, 14(1):81–110.

Dresner, S., Dunne, L., Clinch, P., and Beuermann, C. (2006). Social and political responses to ecological tax reform in europe: an introduction to the special issue. *Energy Policy*, 34(8):895–904. Social and political responses to ecological tax reform in Europe.

Dupoux, M. and Ouvrard, B. (2023). Harnessing social information to improve public support for pigouvian taxes. Working papers, Grenoble Applied Economics Laboratory (GAEL).

Erkal, N., Gangadharan, L., and Nikiforakis, N. (2011). Relative earnings and giving in a real-effort experiment. *American Economic Review*, 101(7):3330–48.

Ewald, J., Sterner, T., and Sterner, E. (2022). Understanding the resistance to carbon taxes: Drivers and barriers among the general public and fuel-tax protesters. *Resource and Energy Economics*, 70:101331.

Fabre, A., Douenne, T., and Mattauch, L. (2023). International attitudes toward global policies. *Available at SSRN 4448523*.

Fehr, E. and Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The quarterly journal of economics*, 114(3):817–868.

Freire-González, J. and Ho, M. S. (2018). Environmental fiscal reform and the double dividend: Evidence from a dynamic general equilibrium model. *Sustainability*, 10(2).

Galanis, G., Napoletano, M., Popoyan, L., Sapio, A., and Vardakoulias, O. (2025). Defining just transition. *Ecological Economics*, 227:108370.

Hammerle, M., Best, R., and Crosby, P. (2021). Public acceptance of carbon taxes in australia. *Energy Economics*, 101:105420.

Hartman, J. L. (2012). Special issue on transport infrastructure: a route choice experiment with an efficient toll. *Networks and Spatial Economics*, 12:205–222.

Heres, D. R., Kallbekken, S., and Galarraga, I. (2017). The role of budgetary information in the preference for externality-correcting subsidies over taxes: a lab experiment on public support. *Environmental and Resource Economics*, 66:1–15.

Horowitz, J. (2006). The use of a real-money experiment in a stated-preference survey. *Using Experimental Methods in Environmental and Resource Economics*, pages 70–90.

Huang, L. and Xiao, E. (2021). Peer effects in public support for pigouvian taxation. *Journal of Economic Behavior & Organization*, 187:192–204.

Janusch, N., Kroll, S., Goemans, C., Cherry, T. L., and Kallbekken, S. (2021). Learning to accept welfare-enhancing policies: an experimental investigation of congestion pricing. *Experimental Economics*, 24:59–86.

Jose Carlos Cañizares, S. C. and Doorn, N. (2024). Embedding justice considerations in climate resilience. *Ethics, Policy & Environment*, 27(1):63–88.

Kahneman, D. and Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, 47(2):263–291.

Kallbekken, S., Kroll, S., and Cherry, T. L. (2011). Do you not like pigou, or do you not understand him? tax aversion and revenue recycling in the lab. *Journal of Environmental Economics and Management*, 62(1):53–64.

Kessler, J. B. and Norton, M. I. (2016). Tax aversion in labor supply. *Journal of Economic Behavior & Organization*, 124:15–28. Taxation, Social Norms and Compliance.

Krüger, T. (2022). The german energy transition and the eroding consensus on ecological modernization: A radical democratic perspective on conflicts over competing justice claims and energy visions. *Futures*, 136:102899.

Maestre-Andrés, S., Drews, S., Savin, I., and van den Bergh, J. (2021). Carbon tax acceptability with information provision and mixed revenue uses. *Nature Communications*, 12:7017.

Maurice, J., Rouaix, A., and Willinger, M. (2013). Income redistribution and public good provision: an experiment. *International Economic Review*, 54(3):957–975.

McCauley, D. and Heffron, R. (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, 119:1–7.

Messer, K. D., Poe, G. L., Rondeau, D., Schulze, W. D., and Vossler, C. A. (2010). Social preferences and voting: An exploration using a novel preference revealing mechanism. *Journal of Public Economics*, 94(3):308–317.

Mohammadzadeh Valencia, F., Mohren, C., Ramakrishnan, A., Merchert, M., Minx, J. C., and Steckel, J. C. (2024). Public support for carbon pricing policies and revenue recycling options: a systematic review and meta-analysis of the survey literature. *npj Climate Action*, 3(1):74.

Musgrave, R. A. and Musgrave, P. B. (1989). *Public finance in theory and practice, Fifth edition.* McGraw-Hill Book Compagny.

Nowlin, M. C., Gupta, K., and Ripberger, J. T. (2020). Revenue use and public support for a carbon tax. *Environmental Research Letters*, 15(8).

Owen, A. and Barrett, J. (2020). Reducing inequality resulting from uk low-carbon policy. *Climate Policy*, 20(10):1193–1208.

Paavola, J. and Adger, W. N. (2002). Justice and adaptation to climate change. Working papers, Tyndall Centre for Climate Change Research.

Rawls, J. (1999). *A Theory of Justice: Revised Edition.* Harvard University Press.

Rouaix, A., Figuières, C., and Willinger, M. (2015). The trade-off between welfare and equality in a public good experiment. *Social Choice and Welfare*, 45:601–623.

Sælen, H. and Kallbekken, S. (2011). A choice experiment on fuel taxation and earmarking in norway. *Ecological Economics*, 70(11):2181–2190.

Sommer, S., Mattauch, L., and Pahle, M. (2022). Supporting carbon taxes: The role of fairness. *Ecological Economics*, 195:107359.

Stiglitz, J. E., Stern, N., Duan, M., Edenhofer, O., Giraud, G., Heal, G. M., La Rovere, E. L., Morris, A., Moyer, E., Pangestu, M., et al. (2017). Report of the high-level commission on carbon prices. Technical report, World Bank, Washington.

Tatham, M. and Peters, Y. (2023). Fueling opposition? yellow vests, urban elites, and fuel taxation. *Journal of European Public Policy*, 30(3):574–598.

Wang, Q., Hubacek, K., Feng, K., Wei, Y.-M., and Liang, Q.-M. (2016). Distributional effects of carbon taxation. *Applied Energy*, 184:1123–1131.

7 Appendix

8 Redistribution pattern

In this section, we will explain the types of redistribution mechanisms discussed in Section 2.1.4. For the notation used in the following, see Section 2.1.1.

Lump sum redistribution

In the case of lump-sum redistribution, the tax revenue is redistributed evenly across all participants. There is no difference between the two populations or between the different modes of transport. The redistribution term is given by:

$$r = \frac{p_r * q_r + p_p * q_p}{n_r + n_p} \tag{28}$$

Environmental redistribution

For environmental redistribution, the tax revenue is redistributed equally to public transport users. No revenue is redistributed to private car users. The redistribution term is given by:

$$\begin{cases} r_T = \dfrac{p\_env_r * q_r + p\_env_p * q_p}{n_r + n_p - (q_r + q_p)}, & \text{for public transport user} \\ r_V = 0, & \text{for private vehicle user} \end{cases} \tag{29}$$

$$\tag{30}$$

Social cushioning

For social cushioning, the tax revenue is first used to equalise the difference in travel costs between the two populations. It is redistributed evenly in population p. If the tax revenue exceeds the total difference in travel costs between the two groups, any additional revenue is redistributed equally between all participants. The redistribution term is given by:

$$\text{If } n_p * (T_r - T_p) \geq p_r * q_r + p_p * q_p :$$

$$\begin{cases} r_p = \dfrac{p_r * q_r + p_p * q_p}{n_p}, & \text{for population p} \\ r_r = 0, & \text{for population r} \end{cases}$$

$$\text{If } n_p * (T_r - T_p) < p_r * q_r + p_p * q_p :$$

$$\begin{cases} r_p = T_r - T_p + \dfrac{p_r * q_r + p_p * q_p - n_p * (T_r - T_p)}{n_r + n_p}, & \text{for population p} \\ r_r = \dfrac{p_r * q_r + p_p * q_p - n_p * (T_r - T_p)}{n_r + n_p}, & \text{for population r} \end{cases}$$