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Abstract

This paper examines how income inequality can affect the polarization of heterogeneous party platforms on climate policy (here: carbon tax). The implied consequences for the uncertainty of climate policy can be relevant for risk-averse investors in "green" technologies. Households are heterogeneous with respect to income and preferences for environmentalism and preferred redistribution. A static game-theoretic model of two-dimensional political competition on a carbon tax (with distributional implications) and an income tax is combined with a model of a carbon-intensive economy. For a higher inequality of pre-tax income and/or a higher salience of the issue of redistribution, polarization of the parties' carbon tax proposals in the equilibrium can increase - even if the income tax is used to counteract the increase in income inequality. This result does not depend on the progressivity of the carbon-tax revenue recycling mechanism.

JEL Code: H23, P16, Q52, Q54
Keywords: Climate policy, inequality, political economy, multidimensional political competition

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1 Introduction

For the last three decades, international climate negotiations were insufficient to reach the proclaimed target of two degrees (or even 1.5 degrees as in the Paris Agreement of 2015) Celsius above the pre-industrial level, as the according report by UNFCCC (2016) emphasizes. There is constant technological progress in the area of "green" technologies and a well-equipped tool box of economic policy (carbon pricing, subsidies, etc.) is in principle available for a reduction of carbon emissions. But a key remaining challenge for an effective tackling of climate change is the lack of "political will", or public support, for ambitious climate policy measures.

The literature and the public debate have paid much attention to international negotiations of a global climate treaty and the important free-riding problem on the international level.[2] But legally binding and effective environmental policy measures are enforced on the level of national politics (in Europe in a complex interplay with the European Union). Therefore, the present paper sees and follows the necessity for more attention to the multi-scale nature of the climate problem, emphasized, e.g., by Ostrom (2010), and examines political economic mechanisms on the national level which could undermine the voters' willingness to engage in climate policy and focuses on the following question: how is public support for climate policy measures like the taxation of carbon emissions affected by their (actual or expected) impact on incomes and on income inequality; by the level of existing socioeconomic inequality and the degree of redistribution in the country; and by the set of values in the population with respect to redistribution, (in)equality, environmental policy, and, in general, government intervention in the economy? The underlying idea is that redistributive policy and climate policy require an integrated analysis, because distributive effects and existing socioeconomic inequality might constitute national impediments to climate policy even if there is a public consensus on the general importance of climate protection.

In the present study I employ a model of two-dimensional policy competition following Roemer (2006) with the dimensions carbon tax and proportional income tax to analyze how income inequality affects the endogenous policy platforms of the two parties in equilibrium. To the best of my knowledge, this analysis is the first to model two-dimensional political competition on an environmental policy with distributional implications and redistributive policy at the same time. The effects of the policies on household incomes are derived in a static model of production of one final good with inelastic labor sup-

[2] For instance, Heitzig et al. (2011), Nordhaus (2015), and Walker et al. (2009).

ply and carbon-intensive energy as inputs. Voter types are heterogeneous in terms of income (log-normal distribution between zero and infinity) and "collective orientation" (uniformly distributed between zero and one) which simultaneously indicates an individual's degree of concern with climate change and her preference for redistribution of income.[3] The voters' utility function comprises consumption utility, utility from the degree of actual redistribution relative to the individual's desired level of redistribution, and utility from climate protection. As a result, both policies affect utility over various channels at the same time: the income tax (with lump-sum revenue recycling) affects consumption utility via the direct monetary effect and utility from redistribution via its effect on the overall (post-tax) income distribution. The carbon tax, the revenue recycling of which can render it overall progressive or regressive, affects consumption utility via the monetary cost of climate protection, redistribution utility over the distributive implications of the tax, and utility from climate protection. The concept of *party-unanimity Nash equilibrium* (PUNE) from Roemer (2006) allows to take all these complex relations into account and to obtain political equilibria numerically with heterogeneous party platforms in the two-dimensional policy space. This would not be possible with a Downsian median-voter approach.

The analysis proceeds in two steps: first, the income tax is exogenously given and policy competition is one-dimensional over the level of the carbon tax. Here the numerical examples show that higher inequality of pre-tax income leads to a higher (lower) carbon tax in equilibrium if it is progressive (regressive). The reason is that voters prefer a higher carbon tax if it is accompanied by desired additional (progressive or regressive) redistribution on top of the fixed level of income taxation. Then, in a second step, the income tax is endogenized as the second dimension of policy competition. In this two-dimensional case a higher exogenous inequality of pre-tax income leads to an increase in the polarization of the parties' carbon tax proposals. This implies a higher degree of policy uncertainty for potential investors in green technologies. The average of the parties' carbon tax proposals, however, stays virtually constant, irrespective of the progressivity of the carbon tax recycling mechanism. Polarization of party platforms also rises with an increase in salience of the ideological political discourse on income redis-

[3] The assumption that environmentalism/concern for climate change and a preference for income redistribution are positively correlated is supported by a number of empirical psychological, sociological, and econometric studies. Papers like Campbell and Kay (2014), Heath and Gifford (2006), Kilbourne et al. (2002), McCright and Dunlap (2011), Rossen et al. (2015), and Ziegler (2017) find (mostly phrased in the opposite way) a positive correlation of climate change skepticism or low concern for the climate issue and a free-market ideology, aversion of government interventions in the economy, and conservatism which are associated with low income redistribution.

tribution. Overall, more income inequality can undermine public support for climate policy. If voters, in contrast, are myopic about the redistributive implication of the carbon tax, then an increase in inequality of pre-tax income does lead to higher (lower) proposals for a progressive (regressive) carbon tax. Thus, in this case the carbon tax revenue recycling mechanism does play a role for public climate policy support.

This paper builds on the literature on distributive effects of environmental policies, particularly carbon taxes, to model the distributional effects of the carbon tax which feed into the political economic dynamics that are in the focus of the paper. A large number of empirical studies find that taxes on greenhouse gas emissions, energy consumption, or industrial pollution are regressive, but well-designed schemes for revenue recycling or transfer payments can lead to an overall progressive distributional effect.[4] In the present paper the design of the tax revenue recycling mechanism also plays a central role in the political economic dynamics. In Rausch et al. (2011) and Rausch and Schwarz (2016) the regressive distributional effects of environmental taxes are driven by heterogeneous consumption patterns and factor income patterns between households. The present paper abstracts from both channels for the sake of modelling simplicity. Instead, the distributive effect of the carbon tax in this study is driven by the revenue recycling mechanism alone, which is sufficient to create progressive and regressive distributional patterns.

Barker and Köhler (2005) and Metcalf (2009) point towards the possibility of reducing the regressive distributional effect by using the environmental tax revenues for the reduction of other distortionary taxes, e.g., on labor or capital. Such additional welfare gains from the reduction of distortive taxes, known under the term "double dividend" is analyzed in an own strand of literature from an optimal taxation perspective.[5] However, in the present version of this paper there are no pre-existing distortions in the factor markets (due to inelastic labor supply) and no direct relation to the double-dividend effect.

In general, the present study with its national perspective does not follow the prescrip-

[4] Examples for this group of papers are Robison (1985), Wier et al. (2005), Brenner et al. (2007), Kerkhof et al. (2008), Callan et al. (2009), Shammin and Bullard (2009), Bureau (2011), Ekins et al. (2011), Rausch et al. (2011), Gonzalez (2012), Chiroleu-Assouline and Fodha (2014), Jiang and Shao (2014), Mathur and Morris (2014), Williams III et al. (2015), da Silva Freitas et al. (2016), Renner (2018). Oladosu and Rose (2007) find a slightly progressive effect for a certain region.

[5] Examples in this context are Bovenberg and Mooij (1994), Babiker et al. (2003), Barrage (2018), Böhringer et al. (2016), Bento and Jacobsen (2007), and Kaplow (2012). For an overview over the double-dividend literature see Freire-González (2018).

tive focus of the literature on optimal taxation (which the double dividend literature is a part of), on the social cost of carbon, and on discounting. Instead, it contributes to the descriptive literature on the political economy of environmental policy, which in the real world can cause substantial deviations from the first-best ideal for many reasons. This field investigates, for instance, the influence of lobbying on national environmental policy making (cf. Heyes and Dijkstra (2002) and Oates and Portney (2003) for according literature overviews.), but also questions of strategic interaction of governments facing the possibility of losing office (cf., for instance, Voß (2015) and Schmitt (2014, chapter 4)). The present paper extends the scarce literature which embeds environmental policy in voting models. A key difficulty of one-dimensional voting models based on environmental policy is that voting outcomes in reality are simultaneously influenced by more dominant political issues. List and Sturm (2006) approach this issue by focusing on the share of voters who determine their voting decision solely based on the secondary issue, which is environmental policy, in contrast to the majority of voters who only care for the primary issue. Therefore, their voters consider only one policy dimension at a time, instead of having truly two-dimensional preferences as in the present paper. Also, in their study the temporal dimension is crucial – with a building up of politicians' reputation over time and the effect of term limits – for their empirical identification strategy. These temporal aspects do not play any role in my static model, as well as the econometric research dimension. McAusland (2003) employs a one-dimensional median-voter model with heterogeneous income streams from green and dirty production factors between voters and a trade component, which is absent from the present study. The factor income composition translates the environmental policy into heterogeneous monetary effects on income streams with homogeneous preferences. Moreover, the econometric study of Kahn and Matsusaka (1997) also involves a one-dimensional political reasoning. Overall, the present paper is the first study to employ a two-dimensional voting model to simultaneously explain the degree of environmental policy (here: climate policy) and income redistribution and their interactions. The present approach gains additional value and relevance by incorporating distributional effects of the environmental policy and a preference of voters for redistribution which is correlated with their environmentalism. These aspects are all absent from previous work.

This study is also a contribution on the more general dimension of the political economy of public good provision in the face of socioeconomic inequality. But the present framework differs in a few aspects from the conventional public-good setting. A reduction of the public bad (emissions) in this case is not funded by additional taxation, e.g. of income or capital, and it is not just costly, but also creates (carbon tax) revenues. The elaboration of the implications in this direction are left for future research steps on the present study.

The present work also contributes to the literature on the application of models of two-dimensional policy competition with heterogeneous party platforms, which, to the best of my knowledge, completely relies on the PUNE concept of Roemer (2006). Roemer (1998), Roemer (1999), Roemer and van der Straeten (2005), Lee and Roemer (2006), Lee et al. (2006) all deal with redistribution as the first dimension and political ideology, xenophobia or racism as the second policy dimension. The present work extends this literature by applying the PUNE concept of two-dimensional political competition to redistribution and environmental policy with its distributive effects in the light of income inequality.

This paper is organized as follows. In Section 2 the economic model is presented. Section 3 introduces the model of political competition based on Roemer (2006). The numerical results are presented and analyzed in Section 4. Section 5 concludes.

2 Model

2.1 Firms

Perfectly competitive firms produce a final good with a Cobb-Douglas aggregate production function

$$Q(L,E) = L^{\gamma} E^{1-\gamma} \tag{1}$$

with the production factors labor L and energy E. The latter contains one unit of carbon per unit of E. The labor input is numeraire (wages set to one) and its supply is inelastic (cf. Section 2.2). Therefore, firms maximize profits only by the choice of the energy input

$$\max_{E} \pi = p_Q Q(L,E) - L - (p_E + \kappa)E$$

with the price of the final good p_Q, the exogenous and constant energy price p_E, and the carbon tax $\kappa \in [0,\infty)$ on every unit of the energy input. The carbon tax is an endogenous outcome of political competition (cf. Section 3), but exogenous from the firms' perspective. With zero profits in the final goods market, final goods price p_Q

reads

$$p_Q = \frac{L + (p_E + \kappa)E}{L^{\gamma}E^{1-\gamma}} \tag{2}$$

Substituting (2) into the first-order condition for energy yields

$$E = L\frac{(1-\gamma)}{\gamma(p_E+\kappa)} \quad \text{with} \quad \frac{\partial E}{\partial \kappa} = -L\frac{(1-\gamma)}{\gamma(p_E+\kappa)^2} < 0 \tag{3}$$

2.2 Households

2.2.1 Household Income

With the total population of the country normalized to one, there is a continuum of household types over two dimensions of heterogeneity: the individual households differ in skill level $h_i \in [0, \infty]$, which determines the household's productivity and is log-normally distributed with the mean h_μ and the median h_{med}. Households also differ with respect to their collective orientation $a_i \in [0, 1]$, which can have different distributions (cf. Section 2.2.2). For simplicity, in the present version of the model the collective orientation a_i is uniformly distributed.

Labor Income and Income Taxation

All households inelastically supply one unit of "effort" $L_i^e = 1$ that is weighted with the skill level h_i, so that resulting household labor supply is $L_i^S = L_i^e h_i = h_i$. By aggregating over all households we obtain the equilibrium labor input, which is equal to inelastic aggregate labor supply

$$L = L^S = \int_{(a_i,h_i)} L_i^S dF(a_i, h_i) = h_\mu \tag{4}$$

With the wage level being equal to one, household labor supply $L_i^S = h_i$ is equal to pre-tax household income. This income is subject to a proportional income tax τ. The income tax revenues are recycled in a lump-sum fashion. Households receive payments $Rec(\kappa)$ from the recycling of carbon tax revenues, so that post-tax income is $y_i = h_i + (h_\mu - h_i)\tau + Rec(\kappa)$. In the case of lump-sum per-capita recycling each household receives $Rec(\kappa) = \kappa E(\kappa) = h_\mu \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}$.[6] More regressive designs of revenue

[6] Since population is normalized to one, average household income h_μ is equal to aggregate income. Therefore, the aggregate carbon tax revenues $\kappa E(\kappa)$ are equal to a lump-sum per-capita payment.

recycling are discussed below in the subsection "Carbon Tax Revenue Recycling". Net income is completely spent on the final good ($y_i = p_Q x_i$). Using (2),(3) and (4), resulting final good consumption x_i then reads

$$\begin{aligned} x_i &= y_i \frac{1}{p_Q} \\ &= y_i \frac{\gamma^\gamma (1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}} \\ &= (h_i + (h\mu - h_i)\tau + Rec(\kappa))\,\frac{\gamma^\gamma (1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}} \end{aligned} \tag{5}$$

The income tax τ redistributes income from households with an above-average skill level ($h_i > h_\mu$) to those with a below-average skill level, leading to less post-tax inequality. For an income tax of $\tau = 1$ post-tax income would be constant across all households. Total output, however, does not change with the income tax since labor supply is inelastic. Therefore, there is also no distortion of the labor market and no according deadweight loss.

The carbon tax κ, in contrast, reduces the energy input with the contained emissions ($\frac{\partial E(\kappa)}{\partial \kappa} < 0$, cf. (3)) and resulting output. Since the implicit carbon intensity of the only good is constant over all households, consumption of every household decreases by the same factor. This does not yet cause a redistributive effect because every household suffers proportionally to their previous income level. But, in addition, the carbon tax revenues are recycled. The net distributive effect of the carbon tax depends on the progressivity of the carbon tax recycling mechanism. With lump-sum recycling certain low-income households can even be better off after levying the carbon tax.

Carbon Tax Revenue Recycling

In principle, all sorts of distribution schemes are possible for the recycling of the carbon tax revenues. To enable more regressive distributions of revenue payments than a lump-sum per-capita recycling (for which $Rec(\kappa) = \kappa E(\kappa) = h_\mu \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}$, as was shown above), the payments can be made proportional to an income distribution which would result from levying a hypothetical income tax τ_κ ("implicit income tax") instead of mean income h_μ:

$$Rec(\kappa) = (h_i + (h_\mu - h_i)\tau_\kappa)\frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma} \tag{6}$$

After substituting (6) into (5), the resulting equation can be transformed to (cf. Appendix A)

$$x_i = \left(1 + \frac{(1-\gamma)\kappa}{\gamma(p_E+\kappa)}\right)(h_i + (h\mu - h_i)\rho(\tau,\kappa,\tau_\kappa))\,\frac{\gamma^\gamma(1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}} \tag{7}$$

In doing so, the redistributive effects of the income tax and of the carbon tax can be combined into the total degree of redistribution $\rho(\tau,\kappa,\tau_\kappa)$ which results from both policy measures together. It is defined as

$$\rho(\tau,\kappa,\tau_\kappa) = \tau\left(\frac{1+\frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}\frac{\tau_\kappa}{\tau}}{1+\frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}}\right) \quad \begin{cases} >\tau & \text{for} \quad \tau_\kappa > \tau \\ =\tau & \text{for} \quad \tau_\kappa = \tau \\ <\tau & \text{for} \quad \tau_\kappa < \tau \end{cases} \tag{8}$$

A lump-sum recycling of carbon tax revenues corresponds to recycling payments proportional to a hypothetical income distribution which would result from an income tax of one ($\tau_\kappa = 1$), that is, a uniform distribution. As long as $\tau < \tau_\kappa = 1$, this would imply that the carbon tax is progressive relative to the post-income-tax distribution of income. If the recycling payments are proportional to the actual post-income-tax distribution of income (so that $\tau_\kappa = \tau$), then the carbon tax does not have any additional redistributive effect on top of the income tax. For $\tau_\kappa < \tau$, the carbon tax is additionally regressive relative to the post-income-tax distribution of income.

2.2.2 Household Preferences

The households' utility function contains three additive terms which all play a role in driving heterogeneous political preferences:

$$\begin{aligned} u(\tau,\kappa;h_i,a_i)) &= ln(x_i(h_i;\tau,\kappa)) - \phi(a_i - \rho(\tau,\kappa,\tau_\kappa))^2 - a_i\frac{\delta}{2}E(\kappa)^2 \\ &= ln(x_i(\tau,\kappa;h_i)) - \phi(a_i - \rho(\tau,\kappa,\tau_\kappa))^2 - a_i\frac{\delta}{2}\left(\frac{h_\mu(1-\gamma)}{(p_E+\kappa)\gamma}\right)^2 \end{aligned} \tag{9}$$

The intuition behind the different components is explained in the following.

Consumption Utility

Consumption utility is logarithmic and concave in x_i ($\frac{\partial u_i}{\partial x_i} > 0$, $\frac{\partial^2 u_i}{\partial x_i^2} < 0$). A property of log utility is that a reduction of x_i by the same factor leads to the same absolute decrease in utility, irrespective of the income level. For this reason, the carbon tax incidence itself does not have a distributional implication despite the concavity of consumption utility, because the carbon tax hits every household with the same factor and leads to same utility decrease for all households. It is the distributional implication of the carbon tax recycling mechanism which leads to a heterogeneous effect of the carbon tax on households with different income levels.

Most empirical studies[7] find that a carbon tax is regressive. This regressivity in reality can be driven by a higher carbon intensity of the consumption bundle due to heterogeneity in final goods, by heterogeneity in factor income streams with differing carbon intensity, or by heterogeneity in the propensity to save (cf. McAusland (2003)). The modelling of heterogeneous consumption goods and savings behavior, which would require investment and a future period, is avoided here for modelling simplicity. In future work, these channels could be investigated. In the present model, it is important that the carbon tax can be made overall progressive or regressive via the recycling mechanism. The design of the recycling mechanism is varied exogenously (cf. Section 4) and is not subject of the political debate. Otherwise, it would constitute a third policy dimension, which is beyond the scope of the present framework.

Redistributive Preference

Besides the skill level h_i, which captures socio-economic inequality, households are heterogeneous on the dimension "collective orientation" $a_i \in [0, 1]$. This parameter indicates a person's degree of environmentalism, as well as her preference for redistribution or her aversion of inequality, respectively. As mentioned in the introduction, the assumption that the voter type dimension a_i in the model drives both the concern for climate change and preference for redistribution is supported by empirical studies which find a positive correlation of climate change skepticism or a non-environmentalist mindset and prevalent attitudes like free-market ideology, conservatism, and a low preference for government intervention, which are all associated with low preference for redistribution (cf. Campbell and Kay (2014), Heath and Gifford (2006), Kilbourne et al. (2002), McCright and Dunlap (2011), Rossen et al. (2015), and Ziegler (2017)).

The term $-\phi(a_i - \rho(\tau, \kappa, \tau_\kappa))^2$ expresses a Euclidian preference for redistribution or for

[7] Cf. Robison (1985), Wier et al. (2005), Brenner et al. (2007), Kerkhof et al. (2008), Callan et al. (2009), Shammin and Bullard (2009), Bureau (2011), Ekins et al. (2011), Rausch et al. (2011), Gonzalez (2012), Chiroleu-Assouline and Fodha (2014), Jiang and Shao (2014), Mathur and Morris (2014), Williams III et al. (2015), da Silva Freitas et al. (2016), Renner (2018). Oladosu and Rose (2007) is an example with a small progressive effect on a regional scale.

government intervention: parameter a_i represents the desired total level of redistribution $\rho(\tau, \kappa, \tau_\kappa)$. Every deviation from this redistribution level ρ causes disutility for household i. Households with a_i close to one want to see a high level of income redistribution and low resulting inequality. These households might have the attitude that individual market incomes are more the result of a collective social effort (by relying, e.g., on public education, health-care, security, infrastructure, coworkers, etc., which are not modelled here) than just individual talent. Thus, they are sympathetic to government intervention if it helps to achieve what they perceive as greater distributive justice. In contrast, households with a low value for a_i are quite averse to redistribution of income, possibly grounded on more individualistic ethics. This implies that they are just fine with the pre-tax level of inequality or that they see government intervention as even more detrimental and, therefore, are less inclined to change market incomes.

Note, that the redistributive preference term is distinct to the person's opinion on how her personal consumption is affected by the income tax, as captured by the first log-utility term. In addition to that, the redistributive preference term comprises the person's political and social value judgments on issues like inequality, distributive justice, fairness or individualism. According to this separation, a poor person who would like the consumption increase from redistribution can at the same time dislike government intervention based on a libertarian economic value system. Or a wealthy person who would face considerable monetary losses from high income taxation might still favor it based on a more egalitarian value system.[8]

The parameter ϕ is a salience parameter which expresses the weight of the redistributive justice issue in the current political discourse. Even if people hold certain views on inequality and redistribution, the according discussion can rise or fall in importance relative to the other issues.

Climate Policy Preference

The third term $-a_i \frac{\delta}{2} E(\kappa)^2$ in the utility function (9) captures household i's disutility (note the negative sign) from carbon emission related climate damages. Emissions rise linearly in the equilibrium energy input $E(\kappa)$, which decreases in the carbon tax κ. Climate damages rise quadratically in emissions.

Since this term relates to households' perceived disutility from climate damages, it is

[8] Two examples for such individuals who gained some media attention are Warren Buffett and Bill Gates (cf. Wearden, 2011 and Frank, 2016).

secondary when and where the damages, which are not explicitly modelled, take place. What matters more for the degree of disutility is how much people care for climate damages, expressed again by the collective orientation parameter a_i.

If a_i is zero, then the person prefers a zero carbon tax, because climate damages do not hit her consumption utility directly, while the carbon tax does. The person may be neglecting damages because of spacial and temporal distance or due to a conviction that a government intervention would be even more harmful than the damages, even if climate change is undesirable.[9] A high value for a_i, i.e., close to one, means that a person cares for the full scale of climate damages or the social cost of carbon, and prefers a higher carbon tax than a person with lower a_i. The parameter δ captures the salience of the climate issue in the political debate, similar to the parameter ϕ in the case of the redistributive preference term.

Effects of the Policies

The income tax τ affects individual utility over two channels: redistribution of income increases consumption utility of low-income individuals with $h_i < h_\mu$ and decreases consumption utility of those with $h_i > h_\mu$. At the same time, τ affects utility over the redistributive preference term. The latter also fulfills a technical function: since a majority of households has an income below the average ($h_i < h_\mu$), it would prefer an income tax of one if there was no counteracting force. Due to the redistributive preference term, the fact that many households with below-average income would like to live in a society with income taxation below 100 percent can drive the equilibrium income tax way below 100 percent. This is more consistent with empirical observations.

The carbon tax κ has three effects on utility: first, the effect on consumption utility is according to the net monetary implication of κ. The net monetary effect of κ and the recycling of the according revenues for the individual household is negative for most households, since overall output decreases with κ. A small share of households at the bottom end of the income distribution might benefit in net monetary terms if the tax recycling payment is higher than the tax-driven income reduction. Without any further benefits form κ, there would be no reason to expect a positive carbon tax in equilibrium as it reduces aggregate consumption. This benefit comes from the fact that, second,

[9] The central idea of Campbell and Kay (2014) that people can be climate change skeptics not because of concern with the scientific argumentation itself, but because of their aversion to the solution of climate policy has a parallel in the classical public choice argument that government intervention to solve a problem is likely to be more costly than the problem itself (cf., for instance, Coase, 1960 and Buchanan and Stubblebine, 1962).

the carbon tax reduces disutility from climate damages. And third, the redistributive implication of the carbon tax affects utility over the redistributive preference term.

3 Political Competition

The model of political competition in the present framework is described in the following. It is built along the lines of the *party unanimity Nash equilibrium* (PUNE) concept of multi-dimensional political competition, as developed by Roemer (2006). The PUNE concept allows to achieve pure strategy equilibria in two-dimensional policy space $T \subset R^2$ with differentiated party platforms $t_A, t_B \in T$, in contrast to the Downsian median-voter concept. The dimensions of competition are income taxation $\tau \in [0, 1]$ and climate policy (carbon taxation $\kappa \in [0, \infty]$). The model takes the number of parties (here: two), the voter preferences (9), and the distribution of voter types $H \subset R^2$ as given. The model delivers as outputs the partition of the electorate in the two sets of party supporters, the two-dimensional policy platforms, and the winning probabilities for each party. A crucial element here, which also adds to realism, is that the respective party platform itself is the result of a bargaining game between two party factions: the Opportunists maximizing the probability of getting into office and the Guardians maximizing average welfare of the party supporters.

3.1 Definitions

The political parties take voter preferences (9) and the two-dimensional distribution of voter types $\mathbf{F}(a, h)$ as given. By announcing their platforms, defined by the policy vector $t_m = (\tau_m, \kappa_m)$ with $m \in \{A, B\}$, the parties A and B divide the electorate, that is, the set of all voter types H in the (a, h) space, into two sets of voters: H^A is the set of those voter types who support party A and H^B is the set of those who support party B. Every voter of the polity belongs to one, and only one, of the two sets, so that $H = H^A \cup H^B$ and $H^A \cap H^B = \varnothing$. The set of party A supporters who prefer party A's platform $t_A = (\tau_A, \kappa_A)$ given that party B proposes $t_B = (\tau_B, \kappa_B)$ is

$$\Omega(t_A, t_B) = \{(a_i, h_i) | u(t_A) > u(t_B)\}$$

The edge of the two sets of voters $\hat{a}(t_A, t_B; h_i)$ is endogenous and defined by those voters who are indifferent between the two platforms:

$$u(t_A; \hat{a}, h_i) = u(t_B; \hat{a}, h_i) \tag{10}$$

By definition, voters with $a_i > \hat{a}$ prefer party A's platform, and voters with $a_i < \hat{a}$ prefer party B's platform. Substituting (9) into (10) and rearranging yields

$$\hat{a}(t_A, t_B; h_i) = \tag{11}$$
$$\left[\ln \left[\frac{(h_i + (h_\mu - h_i)\rho(t_A, \tau_\kappa)) \left(1 + \frac{(1-\gamma)\kappa_A}{\gamma(p_E+\kappa_A)}\right)}{(h_i + (h_\mu - h_i)\rho(t_B, \tau_\kappa)) \left(1 + \frac{(1-\gamma)\kappa_B}{\gamma(p_E+\kappa_B)}\right)} \cdot \left(\frac{p_E + \kappa_B}{p_E + \kappa_A}\right)^{1-\gamma} \right] - \phi(\rho(t_A, \tau_\kappa)^2 - \rho(t_B, \tau_\kappa)^2) \right] \cdot$$
$$\left[\frac{\delta}{2} \left(\frac{(1-\gamma)h_\mu}{\gamma}\right)^2 \left(\frac{1}{(p_E + \kappa_A)^2} - \frac{1}{(p_E + \kappa_B)^2}\right) - 2\phi(\rho(t_A, \tau_\kappa) - \rho(t_B, \tau_\kappa)) \right]^{-1}$$

The curve $\hat{a}(t_A, t_B; h_i)$ divides the voter-type space in two sets which both contain approximatey half of the electorate. If one party managed to improve its voters' welfare by changing its platform, then $\hat{a}(t_A, t_B; h_i)$ would shift and thus increase the party's share of the electorate. This holds for the other party, too, so that in equilibrium, no party and no party faction can deviate from their platform without triggering a detrimental adjustment by the other party. The resulting aggregate welfare of all party A voters if the policy vector t is realized then is

$$W^A(t) = \int_{(a_i,h_i)\in H^A} u(t; a_i, h_i)\, d\mathbf{F}(a_i, h_i) = \int_0^\infty \int_{\hat{a}}^1 u(t; a_i, h_i)\, d\mathbf{F}(a_i)\, d\mathbf{F}(h_i)$$

and the aggregate welfare of the supporters of party B given the policy vector t is

$$W^B(t) = \int_{(a_i,h_i)\in H^B} u(t; a_i, h_i)\, d\mathbf{F}(a_i, h_i) = \int_0^\infty \int_0^{\hat{a}} u(t; a_i, h_i)\, d\mathbf{F}(a_i)\, d\mathbf{F}(h_i)$$

The share of party A supporters, that is, the probability measure $\mathbf{F}(\Omega(t_A, t_B))$ is a discrete number depending on the probability distribution $\mathbf{F}$. Nevertheless, when the parties announce their policy platforms at the beginning of the election campaign, they are only certain up to a margin of error about what their share of the vote will be on election day. Without this uncertainty the winner would be known from the beginning or the chances of each party to win would be exactly $\frac{1}{2}$. In both cases, the result would be clear from the beginning and spending money on election campaigns would be pointless. So, party uncertainty about voter behavior is a vital element of realistic modelling of political competition. The parties believe that the share of voters who prefer t_A to t_B lies in a range of $[-\epsilon, +\epsilon]$ around $\mathbf{F}(\Omega(t_A, t_B))$ with a uniform probability distribution within that range. The expected probability of party A to win with platform t_A if party

B plays platform t_B then reads

$$\pi(t_A, t_B) = \frac{\mathbf{F}(\Omega(t_A, t_B)) + \epsilon - \frac{1}{2}}{2\epsilon} = \frac{\int_{(a_i,h_i)\in H^A} d\mathbf{F}(a_i, h_i) + \epsilon - \frac{1}{2}}{2\epsilon}$$

As a result, each party has a probability of winning the election close to, but not exactly equal to, 50%.

3.2 Party Unanimity Nash Equilibrium

The PUNE equilibrium concept rests on the assumption that two types of politicians try to influence the party policy. On the one hand, the Opportunists try to maximize the party's vote share with the intention of promoting their own career. When facing a given policy platform from the respective other party their payoff functions are

$$\Pi_A^{Opp}(t_A, t_B) = \pi(t_A, t_B)$$

and

$$\Pi_B^{Opp}(t_A, t_B) = 1 - \pi(t_A, t_B)$$

respectively. On the other hand, the Guardians maximize average welfare of their constituents while neglecting the probability of actually getting into office.[10] Their payoff functions are

$$\Pi_A^{Guar}(t_A, t_B) = W^A(t_A)$$

and

$$\Pi_B^{Guar}(t_A, t_B) = W^B(t_B)$$

respectively. The two factions of party A now engage in a bargaining game in which the Guardians try to maximize their constituents' welfare while the Opportunists insist

[10] An additional interpretation of this behavior could be that the Guardians seek to publicly propagate their agenda, even if they end up not putting their policies into practice. In early versions of the PUNE concept, Roemer (2006) included a third faction, the Reformists, who would maximize expected welfare of their voters. Mathematically, the Reformists are redundant and the model is simpler without them.

on a minimal probability of winning π_0, given that party B plays the platform t_B:

$$\max_{t \in T} W^A(t) \quad s.t. \quad \pi(t, t_B) \geq \pi_0^A \tag{12}$$

It would be equivalent to maximize the probability of winning while considering a lower bound to average welfare of the constituents. Party B solves the following problem in a similar way for a given platform t_A of party A:

$$\max_{t \in T} W^B(t) \quad s.t. \quad 1 - \pi(t_A, t) \geq 1 - \pi_0^B \tag{13}$$

Similar to Lee and Roemer (2006) and in consistence with Roemer (2006, Chapter 8) a *party unanimity Nash equilibrium* (PUNE) is defined as

(1) a partition of the type space into two party memberships $H = H^A \cup H^B$, $H^A \cap H^B = \varnothing$, a pair of numbers (π_0^A, π_0^B), and a pair of policies (t_A, t_B), such that:

(2) t_A solves problem (12) and t_B solves problem (13), and

(3) $(a_i, h_i) \in H^A \Rightarrow u(t_A; a_i, h_i) \geq u(t_B; a_i, h_i)$ and $(a_i, h_i) \in H^B \Rightarrow u(t_B; a_i, h_i) \geq u(t_A; a_i, h_i)$.

Condition (3) states that each voter prefers to continue supporting her party. Thus, endogenously formed party membership is stable. If the policy vector (t_A, t_B) is a PUNE, then neither the Opportunists, nor the Guardians can deviate from their position without making the other faction being worse off and the party platform is stable. And the same holds true for the other party. The tuple (π_0^A, π_0^B) reflects the relative bargaining power of the Opportunist faction in each party. Different degrees of relative bargaining power of the factions produce different PUNEs. Therefore, in the case that PUNEs exist, there will be a two-dimensional manifold of them in the space of $T \times T$.

Roemer (2006, Chapter 8) shows that the problem consisting of (12) and (13), which yields PUNEs as solutions, can be restated as a weighted Nash bargaining game. Thus, in party A the policy vector t is chosen which maximizes the Nash product, given that party B plays t_B:

$$\max_{t \in T} (\pi(t, t_B) - 0)^{\alpha} (W^A(t) - W^A(t_B))^{1-\alpha} \tag{14}$$

The according maximization problem for party B, given that party A plays t_A is

$$\max_{t \in T} ((1 - \pi(t_A, t)) - 0)^{\beta} (W^B(t) - W^B(t_A))^{1-\beta} \tag{15}$$

The parameters $\alpha, \beta \in [0,1]$ denote the relative bargaining power of the Opportunists in the respective party. The numbers $((\alpha, \beta), ((1-\alpha), (1-\beta)))$ are the Nash bargaining weights of the problem. If Opportunists and Guardians do not agree on a policy platform in party A, then party B wins the election with certainty and the Opportunists' payoff is zero, while the Guardians' payoff is the average welfare in the case of enactment of party B's policy vector t_B(cf. (14)). The same logic holds for party B (cf. (15)). If there is a weighted Nash bargaining solution, then it must be PUNE. On the other hand, when there is a PUNE, then it is exactly the solution to a corresponding weighted Nash bargaining game if $ln(\pi(\cdot, t_B))$ and $ln(W^A(\cdot) - W^A(t_B))$ are concave functions on T and if $ln(1 - \pi(t_A, \cdot))$ and $ln(W^B(\cdot) - W^B(t_A))$ are concave functions on T (cf. "Assumption A" in Roemer (2006, p. 157)).

There is a convenient differential characterization of PUNEs as formulated by (14) and (15) the simplicity of which is very useful for the numerical calculation of PUNEs (cf. Roemer (2006, Section 8.4)). For the derivation see Appendix A.2. For a policy pair (t_A, t_B) to be a PUNE, the following equation[11] must hold for party A[12]

$$\nabla_{t_A} W^A(t_A) = -\lambda^A(t_A, t_B) \nabla_{t_A} \pi(t_A, t_B) \tag{16}$$

with $\lambda^A(t_A, t_B) := \frac{\alpha}{1-\alpha} \frac{\Delta W^A(t_A)}{\pi(t_A, t_B)}$; and for party B

$$\nabla_{t_B} W^B(t_B) = \lambda^B(t_A, t_B) \nabla_{t_B} \pi(t_A, t_B) \tag{17}$$

with $\lambda^B(t_A, t_B) := \frac{\beta}{1-\beta} \frac{\Delta W^B(t_B)}{\pi(t_A, t_B)}$. Equations (16) and (17) provide a set of $2T = 4$ equations for $2T + 2 = 6$ unknowns $(\tau_A, \tau_B, \kappa_A, \kappa_B, \alpha, \beta)$. The system of equations is numerically solvable for given Nash bargaining weights (α, β).

4 Climate Policy Analysis

In this section the influence of inequality of income on the equilibrium policies is analyzed. First, in Subsection 4.1, the income tax rate τ is exogenously given and policy competition is just one-dimensional over the carbon tax rate κ. Then, in Subsection

[11] Note that the Del or nabla operator ∇_{t_A} indicates a derivative with respect to a vector, in this case t_A, so that $\nabla_{t_A} = \left(\frac{\partial}{\partial \tau_A}, \frac{\partial}{\partial \kappa_A}\right)$ and $\nabla_{t_B} = \left(\frac{\partial}{\partial \tau_B}, \frac{\partial}{\partial \kappa_B}\right)$.

[12] For taking the derivative of party A's winning probability $\pi(t_A, t_B)$ with respect to the vectors t_A and t_B derivatives of $\hat{a}(t_A, t_B; h_i)$ are needed. Since $\hat{a}(t_A, t_B; h_i)$ is a quite complicated function (cf. 11), its derivatives are taken numerically in the simulation which is the basis for the analysis section 4.

4.2, the full two-dimensional competition over both policy dimensions is examined and compared to the one-dimensional setup to carve out the interactions between the policy instruments. For the numerical illustrations, a reference parameter setting is defined and summarized in Table 1.

Mean income h_μ	20
Salience parameter of climate issue δ	5
Salience parameter of redistributive issue ϕ	1
Pre-tax energy price p_E	4
Party error margin ϵ	0.02
Elasticity of production w.r.t. labor γ	0.95
Elasticity of production w.r.t. energy $(1-\gamma)$	0.95

Table 1: Reference parameter setting

4.1 One-Dimensional Policy Competition over Climate Policy

4.1.1 The Role of Income Inequality and Carbon Tax Recycling

In the one-dimensional case the parties only compete over the carbon tax rate κ on every energy unit, while the income tax rate τ is exogenously given and fixed. Given the log-normally distributed skill level h_i, which is equal to pre-tax income (cf. Section 2.2.1), the ratio of median income to mean income $\frac{h_{med}}{h_\mu}$ is the measure for pre-income-tax inequality which is used in the following analysis. The fixed income tax leads to a certain degree of redistribution, so that post-income-tax inequality of income is lower. But, nevertheless, a decrease of $\frac{h_{med}}{h_\mu}$ increases inequality before and after levying the income tax.[13] The resulting PUNEs in one-dimensional policy competition over the carbon tax are shown in Figure 1 for a regressive carbon tax recycling ($\tau_\kappa = 0$), for different levels of the inequality measure $\frac{h_{med}}{h_\mu}$ and for different bargaining power parameters of the Opportunist factions $(\alpha, \beta) \in \{(0.1, 0.1), (0.5, 0.5), (0.9, 0.9)\}$.[14] Since labor is the numeraire good and wages are equal to one, the unit of the carbon tax κ in this and all the following figures must be read as "wage units/energy unit".

[13] By assumption, "increases" or "decreases" in pre-income-tax inequality throughout the analysis imply that median income h_{med} changes while mean income $h_\mu$stays the same. In this way, a different degree of inequality means a different distribution of an otherwise constant aggregate pre-tax income.

[14] In this and the following figures the bargaining weights of the Opportunist faction are assumed to be equal in both parties for simplicity. The case with low Opportunist bargaining weights of $\alpha, \beta = 0.1$ is always depicted with dashed curves, the case $\alpha, \beta = 0.5$ with solid curves, and the case with high Opportunist bargaining weights of $\alpha, \beta = 0.9$ with dash-dotted curves. The color blue is assigned to party A, red is assigned to party B.

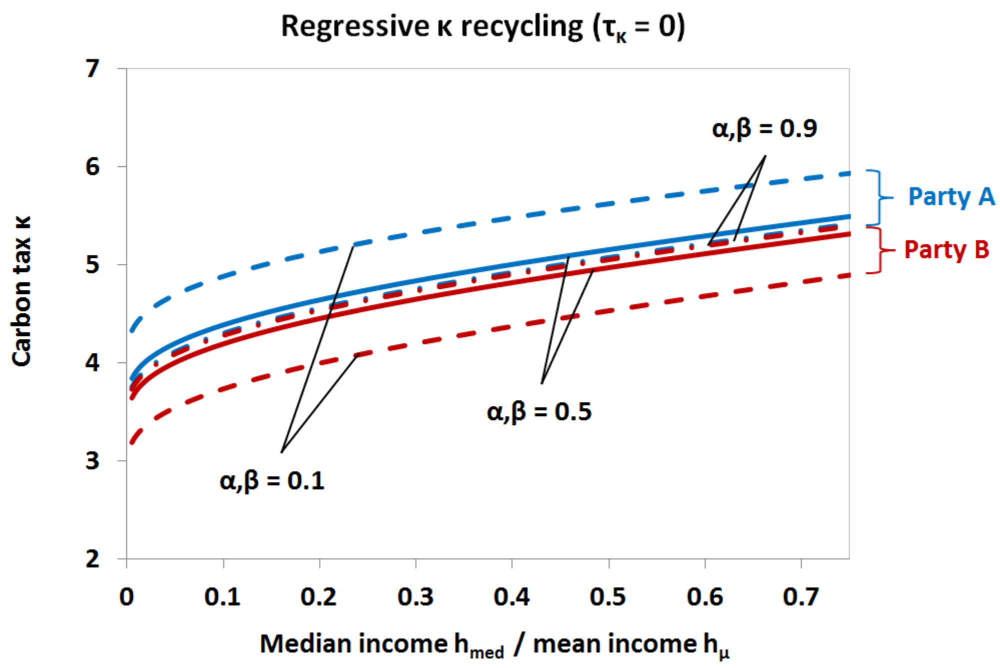

Figure 1: PUNEs for one-dimensional policy competition over the carbon tax rate κ for regressive carbon tax recycling ($\tau_\kappa = 0$) and $\tau = 0.5$.

Party A in all cases proposes a higher carbon tax rate than party B. This is due to the definition of party A as the one which represents the voters with a collective orientation above the indifference threshold $a_i > \hat{a}(t_A, t_B; h_i)$ (cf. Section 3.1), who have a higher preference for climate protection and for redistribution of income than supporters of party B.

The higher the bargaining power of Opportunists in both parties, the closer are the resulting party platforms. This is not surprising since focusing mainly on the probability to win, as strongly Opportunist parties do, brings the parties closer to the median-voter logic. The most striking result is, however, that more income inequality (decreasing median income h_{med}) leads to lower carbon tax proposals of both parties in equilibrium. The reason is the regressivity of the carbon tax recycling mechanism. Recall that a recycling distribution parameter τ_κ of zero implies that the carbon tax revenues are recycled to each household proportionally to their pre-income-tax income.[15] The distributional impact of the carbon tax in part counteracts the progressive redistribution from the (fixed) income tax. Therefore, increasing income inequality (while mean income and the income tax τ stay fixed) raises the share of voters with an income below the mean

[15] In principle, even more regressive revenue recycling schemes are possible. But for simplicity, here the implicit redistribution parameter τ_κ is used. If τ_κ fell below zero, then some poor households would receive "negative recycling payments", which would not make sense in reality.

($h_i < h_\mu$) who have a low preference for a regressive carbon tax and strengthens their aversion against regressive policies like a carbon tax with $\tau_\kappa = 0$.

To point out the crucial role of the recycling mechanism, Figure 2 shows the opposite result for a progressive recycling of carbon tax revenues, that is for a distributive parameter of carbon tax recycling τ_κ equal to one. This implies, that households receive lump-sum payments.

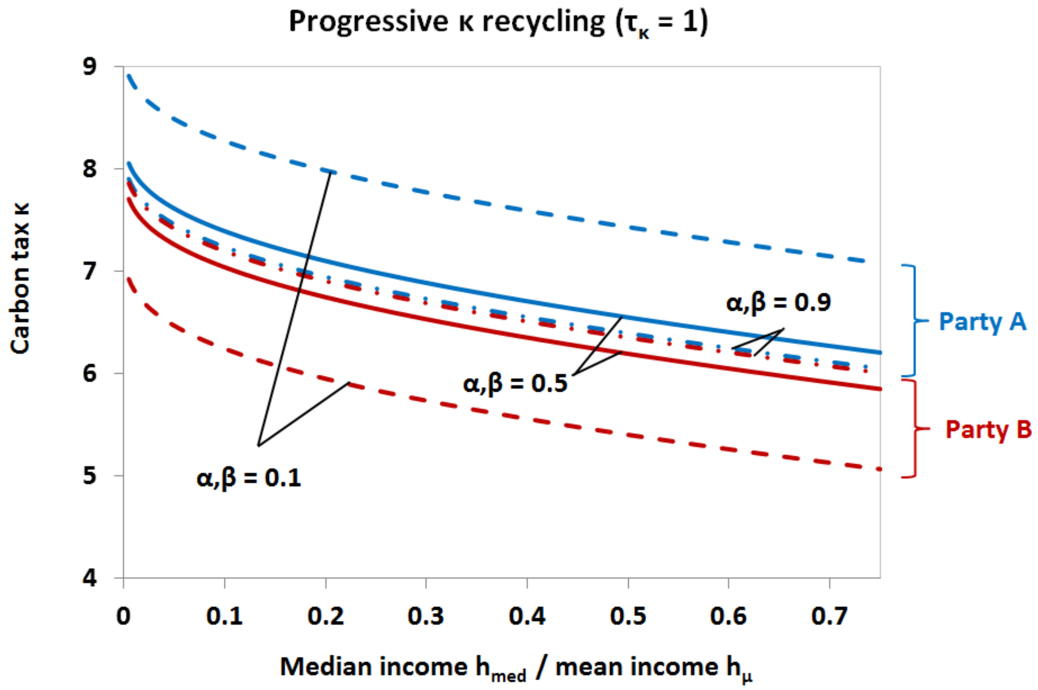

Figure 2: PUNEs for one-dimensional policy competition over the carbon tax rate κ for progressive carbon tax recycling ($\tau_\kappa = 0$) and $\tau = 0.5$.

Party A is still more environmentalist than party B and the policy proposals are more polarized if the Guardians have a higher bargaining power in the parties (that is, α, β are lower). But an increase in income inequality (in contrast to the case $\tau_\kappa = 0$) raises the preference of the majority of households with $h_i < h_\mu$ for a progressive carbon tax policy and also the share of households with $h_i < h_\mu$. The result is higher carbon tax proposals by both parties in equilibrium.

Polarization between the parties on climate policy is higher for a progressive carbon tax ($\tau_\kappa = 1$) than for a regressive carbon tax ($\tau_\kappa = 0$).[16] The reason is that a higher progressivity additionally benefits primarily low-income voters represented by party A

[16] Note that the scaling of the y axis in Figures 1 and 2 is the same.

at the expense of high-income voters of party B. Consequently, party A proposes a higher carbon tax and party B a lower carbon tax if the respective revenue recycling is more progressive.

4.1.2 The Effect of the Exogenous Income Tax Rate

The exogenously given income tax rate is an important determinant of the resulting equilibrium due to its role in the pass-through of pre-tax inequality to post-income-tax inequality. The latter ultimately affects the voters' evaluation of the distributive consequences of the carbon tax. Figure 3 demonstrates the impact of an increase in the exogenous income tax rate from $\tau = 0.5$ (grey curves) to $\tau = 0.7$ (blue and red curves) on the parties' equilibrium carbon tax proposals for different degrees of pre-tax inequality $\frac{h_{med}}{h_\mu}$. To allow a better comparison, only the curves for high bargaining power of the Opportunist factions of $\alpha, \beta = 0.9$, which are closer to the average proposals of both parties, are shown.

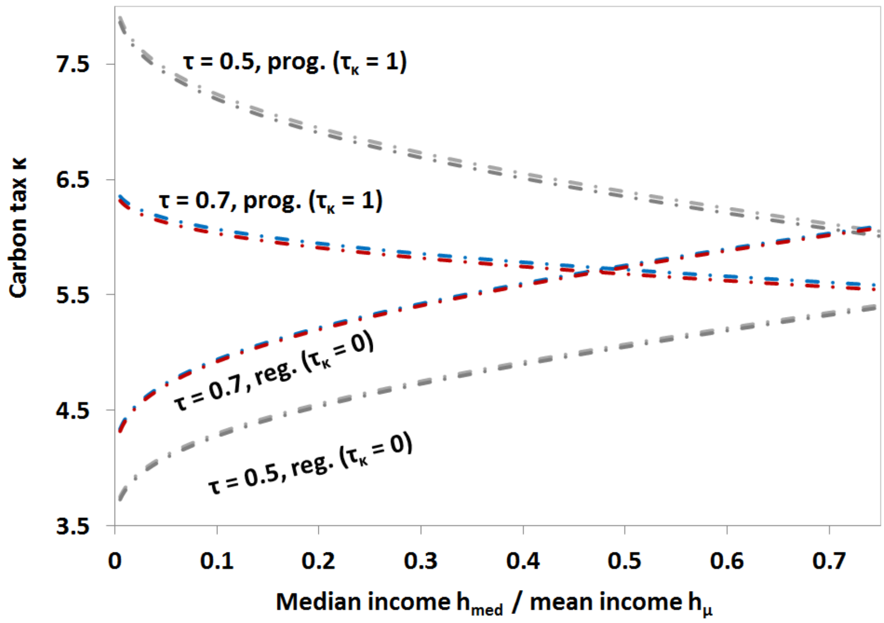

Figure 3: Comparison of the parties' carbon tax proposals for different levels of pre-tax income inequality $\frac{h_{med}}{h_\mu}$ at $\tau = 0.5$ and $\tau = 0.7$ $(\alpha, \beta = 0.9)$.

The increase in the income tax rate reduces post-income-tax inequality of income and, thereby, also the perceived need for further redistribution. As a result, the voters' preference for the redistributive effect of a progressive carbon tax ($\tau_\kappa = 1$) decreases as well, while their preference for the emission reduction effect of the carbon tax remains the same. This leads to lower equilibrium carbon tax proposals by both parties than for

$\tau = 0.5$. The voter preference for a regressive carbon tax ($\tau_\kappa = 0$), however, increases relative to $\tau = 0.5$ as the regressive distributional effect of the carbon tax is perceived as less harmful, leading to higher carbon tax proposals by both parties. Overall, the gap between carbon tax proposals in the cases of progressive and regressive revenue recycling is diminished and even reversed in sign for approximately $\frac{h_{med}}{h_\mu} > 0.48$. A reversal of the gap for low inequality of pre-tax income (high $\frac{h_{med}}{h_\mu}$) implies that a majority of the electorate perceives the exogenous tax rate of 0.7 as too high[17] and under these circumstances prefers a regressive carbon tax to a progressive one. At the inequality level corresponding to $\frac{h_{med}}{h_\mu} = 0.48$ the exogenous income tax rate of 0.7 is equal to the average desired tax rate according to the average preference of voters for redistribution (cf. "Redistributional Preference" in Subsection 2.2.2). Therefore, the progressive or regressive character of the carbon tax does not matter at this point and the according curves intersect. But, despite the impact of the income tax rate, the general influence of an increase in pre-tax inequality on the carbon tax proposals – positive for $\tau_\kappa = 1$, negative for $\tau_\kappa = 0$ – remains unchanged.

To sum up, voters favor a progressive carbon tax over a regressive one if it promises additional redistribution which they desire but did not yet obtain. An increase in post-tax income inequality can result from a higher pre-tax inequality or a lower income tax and raises the desire for more redistribution. This leads to higher proposals for a progressive carbon tax and lower proposals for a regressive carbon tax.

4.2 Two-Dimensional Policy Competition over Climate Policy and Income Tax

4.2.1 The Role of Income Inequality

Now the income tax rate τ is endogenized and turns into a second dimension of political competition, next to the carbon tax κ. A higher pre-tax inequality of income (that is, a lower ratio $\frac{h_{med}}{h_\mu}$) increases the share of voters with an income lower than the mean h_μ and, thus, leads to a more pronounced support for higher redistribution via the income tax and the according proposals by both parties for different levels of Opportunist bargaining power in two-dimensional policy equilibrium, as Figure 4 confirms.[18] The overall net effect of an exogenous increase in pre-income-tax inequality and an associated

[17] The according two-dimensional policy case (cf. Section 4.2) yields endogenous income tax rates between 0.58 and 0.63 at $\frac{h_{med}}{h_\mu} = 0.75$.

[18] Note, that along the curves in Figure 4 the equilibrium carbon tax rate changes as well.

increase in redistribution via income taxation on the resulting inequality in post-income-tax (but pre-carbon-tax) income is a priori ambiguous.

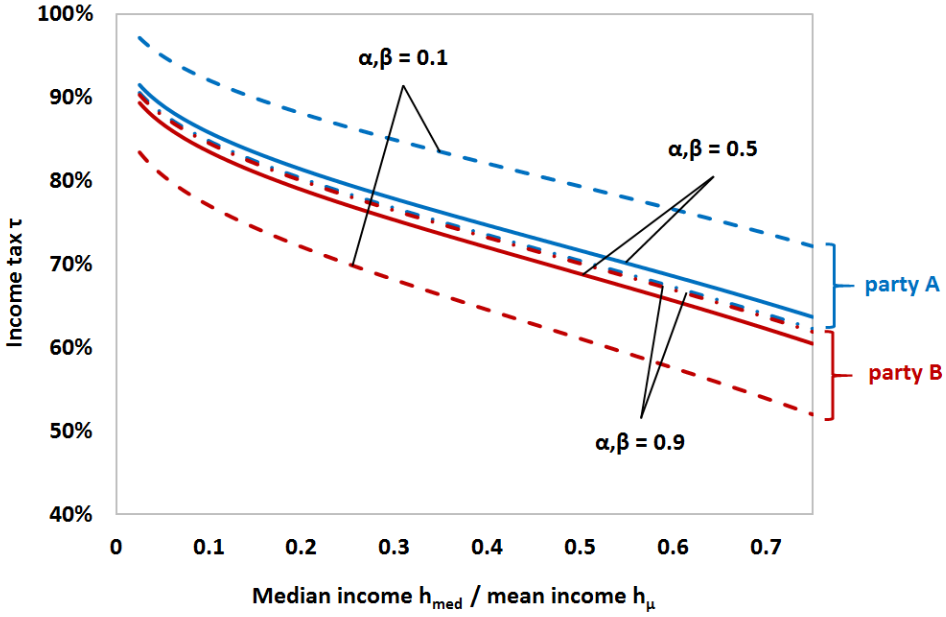

Figure 4: Income tax proposals of the parties in two-dimensional competition for different levels of pre-tax income inequality $\frac{h_{med}}{h_\mu}$.

At the same time, a rising inequality in pre-tax income affects the stance of both parties on climate policy, as Figure 5 shows. Like in the one-dimensional setup (cf. Section 4.1), the results are shown for three different levels of bargaining power of the respective Opportunist factions (0.1, 0.5, and 0.9).

A striking difference to the one-dimensional case with exogenous income tax is that rising inequality impacts the two party platforms in different ways: starting with low inequality (high $\frac{h_{med}}{h_\mu}$), an intensifying of pre-tax income inequality until approximately $\frac{h_{med}}{h_\mu} = \frac{8.3}{20} = 0.415$ at first reduces polarization between the two parties on the climate policy issue, that is, the difference in proposed carbon tax rates. But then, for a further rising pre-tax inequality (falling $\frac{h_{med}}{h_\mu}$), party polarization on the climate issue increases. The change in polarization is also stronger if the Opportunist factions have a low bargaining power, that is, if the Guardians dominate the parties.

The polarization of party platforms on the climate issue is important for the climate policy uncertainty from the perspective of risk-averse investors, e.g., in the energy sector. Even if the average carbon tax proposal[19] remained unaffected by changes in

[19] Each party's probability to win is close, but not exactly equal, to 50%. Therefore, the expected

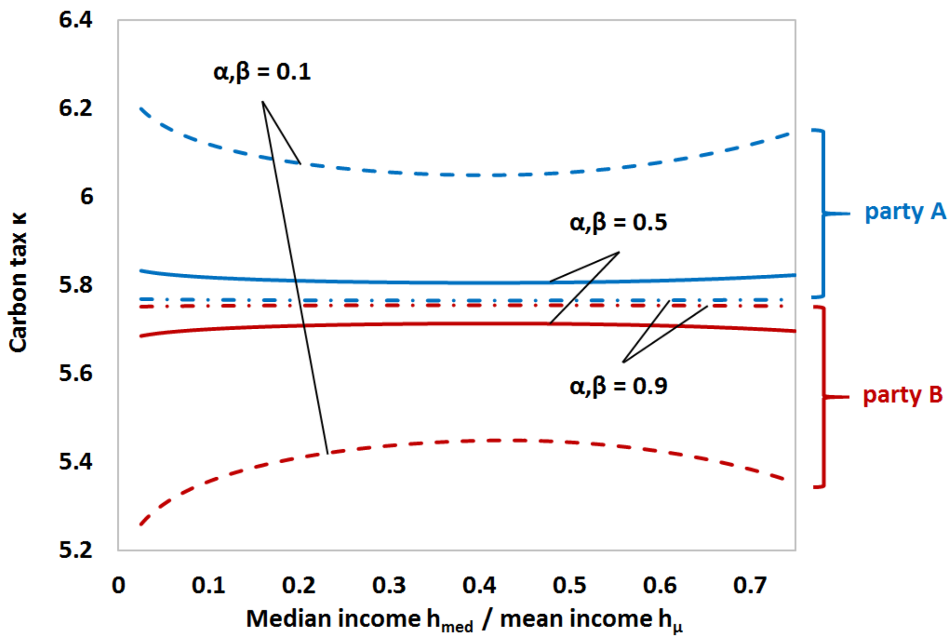

Figure 5: Carbon tax proposals of the parties in two-dimensional competition for different levels of pre-tax income inequality $\frac{h_{med}}{h_\mu}$.

income inequality, a rise in climate policy uncertainty could induce risk-averse investors to invest more cautiously. In this case, a rising inequality and its effects on the climate policy proposals via the political competition dynamics could turn out as hampering the decarbonization of the economy.

At the same time with the change in polarization, the average carbon tax proposal is virtually not affected by a change in income inequality.[20] Apparently, changes in the inequality of pre-tax income are neutralized by the endogenous income tax adjustment, so that the average carbon tax proposal is not affected by any change in the voter preference in favor or against redistribution. With the income tax the voters have a policy instrument available which directly targets the income distribution. Therefore, they do not have to rely on the carbon tax for redistributional purposes.

Moreover, and also in contrast to the one-dimensional case (cf. Section 4.1), the progressive or regressive character of carbon tax recycling does not play any role for the level of the carbon tax proposals (cf. Table 2). With a more progressive carbon tax a

carbon tax in the sense of the average of carbon tax proposals weighted with the respective party's winning probability is close, but not exactly equal to, the average carbon tax proposal. For simplicity, the term "average carbon tax proposal" is used here.

[20] Calculating the actual average of the proposals shows that it is not exactly constant, but the average changes only very little (cf. Figure 9 in Appendix B) with income inequality.

lower degree of progressive redistribution is needed via the income tax to reach the same desired average level of redistribution $\rho(\tau, \kappa, \tau_\kappa)$. Therefore, income tax proposals are lower (higher) if the carbon tax is more (less) progressive, but the carbon tax proposals remain absolutely unaffected by their degree of progressivity.

	τ_A	τ_B	κ_A	κ_B
Regressive recycling ($\tau_\kappa = 0$)	79.528%	77.044%	5.8078	5.7104
Progressive recycling ($\tau_\kappa = 1$)	76.412%	73.949%	5.8078	5.7104

Table 2: Comparison of equilibrium policy platforms for progressive and regressive carbon tax revenue recycling ($\alpha, \beta = 0.5$, $\frac{h_{med}}{h_\mu} = \frac{5}{20}$, other parameters as in reference case).

A characteristic feature of the present setup is that the two dimensions of voter types a_i (uniform distribution) and h_i (log-normal distribution) are not correlated. An change of the inequality of pre-tax income, therefore, changes the distribution of voters w.r.t h_i, but not w.r.t. a_i. In future research a correlation of both dimensions could be assumed. For instance, rich voters (high h_i) could, on average, exhibit a higher (or lower) collective orientation a_i. Then the implications of changes in the progressivity of carbon tax recycling or in the inequality of pre-tax income could change.

4.2.2 Myopia w.r.t. the Distributive Effects of the Carbon Tax

In the voter preferences as presented in Equation 2.2.2 (cf. Section 2.2) the voters have a stance on their desired degree of total redistribution $\rho(\tau, \kappa, \tau_\kappa)$ via the income tax and the carbon tax. This can be interpreted as the voters' opinion on inequality aversion, social policy, or fairness. The assumption there is that the voters fully understand and evaluate redistributional implications not only of the income tax, but also of the carbon tax. Issues like distributional justice and income inequality are usually discussed in the political debate in the context of income tax policy or social security systems. It is not obvious that voters in reality account for the overall distributional effects of environmental policy measures like a carbon tax when they are forming their opinion on the appropriate degree of the measure. However, voters can be expected to notice and care for the impact that an environmental policy has on their own income, at least once it materializes.

Therefore, the present section focuses on the changes in the previously presented results when the assumption of full understanding and internalization of the distributive nature of the carbon tax by the voters is released. Instead it is assumed that they only consider the impact of the carbon tax on their utility via the climate preference term and the consumption utility term (cf. Section 2.2.2), but neglect the redistributive character of the carbon tax (progressive or regressive) in the redistributive preference term: the total degree of redistribution $\rho(\tau, \kappa, \tau_\kappa)$ in the latter is substituted by the income tax rate τ only. The redistributive preference term in (9), thus, turns from $-\phi(a_i - \rho(\tau, \kappa, \tau_\kappa))^2$ to $-\phi(a_i - \tau)^2$. Note, that the total degree of redistribution $\rho(\tau, \kappa, \tau_\kappa)$ in the consumption utility term $ln(x_i(h_i; \tau, \kappa))$ with $x_i(h_i; \tau, \kappa)$ from (7) remains unchanged, because the monetary consequences of carbon tax recycling do take place even though the voters do not account for the impact on the overall distribution of income.

Under these circumstances, an increase of inequality of pre-tax income (that is, a decrease in $\frac{h_{med}}{h_\mu}$) yields again an increase in the proposed income tax rates, just as in the full internalization setting in Section 4.2.1.[21] Figure 6 shows how the impact of, e.g., an increase in pre-tax inequality on the average carbon tax proposals now changes in comparison to Figure 5, where it is virtually zero.

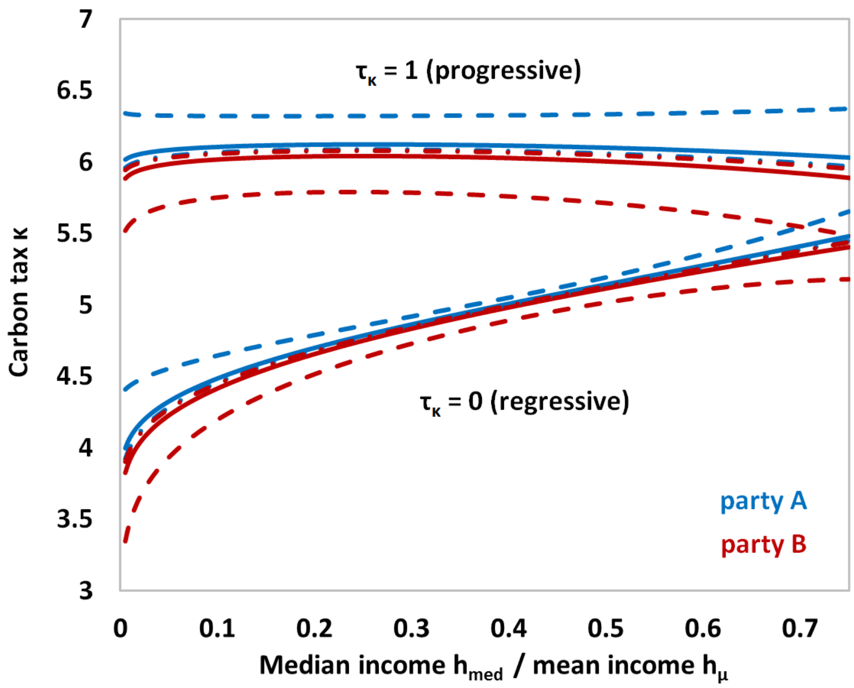

Figure 6: Carbon tax proposals for voters who are myopic w.r.t. the redistributional implications of the carbon tax κ.

Unlike the fully informed voters of Section 4.2.1, the average proposal for a regressive

[21] In fact, the income tax proposals with voters who are myopic in the described sense is slightly below the tax rates with full internalization of the distributive impact of κ if $\tau_\kappa = 0$. The reason is that the myopic voters underestimate the regressivity of the carbon tax and do not sufficiently favor an according increase in τ to compensate the regressivity of the carbon tax.

carbon tax ($\tau_\kappa = 0$) is significantly reduced by an increase in pre-tax inequality. For a progressive carbon tax ($\tau_\kappa = 1$) the relationship appears to be non-monotonic, even when it is quite weak: when coming from a rather equal income distribution at the right of Figure 6, a decrease in $\frac{h_{med}}{h_\mu}$ slightly increases the average carbon tax proposal of the two parties, but then, for high levels of inequality closer to the left boundary of Figure 6, more inequality decreases the average carbon tax proposal. It also appears that the degree of regressivity of carbon tax recycling is no longer neutral due to the myopia assumption. Instead, a progressively designed carbon tax exhibits more public support than a regressively designed one. Furthermore, the advantage due to a more progressive design of carbon tax revenue recycling is more pronounced for higher levels of pre-income-tax inequality.

To sum up, even though the income tax adjusts to the increase in pre-tax inequality, the changes in inequality affect the voters' preference for the carbon tax, depending on its degree of progresivity. If the tax is regressive, then a majority of voters suffers individual monetary losses caused by its regressive character and prefers a lower carbon tax than in the case of a progressive carbon tax. If they were not myopic, they would want to compensate the regressive implication of the carbon tax via an income tax increase. But with the myopia assumption they do not account for the overall regressive distributional implication of the carbon tax and do not demand an income tax increase, thinking erroneously that their desired level of redistribution is reached. In the case of a progressive carbon tax a majority of voters enjoys additional monetary benefits from progressive revenue recycling (compared to regressive revenue recycling) without accounting for this additional progressive redistribution by choosing a lower income tax (in order to restore the average "desired" level of redistribution). In this way the carbon tax turns into a redistributive instrument without affecting the myopic people's utility over the redistributive preference term. Even if only a share of the electorate is myopic in the described sense, then this fact can also be expected to affect the equilibrium policy platforms.

4.2.3 Role of the Salience of the Redistribution Discourse ϕ

In this Subsection the question is raised how an increase in the salience of the political discourse on the distribution of income and the desired level of redistribution affects the PUNE outcomes. The salience of the distributional ideological issue is captured by the parameter ϕ in the term $-\phi(a_i - \rho(\tau, \kappa, \tau_\kappa))^2$, which expresses the disutility from deviations of the actual level of income redistribution from the individual's desired level (cf. Equation (9)). Without this ideological stance on redistribution the majority of voters with $h_i < h_\mu$ would prefer an income tax of one based only on the implications of redistribution for consumption utility. So, it reduces income taxation below one out of ideological concerns with regard to the degree of redistribution.

An increase in the salience of the related public discourse strengthens these ideological distributional concerns and can be expected to decrease the voter preference for income taxation. Figure 7 demonstrates this effect on the two-dimensional PUNEs for different bargaining weights of the Opportunist factions in the reference parameter setting. With the salience parameter ϕ going towards zero, income taxation in the equilibrium tends towards one. But an increasing ϕ reduces the proposed income tax rates of both parties for all relative bargaining weights. If the ideological stance on redistribution becomes so salient in voters' minds that it dominates the consumption related implications of the income tax, then the average income tax proposal approaches the average value for $a_i \in [0, 1]$, which is 0.5 for a uniform distribution of a_i.

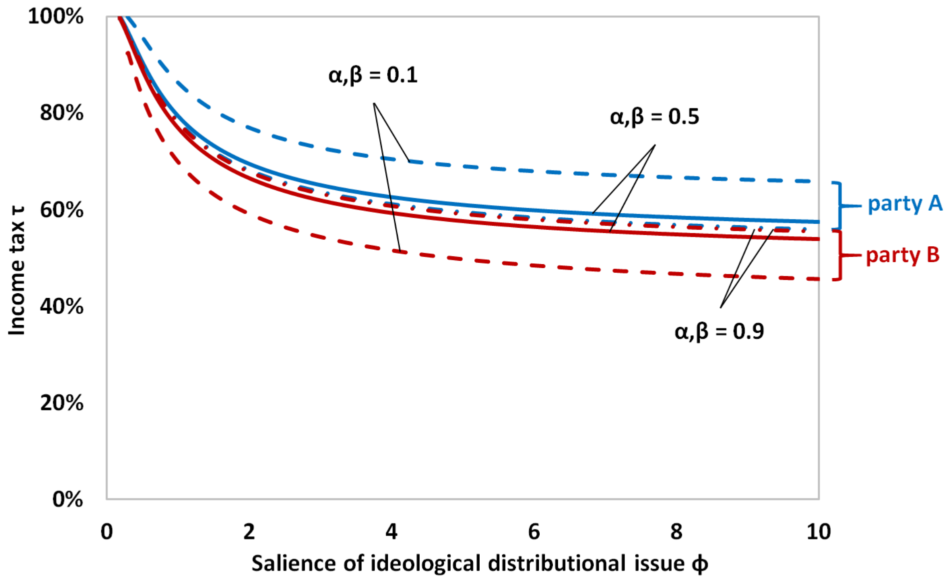

Figure 7: Effect of the salience of the ideological discourse on redistribution ϕ on the equilibrium income tax proposals.

The effect of a rise in the salience parameter ϕ on the parties' simultaneous carbon tax proposals is shown in Figure 8. as a reaction, the polarization of the carbon tax proposals increases, particularly strongly in the range $0 < \phi < 3$, where the income tax decrease is most pronounced. This indicates that it is the rising post-income-tax inequality after the associated income tax reduction of Figure 7 which drives the polarization in carbon tax proposals. The result that, by leading to lower redistribution, an increase in ϕ fosters climate policy uncertainty seems to reaffirm the point from

Section 4.2.1 that higher inequality of (pre-tax) income can raise policy uncertainty with regard to the carbon tax.

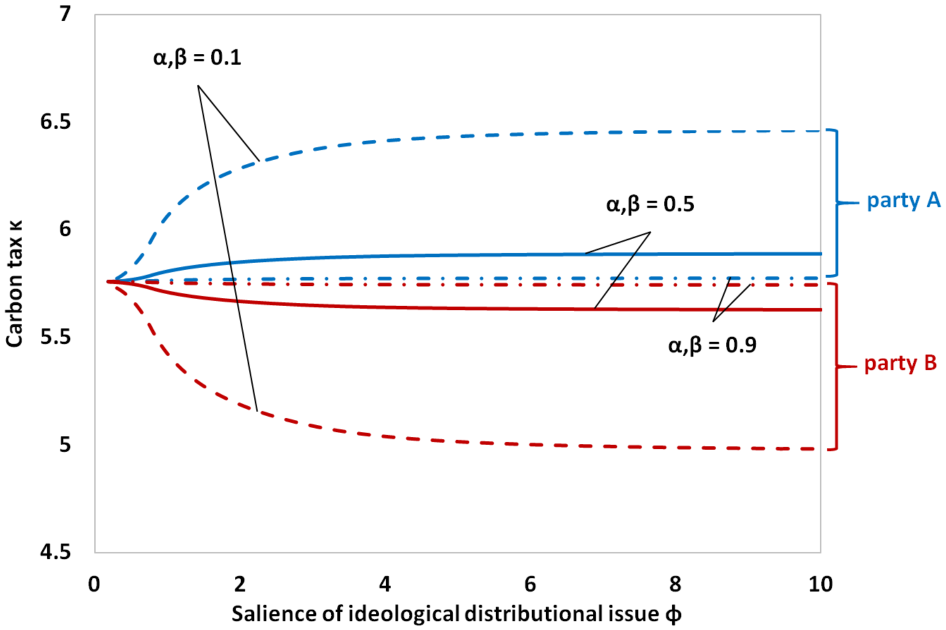

Figure 8: Increase in party polarization on the climate issue with increasing salience of the redistributive discourse ϕ

5 Conclusion

This paper presents the first analysis of two-dimensional political competition over a carbon tax and a proportional income tax in a static model of production with labor and carbon-intensive energy. Voter types are heterogeneous in pre-tax income and in their "collective orientation", which stands behind the individual preference for climate protection and for inequality aversion. The fact that the results differ significantly between a model version with a fixed exogenous income tax and one-dimensional political competition over the carbon tax and the full two-dimensional model emphasizes the importance of the two-dimensional approach.

In the one-dimensional case an increase in pre-tax inequality leads to higher (lower) carbon tax proposals by both parties if the carbon tax revenue recycling mechanism is progressive (regressive). In contrast, in the two-dimensional case the income tax compensates changes in inequality in pre-tax income and the average carbon tax proposal remains largely unaffected. The polarization of party platforms on the climate issue, however, changes non-monotonically with inequality of pre-tax income. For a low ratio of median income to mean income of approximately $\frac{h_{med}}{h_\mu} < 0.4$ the difference in the parties' carbon tax proposals increases with rising inequality. This implies that policy uncertainty, in the sense of the standard deviation from the expected value of the carbon tax, for investors in sectors heavily affected by climate policy – like renewable energy or other low-carbon technologies – can be exacerbated by rising inequality in market incomes. Party polarization and resulting policy uncertainty on the climate issue is also reinforced in the model by a higher salience of the normative discourse on the "appropriate", or individually desired, level of redistribution. This discourse reduces redistribution below 100 percent, which would result from purely monetary loss/benefit considerations of the voters, on the grounds of fairness, aversion to government intervention, distributive justice, and the like. The analysis also shows that it plays a significant role for the political equilibrium whether voters take the overall redistributive implication of the carbon tax into account in their utility function. If they are myopic in this respect, then the redistributive effect of the carbon tax is not offset by an adjustment in the income tax and changes in pre-tax inequality do affect the average carbon tax proposal, in contrast to the non-myopic case. The study reaffirms that distributive effects can play a very important role for the level of public support for climate policy measures. The way that carbon tax revenues are recycled, the way that climate policy is combined with income tax measures, the question what is taken into account in the public debate, the distribution of views on redistribution and inequality aversion, and the salience of the according public discourse are all important factors in the formation of public opinion on climate policy proposals.

The present work is only a first step in the analysis of the complex relationships between climate policy, or more general public good provision, political competition, inequality, and redistribution. The presented effects should be analyzed more in depth in future research to better understand some mechanisms, e.g. of increasing party polarization with changing pre-tax income inequality, to examine the sensitivity of the observed effects to further parameter changes, and to get closer to an empirical evaluation of the effects with real-world data. As a part of the sensitivity analysis, but also of a calibration, different distributions of the voter type parameter for "collective orientation" (uniformly distributed in this paper) should be considered. Then also different party profiles like high redistribution/low climate policy and low redistribution/high climate policy could be possible.

A large number of extensions is possible for the presented framework: by extending the model to include elastic labor supply and, possibly, capital with capital income taxation the interaction of tax-related distortions in these factor markets and the endogenous climate policy dynamics could deliver additional insights for the debate on optimal carbon taxation and a double dividend. On this front, it could be quite insightful to establish an optimal taxation setting and to compare it with the outcome of political competition. In this way, the welfare reducing effects of different political economic aspects could be investigated. The model could also be combined with a temporal dimension to create economic growth, saving behavior, endogenous investments in green technologies, and an endogenous evolution of income inequality over time. In doing so, the feedback loop between economic processes affecting inequality, the political process which determines party platforms, and resulting decarbonization of the economy, which again creates winners and losers, could be closed to get a better understanding of the involved mechanisms. Such an extension could possibly yield a contribution to the debate on the environmental Kuznets curve. Also, the assumption of just two parties, although satisfying for the U.S., is quite restrictive for the explanation of the according political competition in other countries with proportional representation and coalition governments. Another possible future extension could aim at a combination of the present model of national political economic dynamics for a number of country blocs which are heterogeneous in income level, income distribution, and distribution of what I called "collective orientation" in this paper with a model of international climate negotiations.

Appendix

A Model Derivations

A.1 Total degree of redistribution

The sum of carbon tax revenues $\kappa E(\kappa)$ is recycled proportionally to the income distribution which would result from an income tax of τ_κ. The according formulation of $Rec(\kappa)$ from (6) is substituted into (5), which yields

$$\left[h_i + (h\mu - h_i)\tau + \underbrace{(h_i + (h_\mu - h_i)\tau_\kappa)\frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}}_{Rec(\kappa)} \right] \frac{\gamma^\gamma(1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}} =$$

$$\left[h_i \left(1 + \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}\right) + (h_\mu - h_i)\tau \left(1 + \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}\frac{\tau_\kappa}{\tau}\right)\right] \frac{\gamma^\gamma(1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}} =$$

$$\left(1 + \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}\right) \left[h_i + (h_\mu - h_i) \underbrace{\tau \left(\frac{1 + \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}\frac{\tau_\kappa}{\tau}}{1 + \frac{\kappa(1-\gamma)}{(p_E+\kappa)\gamma}} \right)}_{\rho(\tau,\kappa,\tau_\kappa)} \right] \frac{\gamma^\gamma(1-\gamma)^{(1-\gamma)}}{(p_E+\kappa)^{(1-\gamma)}}$$

with the total degree of redistribution $\rho(\tau, \kappa, \tau_\kappa)$.

A.2 Differential Formulation of PUNE

This differential formulation of PUNE is taken from Roemer (2006). In the case of party A, the weighted Nash bargaining game is defined by a maximization of the Nash product, as stated in (14) in Section 3.2

$$\max_{t \in T} (\pi(t, t_B) - 0)^\alpha (W^A(t) - W^A(t_B))^{1-\alpha}$$

Applying logs yields

$$\max_{t \in T} \alpha \, ln(\pi(t, t_B)) + (1-\alpha) \, ln(\Delta W^A(t))$$

with $\Delta W^A(t) = W^A(t) - W^A(t_B)$. For maximization, the gradient w.r.t. the policy vector t is taken and set to zero

$$\frac{\alpha}{\pi(t,t_B)}\nabla_t \pi(t,t_B) + \frac{(1-\alpha)}{\Delta W^A(t)}\nabla_t W^A(t) = 0$$
$$\nabla_t W^A(t) = -\frac{\alpha}{1-\alpha}\frac{\Delta W^A(t)}{\pi(t,t_B)}\nabla_t \pi(t,t_B)$$

Defining $\lambda^A(t,t_B) = \frac{\alpha}{1-\alpha}\frac{\Delta W^A(t)}{\pi(t,t_B)}$ yields the equation

$$\nabla_t W^A(t) = -\lambda^A(t,t_B)\nabla_t \pi(t,t_B)$$

In the same way, the according maximization problem for party B from (15)

$$\max_{t\in T}((1-\pi(t_A,t)) - 0)^\beta (W^B(t) - W^B(t_A))^{1-\beta}$$

can be transformed to

$$\nabla_t W^B(t) = \lambda^B(t_A,t)\nabla_t \pi(t_A,t)$$

with $\lambda^B(t_A,t) = \frac{\beta}{1-\beta}\frac{\Delta W^B(t)}{\pi(t_A,t)}$

B Climate Policy Analysis

In the case of two-dimensional policy competition a variation of the inequality of pre-tax income $\frac{h_{med}}{h_\mu}$ is taken care of by the income tax τ. The carbon tax proposals of the parties remain largely unaffected for the three examined bargaining weights of the Opportunist factions in both parties.

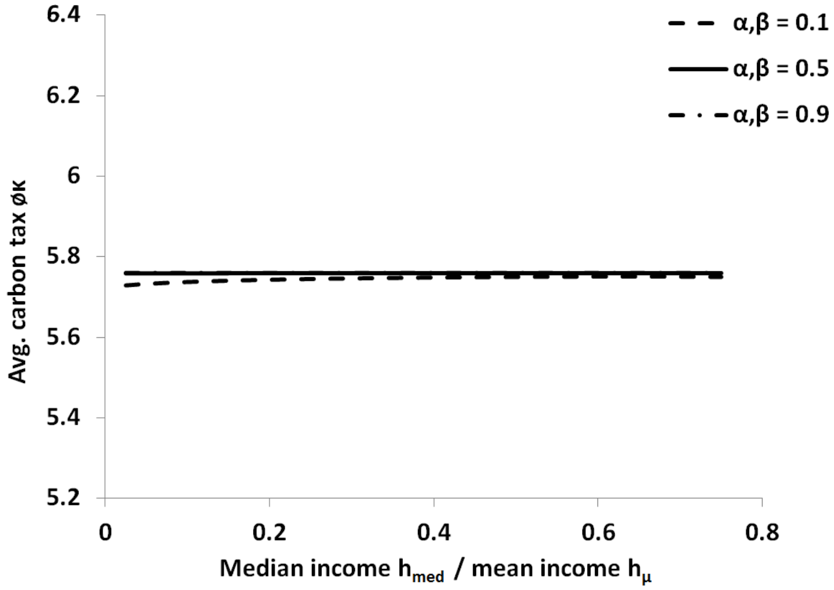

Figure 9: Average carbon tax proposals for two-dimensional PUNEs at the reference parameter setting (cf. Table 1)

References

Babiker, Mustafa H., Gilbert E. Metcalf, and John Reilly (2003). "Tax distortions and global climate policy". *Journal of Environmental Economics and Management* 46 (2), pp. 269–287.

Barker, Terry and Jonathan Köhler (2005). "Equity and ecotax reform in the EU: Achieving a 10 per cent reduction in CO2 emissions using excise duties". *Fiscal Studies* 19 (4), pp. 375–402.

Barrage, Lint (2018). "Optimal dynamic carbon taxes in a climate-economy model with distortionary fiscal policy". *Review of Economic Studies* (forthcoming).

Bento, Antonio M. and Mark Jacobsen (2007). "Ricardian rents, environmental policy and the 'double-dividend' hypothesis". *Journal of Environmental Economics and Management* 53 (1), pp. 17–31.

Böhringer, Christoph, Nicholas Rivers, and Hidemichi Yonezawa (2016). "Vertical fiscal externalities and the environment". *Journal of Environmental Economics and Management* 77, pp. 51–74.

Bovenberg, A. Lans and Ruud A. de Mooij (1994). "Environmental levies and distortionary taxation". *The American Economic Review* 84 (4), pp. 1085–1089.

Brenner, Mark, Matthew Riddle, and James K. Boyce (2007). "A Chinese sky trust? Distributional impacts of carbon charges and revenue recycling in China". *Energy Policy* 35 (3), pp. 1771–1784.

Buchanan, James M. and Wm Craig Stubblebine (1962). "Externality". *Economica* 29 (116), pp. 371–384.

Bureau, Benjamin (2011). "Distributional effects of a carbon tax on car fuels in France". *Energy Economics* 33 (1), pp. 121–130.

Callan, Tim, Sean Lyons, Susan Scott, Richard S.J. Tol, and Stefano Verde (2009). "The distributional implications of a carbon tax in Ireland". *Energy Policy* 37 (2), pp. 407–412.

Campbell, Troy H. and Aaron C. Kay (2014). "Solution aversion: On the relation between ideology and motivated disbelief". *Journal of Personality and Social Psychology* 107 (5), pp. 809–824.

Chiroleu-Assouline, Mireille and Mouez Fodha (2014). "From regressive pollution taxes to progressive environmental tax reforms". *European Economic Review* 69, pp. 126–142.

Coase, Ronald H. (1960). "The problem of social cost". *The Journal of Law & Economics* 3, pp. 1–44.

da Silva Freitas, Lucio Flavio, Luiz Carlos de Santana Ribeiro, Kênia Barreiro de Souza, and Geoffrey John Dennis Hewings (2016). "The distributional effects of emissions taxation in Brazil and their implications for climate policy". *Energy Economics* 59, pp. 37–44.

Ekins, Paul, Hector Pollitt, Jennifer Barton, and Daniel Blobel (2011). "The implications for households of environmental tax reform (ETR) in Europe". *Ecological Economics* 70 (12), pp. 2472–2485.

Frank, Robert (2016). *Bill Gates calls for higher capital gains taxes.* Ed. by CNBC. URL: https://www.cnbc.com/2016/05/02/bill-gates-calls-for-higher-capital-gains-taxes.html (visited on 09/13/2018).

Freire-González, Jaume (2018). "Environmental taxation and the double dividend hypothesis in CGE modelling literature: A critical review". *Journal of Policy Modeling* 40 (1), pp. 194–223.

Gonzalez, Fidel (2012). "Distributional effects of carbon taxes: The case of Mexico". *Energy Economics* 34 (6), pp. 2102–2115.

Heath, Yuko and Robert Gifford (2006). "Free-market ideology and environmental degradation: The case of belief in global climate change". *Environment and Behavior* 38 (1), pp. 48–71.

Heitzig, Jobst, Kai Lessmann, and Yong Zou (2011). "Self-enforcing strategies to deter free-riding in the climate change mitigation game and other repeated public good games". *Proceedings of the National Academy of Sciences.*

Heyes, Anthony and Bouwe Dijkstra (2002). "Interest groups and the demand for environmental policy". In: *The international yearbook of environmental and resource economics 2001/2002.* Ed. by Tom Tietenberg and Henk Folmer. Cheltenham: Edward Elgar.

Jiang, Zhujun and Shuai Shao (2014). "Distributional effects of a carbon tax on Chinese households: A case of Shanghai". *Energy Policy* 73, pp. 269–277.

Kahn, Matthew E. and John G. Matsusaka (1997). "Demand for environmental goods: Evidence from voting patterns on California initiatives". *The Journal of Law & Economics* 40 (1), pp. 137–174.

Kaplow, By Louis (2012). "Optimal control of externalities in the presence of income taxation". *International Economic Review* 53 (2), pp. 487–509.

Kerkhof, Annemarie C., Henri C. Moll, Eric Drissen, and Harry C. Wilting (2008). "Taxation of multiple greenhouse gases and the effects on income distribution: A case study of the Netherlands". *Ecological Economics* 67 (2), pp. 318–326.

Kilbourne, William E., Suzanne C. Beckmann, and Eva Thelen (2002). “The role of the dominant social paradigm in environmental attitudes: A multinational examination”. *Journal of Business Research* 55 (3), pp. 193–204.

Lee, Woojin and John E. Roemer (2006). “Racism and redistribution in the United States: A solution to the problem of American exceptionalism”. *Journal of Public Economics* 90 (6-7), pp. 1027–1052.

Lee, Woojin, John Roemer, and Karine van der Straeten (2006). “Racism, xenophobia, and redistribution”. *Journal of the European Economic Association* 4 (2-3), pp. 446–454.

List, John A. and Daniel M. Sturm (2006). “How elections matter: Theory and evidence from environmental policy”. *The Quarterly Journal of Economics* 121 (4), pp. 1249–1281.

Mathur, Aparna and Adele C. Morris (2014). “Distributional effects of a carbon tax in broader U.S. fiscal reform”. *Energy Policy* 66, pp. 326–334.

McAusland, Carol (2003). “Voting for pollution policy: The importance of income inequality and openness to trade”. *Journal of International Economics* 61 (2), pp. 425–451.

McCright, Aaron M. and Riley E. Dunlap (2011). “The politicization of climate change and polarization in the American public’s views of global warming, 2001-2010”. *The Sociological Quarterly* 52 (2), pp. 155–194.

Metcalf, Gilbert E. (2009). “Designing a carbon tax to reduce U.S. greenhouse gas emissions”. *Review of Environmental Economics and Policy* 3 (1), pp. 63–83.

Nordhaus, William (2015). “Climate clubs: Overcoming free-riding in international climate policy”. *American Economic Review* 105 (4), pp. 1339–1370.

Oates, Wallace E. and Paul R. Portney (2003). “Chapter 8 - The political economy of environmental policy”. In: *Handbook of environmental economics : environmental degradation and institutional responses*. Ed. by Karl-Göran Mäler and Jeffrey R. Vincent. Vol. 1. Elsevier, pp. 325–354. DOI: 10.1016/S1574-0099(03)01013-1.

Oladosu, Gbadebo and Adam Rose (2007). “Income distribution impacts of climate change mitigation policy in the Susquehanna River Basin economy”. *Energy Economics* 29 (3), pp. 520–544.

Ostrom, Elinor (2010). “A multi-scale approach to coping with climate change and other collective action problems”. *Solutions* 1, pp. 27–36.

Rausch, Sebastian, Gilbert E. Metcalf, and John M. Reilly (2011). “Distributional impacts of carbon pricing: A general equilibrium approach with micro-data for households”. *Energy Economics* 33, S20–S33.

Rausch, Sebastian and Giacomo A. Schwarz (2016). “Household heterogeneity, aggregation, and the distributional impacts of environmental taxes”. *Journal of Public Economics* 138, pp. 43–57.

Renner, Sebastian (2018). “Poverty and distributional effects of a carbon tax in Mexico”. *Energy Policy* 112, pp. 98–110.

Robison, H. David (1985). “Who pays for industrial pollution abatement?” *Review of Economics & Statistics* 67 (4), p. 702.

Roemer, John E. (1998). “Why the poor do not expropriate the rich: An old argument in new garb”. *Journal of Public Economics* 70 (3), pp. 399–424.

Roemer, John E. (1999). “The democratic political economy of progressive income taxation”. *Econometrica* 67 (1), pp. 1–19.

Roemer, John E. (2006). *Political competition: Theory and applications.* 1. paperback ed. Cambridge, Mass.: Harvard Univ. Press.

Roemer, John E. and Karine van der Straeten (2005). “Xenophobia and the size of the public sector in France: A politico-economic analysis”. *Journal of Economics* 86 (2), pp. 95–144.

Rossen, Isabel L., Patrick D. Dunlop, and Carmen M. Lawrence (2015). “The desire to maintain the social order and the right to economic freedom: Two distinct moral pathways to climate change scepticism”. *Journal of Environmental Psychology* 42, pp. 42–47.

Schmitt, Alex (2014). *Beyond Pigou: Climate change mitigation, policy making and distortions.* Vol. 85. Institute for International Economic Studies Monograph Series. Stockholm: Stockholms Universitet.

Shammin, Md Rumi and Clark W. Bullard (2009). “Impact of cap-and-trade policies for reducing greenhouse gas emissions on U.S. households”. *Ecological Economics* 68 (8), pp. 2432–2438.

United Nations Framework Convention on Climate Change (2016). *Report of the Conference of the Parties on its twenty-first session, held in Paris from 30 November to 13 December 2015 - Addendum: Part two: Action taken by the Conference of the Parties at its twenty-first session.* URL: `https://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf` (visited on 09/13/2018).

Voß, Achim (2015). “How disagreement about social costs leads to inefficient energy-productivity investment”. *Environmental and Resource Economics* 60 (4), pp. 521–548.

Walker, Brian, Scott Barrett, Stephen Polasky, Victor Galaz, Carl Folke, Gustav Engström, Frank Ackerman, Ken Arrow, Stephen Carpenter, Kanchan Chopra, Gretchen

Daily, Paul Ehrlich, Terry Hughes, Nils Kautsky, Simon Levin, Karl-Göran Mäler, Jason Shogren, Jeff Vincent, Tasos Xepapadeas, and Aart de Zeeuw (2009). "Looming global-scale failures and missing institutions". *Science* 325 (5946), p. 1345.

Wearden, Graeme (2011). *Warren Buffett calls for higher taxes for US super-rich.* Ed. by The Guardian. URL: https://www.theguardian.com/business/2011/aug/15/warren-buffett-higher-taxes-super-rich (visited on 09/13/2018).

Wier, Mette, Katja Birr-Pedersen, Henrik Klinge Jacobsen, and Jacob Klok (2005). "Are CO2 taxes regressive? Evidence from the Danish experience". *Ecological Economics* 52 (2), pp. 239–251.

Williams III, Roberton C., Hal Gordon, Dallas Burtraw, Jared C. Carbone, and Richard D. Morgenstern (2015). "The initial incidence of a carbon tax across income groups". *National Tax Journal* 68 (1), pp. 195–213.

Ziegler, Andreas (2017). "Political orientation, environmental values, and climate change beliefs and attitudes: An empirical cross country analysis". *Energy Economics* 63, pp. 144–153.