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Department of Environmental Technology
Sustainability Science and Solutions
Master's Thesis 2020

Atte Pitkänen

PROMOTING EQUITY IN URBAN MOBILITY THROUGH PERSONAL CARBON TRADING

Examiners: Helena Kahiluoto, Professor in Sustainability Science
Junior researcher, M.Soc.Sc. Tuuli von Wright

ABSTRACT

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22 pages, 5 tables, 2 figures, 2 appendices

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Perceived fairness of the effects of a climate policy such as PCT are studied through a survey. The results show that redistributions under a PCT scheme are perceived fair if they place burdens only on people with high income. Perceived fairness of policies is largely linked to individual's political orientation and attitudes towards responsibility for emission reductions. There is also some evidence of self-interest explaining perceptions of fairness, as people might find policies fairer if they increase their personal material welfare.

This Master's Thesis was written in the format of a scientific article.

TIIVISTELMÄ

Lappeenrannan-Lahden teknillinen yliopisto LUT
School of Energy Systems
Ympäristötekniikan koulutusohjelma
Sustainability Science and Solutions

Atte Pitkänen

Kaupunkiliikkumisen oikeudenmukaisuuden edistäminen henkilökohtaisen päästökaupan avulla

Diplomityö

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Keywords: personal carbon trading, urban mobility, equity, fairness, distributional effects

Henkilökohtaista päästökauppaa (personal carbon trading, PCT) on ehdotettu keinoksi vähentää liikkumisen kasvihuonekaasupäästöjä. Sillä, kuten kaikilla ilmastopolitiikan toimenpiteillä, on väistämättä vaikutuksia oikeudenmukaisuuteen, liittyen pääasiassa tulonjakovaikutuksiin. Tämän työn tavoitteena on selvittää, miten liikenteen henkilökohtainen päästökauppa voi edistää oikeudenmukaisuutta. Liikkuminen on tärkeä edellytys riittävään hyvinvointiin, mutta liikkumisen hyödyt ja haitat jakautuvat epäoikeudenmukaisesti eri väestöryhmien kesken. Liikenteen henkilökohtaisella päästökaupalla olisi progressiivisia tulonjakovaikutuksia, koska liikkumisen päästöt keskimäärin nousevat moninkertaisesti tulotason mukana. PCT voi progressiivisilla vaikutuksilla vähentää sosiaalisia ja liikkumiseen liittyviä haittoja, ja sen aikaansaamat päästövähennykset johtavat pienempään altistukseen liikenteen ulkoisvaikutuksille.

PCT:n kaltaisen päästövähennysmekanismin vaikutusten reiluutta tutkitaan kyselyn avulla. Tulokset osoittavat, että sen aiheuttamat tulonsiirrot koetaan reiluksi, jos ne aiheuttavat taakan vain hyvätuloisille ihmisille. Tulonsiirtojen koettuun reiluuteen vaikuttaa suurelta osin vastaajan poliittinen suuntaus ja asenteet päästövähennyksien vastuunjaosta ja tärkeydestä. Oman hyödyn tavoittelu vaikuttaa myös käsityksiin reiluudesta, sillä joissain tapauksissa toimenpiteet koetaan reilummaksi, jos ne lisäävät vastaajan omaa aineellista hyvinvointia.

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Abstract

Personal carbon trading (PCT) has been proposed as a policy measure to reduce greenhouse gas emissions from mobility. Like all climate policies, PCT inevitably has equity impacts, which are mainly linked to its distributional effects. The aim of this paper is to find out whether a PCT scheme for mobility can promote equity. Mobility is fundamental to people, but the benefits and burdens of mobility are currently inequitably distributed between population groups. A PCT scheme on mobility would have generally progressive income effects as mobility emissions tend to rise in line with income level. PCT has the potential to reduce social and transport disadvantage with its progressive effects and through reducing exposure to transport externalities.

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1. Introduction

Governments have agreed to a long-term goal of keeping the increase in global average temperature to well below 2°C above the pre-industrial levels (United Nations, 2015). This agreement requires rapid reductions in global greenhouse gas (GHG) emissions in all sectors. In the EU, transport sector contributes to 28% of total GHG emissions and emissions from transport are expected to grow at a faster rate than in any other sector (EEA, 2019a). Transport sector has suffered from a lack of efficient, effective, and equitable policies targeting reductions in emissions.

In Finland, mobility contributes by 27% of the average personal carbon footprint and 80% of mobility emissions occur from private car use (IGES et al., 2019). Individuals' emission levels tend to rise in line with income level causing disparities in the distribution of GHG emissions. In Finland, the average carbon footprint from consumption in the highest income decile is 2.6 times that of the lowest income decile, while in mobility it is even higher, with a 3.8 times difference. (Nissinen and Savolainen, 2019). Global emissions remain highly concentrated: the richest 10% of world population is responsible for half of total lifestyle emissions, while the poorest half of world population is responsible for 10% of emissions (Oxfam, 2015). The focus of climate policies should be in individual high-emitters rather

than high-emitting countries, due to a decreasing trend in inequality in international distribution of emissions and increasing trend in inequality in intranational emissions (Chancel and Piketty, 2015).

Personal carbon trading (PCT) is an umbrella term for downstream cap-and-trade policies (see e.g. Fawcett and Parag, 2010). Under PCT a cap is set on individuals' emissions in chosen sectors, such as mobility and housing, and a corresponding amount of emission rights is allocated to individuals. The cap reflects the emission reduction target in the sector and is to be reduced over time. Those exceeding the personal emission budget are required to purchase additional emission rights while those who emit below their budget can sell their unused rights, and therefore make a profit from low emissions. The emission right price is determined in the market, but market operator can set a minimum and maximum price or reduce the number of emission rights available in the market. PCT policies differ from other carbon pricing mechanisms as they set a tangible cap on individuals' emissions.

Equity is one of three key criteria for evaluating the effects of a climate policy alongside with efficiency and effectiveness (Klinsky et al., 2017; Starkey, 2012; Wadud et al., 2008). Principle of efficiency requires a policy to be implemented in the most cost-effective way, and principle of effectiveness requires a climate policy to lead to the required level of emission reductions (Stern, 2008). Equity as a distributive justice principle delineates that, outcomes should be allocated according to contributions, which in climate policy context is often called the polluter-pays principle (Colquitt and Rodell, 2015; Deutsch, 1975; Hammar and Jagers, 2007). The ethical and political issues that arise from climate change mitigation are the concerns of climate justice. Its key issues are a just distribution of benefits and burdens associated with GHG emissions with an emphasis on global and intergenerational justice (Meyer and Roser, 2006). The debate on climate justice has primarily focused on the rights and responsibilities of nations at the international level, while intranational and urban scale questions of climate justice have gained less attention (Bulkeley et al., 2014).

The equity implications of a climate policy instrument are usually linked to distributional effects, which all policy measures targeting emission reductions will inevitably have. Progressive policies promote social equity as they make those with low income financially better off relative to those with high income. The distributional effects of climate policies depend on the design of the instrument, the sector which it addresses and the initial socio-economic conditions in the implementation area (Zachmann et al., 2018). Besides income distribution, targeting emissions reductions in transport sector requires considering transport-related equity implications. Mobility is a fundamental requirement for well-being and affects people's economic and social opportunities. Social equity requires an equitable distribution of all benefits and burdens that arise from mobility over different population groups, with particular emphasis on the most disadvantaged people (Litman, 2002).

The distributional effects of PCT have been theoretically assessed in a few national contexts (Li et al., 2015; Thumim and White, 2008; Wadud et al., 2008), and the perceived fairness of PCT has been studied through surveys (Bird and Lockwood, 2009; Jagers et al., 2010). There is a growing body of literature on mobility-related equity (see Section 2.1). There is, however, still a lack of knowledge on how these topics are connected to each other, i.e. whether a climate policy instrument such as PCT can promote mobility-related equity. This paper will tackle this knowledge gap, i.e., examine the potential of a PCT scheme for mobility to address equity issues. The research question is: How can personal carbon trading for mobility promote equity? More specifically: What kind of equity issues exist related to mobility? Which equity issues can PCT address? How fair are the impacts of PCT perceived? And which personal factors affect the perceived fairness?

2. Theoretical framework

2.1 Equity in mobility

Mobility is fundamental for individual well-being as it provides social connectivity and access to key activities such as work, education, and health care. Level of mobility significantly affects people's economic and social opportunities and the potential for interaction (Litman, 2002; Martens, 2016). Mobility-related equity concerns have gained attention in research during the last decade, yet there is a lack of adequate methods to assess equity in mobility (Di Ciommo and Shiftan, 2017). Litman (2002) defines three categories of transport equity: horizontal equity, vertical equity with regard to income and social class, and vertical equity with regard to mobility need and ability. Horizontal equity concerns the distribution of transport benefits and burdens between individuals and groups considered equal in ability and need. Vertical equity is concerned with the distribution of benefits and burdens between individuals and groups that differ by income or social class. Transport policies are vertically equitable if they favour economically and socially disadvantaged groups. Transport-related vertical equity can also be concerned with the distribution of impacts between individuals and groups that differ in mobility ability and need.

Lucas et al. (2019) propose a framework for measurement of equity in the distribution of transport outcomes through principles of distributive justice. The framework builds on three key components: 1) defining the benefits and burdens of interest, 2) distinguishing the population groups across which they are distributed, and 3) defining the principle for determining whether a given distribution is just, fair, or equitable. Accessibility, defined as the ease of reaching key activities and opportunities, is often considered the main benefit of transport. Accessibility level experienced by a person depends on context, for instance transport systems and land use patterns, as well as personal attributes such as income level, physical abilities and access to vehicles (Martens, 2016). Pereira et al. (2017) suggest that some minimum level of accessibility to key destinations is a basic capability that is necessary for people to satisfy their basic needs, and that fair distribution of accessibility should not violate individuals' basic rights, should reduce inequalities of opportunities, prioritise disadvantaged and vulnerable groups, and mitigate transport externalities. An equitable transport system provides every person the required level of accessibility to opportunities, services, and social networks to participate in the economic, political, and social life of the community (Kenyon et al., 2002).

An unfair distribution of benefits and burdens of transport causes adverse social impacts, such as transport poverty. Lucas (2012) defines the concept of 'transport poverty' to exist at the interface of 'transport disadvantage' and 'social disadvantage', thereby combining issues such as lack of access to private vehicle or poor public transport services with social issues such as low income and unemployment. According to Lucas, transport poverty leads to 'inaccessibility', which in turn may result in 'social exclusion' of certain population groups. Mattioli et al. (2017) distinguish two different ways in which the term 'transport poverty' is used in literature. First is a broader understanding where it refers to all kinds of inequalities in transport and access along with notions such as 'transport disadvantage' and 'transport-related social exclusion'. Second is a more specific meaning where 'transport poverty' is used to refer to the affordability of transport alongside with notions of 'transport affordability', 'forced car ownership' and 'car-related economic stress'. Mattioli et al. (2017) themselves use 'transport poverty' to refer to the former and 'transport affordability' to refer to the latter meaning.

Lucas et al. (2016) explain transport poverty as an overarching combination of the subset of transport affordability, mobility poverty, accessibility poverty, and exposure to transport externalities. They make a comprehensive definition that individual is transport poor if, in order to satisfy his/her daily basic activity needs, at least one of the following conditions apply: 1) There is no transport options available that is suited to the individual's physical condition and capabilities; 2) The existing transport options

do not reach destinations where the individual can fulfil his/her daily activity needs, in order to maintain a reasonable quality of life; 3) The necessary amount spent on transport leaves the household with a residual income below the official poverty line; 4) The individual needs to spend an excessive amount of time travelling, leading to time poverty or social isolation, and 5) The prevailing travel conditions are dangerous, unsafe or unhealthy for the individual.

Certain socio-demographic groups have been identified at greater risk to suffer from transport poverty than others (see e.g. Combs et al., 2016). These vulnerable population groups include low-income households, rural households, households without a motorised vehicle, children and the elderly, people with physical or cognitive limitations, and immigrants and ethnical minority groups. The vulnerable groups not only travel less but are most often worse impacted by the disbenefits and externalities of the transport system (EEA, 2019b; Kay, 2011). The uneven outcomes of transport, especially on vulnerable groups, can reduce people's ability to fully participate in society and can ultimately lead to their social exclusion (Lucas and Jones, 2012).

Some transport modes, especially motorised private road transport, impose negative externalities on society, including environmental damage, accidents and congestion, the cost of which are generally not reflected in the current market prices (Santos et al., 2010). According to Gössling et al. (2019), each kilometer driven by car in the EU incurs an external social cost of 0,11 €, while walking and cycling represent external benefits of 0,18 € and 0,37 € per kilometer due to public health improvements. The underestimated social cost leads to disadvantageous favouring of car transport in current transport investment policies, while considerable burdens are put on other users of transport systems and the whole society. Most severely, air and noise pollution from road transport have significant impacts on public health, especially in urban areas. In the EU, road transport contributes to thousands of annual premature deaths through nitrogen oxides and particulate matter concentrations and noise pollution (EEA, 2019b, 2016). The health impacts of air and noise pollution are not evenly distributed as lower socio-economic groups tend to be more exposed, and elderly people, children and people with pre-existing health conditions are more vulnerable to them (EEA, 2019b; Li et al., 2018).

There is a robust and significant relationship between households' income and their carbon footprint, and low-income households are generally characterised by lower car ownership rates and higher use of sustainable modes of travel (see e.g. Gough, 2013; Ivanova et al., 2016; Nissinen and Savolainen, 2019). Brand et al. (2013) found highly unequal distribution of transport emissions in their survey in the UK, while the main characteristics explaining high emissions were car ownership, full-time employment, and home-work distance. Energy-intensive goods, such as mobility, tend to have higher income elasticity of demand (Oswald et al., 2020). Therefore, as income increases people spend more of their money on energy-intensive goods, leading to disproportionately high energy and carbon footprints of high-income individuals. Inequality in energy consumption adversely affects the distribution of benefits that result from mobility-related energy use.

2.2 Distributional effects of PCT

Studies on distributional effects of PCT schemes for mobility find generally progressive effects, but there is some variation depending on the chosen emission right allocation method. Wadud et al. (2008) evaluate the welfare distribution caused by a PCT scheme for personal road transport sector with equal-per-capita allocation. Distribution of relative burden between income groups is presented among all households, as well as representative vehicle-owning and non-vehicle-owning households. The results show that among all households, PCT is strictly progressive when demand responses of different socio-economic groups are not considered, and mostly progressive when demand response is considered. Among vehicle-owning households PCT is generally progressive but situations of regressivity exist, notably between the lowest and second lowest quintile. Among non-vehicle-owning households the distribution of relative burden is strictly progressive, and the welfare gains for non-vehicle-owning households provide a significant incentive not to drive a vehicle. Although vehicle-owning households

in the lowest income quintile suffer a welfare loss, there are more households in the lower income quintiles with welfare gains, as vehicle ownership is relatively lower among them.

The distributional effects of a PCT scheme for mobility and heating with equal-per-capita allocation among adult population are found progressive with majority of low-income households gaining benefits from surplus allowances and majority of high-income households having to buy allowances or reduce emissions (Thumim and White, 2008). The effects vary within income groups depending on households' mobility and housing energy consumption patterns. Urban households and larger households in terms of number of adult occupants are more likely to have surplus allowances than rural and smaller households. A study on an equilibrium price for emission allowances and potential welfare changes under a PCT scheme with equal-per-capita allocation find PCT to be progressive due to generally lower emission levels of poorer people (Li et al., 2015). A study on PCT with equal allocation among car owners find similar distributional effects (Raux and Marlot, 2005). High-income households face more losses than low-income households and necessary travel would generally not be affected. Situations of fragility might exist among vulnerable groups, such as rural low-income households dependent on private car transport. In addition to overall progressive effects, population density has been found as major determinant of welfare changes of PCT for transport, with rural individuals more likely to experience negative welfare change (McNamara and Caulfield, 2013).

One of major barriers to the adoption of effective climate change mitigation policies is that they are widely perceived to have regressive effects (Büchs et al., 2011). Being generally progressive, PCT addresses this concern. The remaining distributive problem is caused by variation in emissions between households of similar incomes as, for instance, PCT on mobility and housing would leave nearly 10% of all households as "low-income losers" (Thumim and White, 2008). Focusing solely on distributional effects between income groups, instead of a wider range of socio-economic characteristics, may disguise considerable variations of the distribution of benefits and burdens within income groups (Büchs et al., 2011). Low-income rural households are a typical group facing losses by being vulnerable to distributional effects of carbon pricing in transport (McNamara and Caulfield, 2013; Perrels, 2010). They are often in a position where mobility emission reductions cannot be achieved because all potential measures require investments they cannot afford. Their investment capacities could be improved by a public support mechanism taken simultaneously with the introduction of carbon pricing. Besides monetary support, the support measures could include improvement of public transport services, support for telecommuting and energy efficiency based car purchase taxes. Zachmann et al. (2018) argue that the harmful distributional effects of climate policies can be addressed by compensating low-income households or designing the policies in a way that reduces adverse distributional effects or introduces progressive features.

Two distinct approaches have been proposed to moderate the negative equity impacts of PCT: modifying the way in which allowances are allocated and financially compensating low-income households (White and Thumim, 2009). Moderating the adverse impacts on low-income households requires identifying key characteristics that increase the likelihood of a low-income household to be made worse off under PCT. When mobility-related structural factors are concerned, these include number of children, rurality, and age of household reference person. Both approaches seem applicable to increase the likelihood of a household to be able to avoid deficit through behavioural change and measures to cut emissions, but they may face other drawbacks, such as high costs of a financial compensation system. In addition to these two approaches, a revised PCT model has been proposed to address the distributional issue of low-income losers (Burgess, 2016). In the revised model, the emission cap for being required to purchase top-up allowances is higher than the cap for being able to sell surplus allowances, reducing the number of low-income people suffering welfare losses.

2.3 Impacts of PCT on transport poverty

Transport poverty is a major consequence of an unequitable distribution of benefits and burdens of mobility, and exists at the interface of transport disadvantage and social disadvantage (Lucas, 2012). With generally progressive effects between income groups, PCT can address social disadvantage of low-income groups by making them financially better off. The progressive effects of PCT can improve transport affordability of low-income groups**,** and improved affordability can indirectly address mobility and accessibility poverty (Lucas et al., 2016). PCT improves particularly the affordability of sustainable transport modes as it incentivises reductions in mobility emissions. PCT can also help low-income individual to stay above the poverty line after the necessary amount spent on transport, and mobility emission reductions achieved under PCT can improve individuals' travel conditions by reducing air and noise pollution and injury risk through reducing conventional vehicle use (see definition of a transport poor by Lucas et al.). Mobility emission reductions achieved under PCT would reduce exposures to a variety of transport externalities. Predetermined reduction in GHG emissions is guaranteed under PCT, and reduced use of conventional vehicles would also reduce other externalities associated with them, such as air pollution. A major reduction in all motorised transport would reduce externalities such as noise pollution, traffic injuries, and congestion**.** Internalising at least part of the costs of GHG emissions and other transport externalities would reduce social costs of transport, which can be remarkable (Gössling et al., 2019).

PCT has a potential distributive problem of low-income groups facing additional burdens. A number of common characteristics were found between vulnerable groups likely to suffer from transport poverty and low-income groups likely to end up worse off under PCT, including rurality, number of children in the household and age (Combs et al., 2016; White and Thumim, 2009). Typical example of low-income loser groups and transport poor groups are car-dependent low-income rural households. Mattioli et al. (2018) study the "car-related economic stress", defined as a subset of transport affordability issues that are related to expenditure on motoring. They find that 9% of households have low income and high motoring expenditure and low response to fuel price changes. These households have distinct socio-demographic characteristics, such as low employment rates, over-presentation of ethnic minorities and rurality. Most low-income car owning households are included in this group, which implies an adverse car-dependency among low-income households.

From the definitions of transport poverty, it can be concluded that PCT has the potential to address transport affordability issues and reduce exposure to transport externalities, as long as adverse effects on certain low-income groups are mitigated through modified allocation or additional compensation. Progressive effects of PCT may reduce social disadvantage of low-income individuals and emission reductions and reduced car use may reduce transport disadvantage of people adversely exposed to these transport externalities. Low-income disadvantaged and vulnerable groups would gain relatively more welfare from these improvements as they are more exposed or more vulnerable to transport externalities. These effects have the potential to make the distribution of benefits and burdens of mobility more equitable.

2.4 Perceived fairness of PCT

Distributional effects of climate policies raise questions about fairness, and public acceptability of such policies increase the likelihood that governments adopt them (Büchs et al., 2011). Hammar and Jagers (2007) show that besides personal material welfare, fairness in climate policy design does matter. Their study points at self-interest being an important factor explaining whether people tend to accept climate policies or not. Self-interest, i.e putting one's own material welfare ahead of others, stands out especially regarding car users and non-car users. An overview of perceived fairness of carbon pricing policies by Maestre-Andrés et al. (2019) indicates a high concern over distributional effects, especially in relation to vulnerable groups, and on the other hand little trust on governments to mitigate adverse effects. They find that majority of people prefer the use of carbon pricing revenues in a range of environmental

projects instead of redistribution to reduce the regressive effects of policies, but those who better understand the principles of carbon pricing prefer using revenues for redistribution.

Despite the overall progressiveness of PCT, equal allocation of emission rights has been considered unfair from environmental justice perspective (Starkey, 2012). A 2009 survey showed similar perceptions of the fairness of equal allocation: 70% strongly agreed that PCT with equal-per-capita allocation "would be unfair because some people need more carbon credits than others" (Bird and Lockwood, 2009). A survey on the perceived fairness of expected distributional effects under equal-per-capita PCT showed that the only redistribution considered as fair by most respondents was from people with high income to those with low income, as 59% found it fair (Jagers et al., 2010). The redistributions that were considered most unfair were from rural to urban people and from households with children to households without children with ca. 80% finding them unfair.

Fairness of policies is largely subjective and affected by factors such as perceived inequality, self-interest, and ideology. Preferences for redistribution are one of the key determinants between political left and right. Left-right political orientation is shaped by individuals' socioeconomic background and has a causal effect on support for redistribution, with left-wing voters supporting redistributions and right-wing voters opposing them (Jæger, 2008). Individual labour market position and household income are main factors shaping preferences for redistribution, followed by perceptions of social mobility and the effects of prevailing political regime (Guillaud, 2013). Durante et al. (2014) find self-interest of those in low-income brackets as the dominant motive for preferences for redistribution followed by perceptions of fairness and social preferences. Perceived inequality often differs from actual inequality and is rather linked to socio-economic variables, self-interest, and ideological beliefs (Bobzien, 2019). Perceptions of inequality are associated with preferences for redistribution: stronger perception of inequality leads to stronger preference for redistribution and vice versa.

3. Materials and methods

3.1 Study area

The city of Lahti was used as a site of study due to a PCT pilot which took place at the area in 2018-2021. The city represents a typical mid-sized Finnish city with average population characteristics and had 119 917 inhabitants at the time of the study (January 2020, SVT 2020). The city is also a model example of typically Finnish car culture which is due to a cold northern climate, limited public transport services as well as relatively long living distances, which make for an average of 40 km of car travel per person a day (Lahti 2018).

The average annual income of Lahti citizens is a little less (27 016 €/year, in 2015) than that of the entire country (28 750 €/year), and spans between the averages of 20 758 € and 48 519 € according to neighborhood within the city (Lahti 2017). The average annual income of the Lahti citizens is generally higher in neighborhoods that are located outside of the city center, while it is the opposite for the low income groups (with one notable exception of the affluent neighborhood of Jalkaranta near the city center).

In the last general elections in Lahti – 2019 Finnish parliamentary elections (April 19th 2017) – The Social Democratic Party gained the largest number of seats in the parliament with 25,2 per cent share, with Finns Party coming in at second with 21,2 per cent, and National Coalition at 20 per cent. The top parties were followed by Green League (10%), Left Alliance (6,9%), Centre Party (6,5%) and Christian Democrats (6,1%) respectively (Finnish Ministry of Justice 2019a). The Lahti popular vote hence resembled that of the national average which saw Social Democratic Party come at the top (17,7%), Finns Party second (17,5%), Followed by National Coalition Party (17 %), Centre Party (13,8%), Green League (11,5%) and Left Alliance (8,2%) respectively (Finnish Ministry of Justice 2019b).

3.2 Data

The data for this paper was collected via a survey conducted in Lahti. A questionnaire was sent to a random sample of 1 200 Lahti residents in December 2019 followed by second round in January 2020. The random sample was provided by the Finnish Population Register Centre and the sample was limited to residents aged 16 and over. The questionnaire was sent by mail with an opportunity to respond online. A total of 358 responses were gathered, of which 61 online, making the response rate 30 per cent. Despite the relatively low response rate, the sample was adequately representative of the Finnish population aged 16 and over (Table 1). In terms of residential location, the sample was not representative of the population as a whole as it consisted of people from mostly urban or peri-urban areas. Due to the lack of rural respondents, the survey considers urban mobility rather than mobility in general.

Table 1. Comparison of socio-economic characteristics in survey sample and Finnish population (data by Statistics Finland).

		Sample	**Finnish population (age 16-)**
Gender	Male	47%	49%
	Female	53%	51%
Age group	16-29	20%	20%
	30-39	12%	15%
	40-49	15%	14%
	50-59	17%	16%
	60-69	17%	16%
	70-	19%	18%
Education level	Primary school or less	21%	27%
	Secondary school	50%	51%
	Bachelor's degree	16%	12%
	Master's degree	10%	10%
	Licentiate or doctoral degree	3%	1%
Household's yearly income divided by number of adults (€)	0–12 000	13%	16%
	12 001–18 000	18%	23%
	18 001–24 000	23%	20%
	24 001–30 000	20%	18%
	30 001 - 42 000	15%	16%
	42 001 - 60 000	9%	6%
	60 001 -	3%	3%
Employment status	Employed	47%	47%
	Unemployed/jobseeker	6%	5%
	Retired	34%	31%
	Student	10%	16%
Social classes (EG) *,**	Upper service (I)	7%	9%
	Lower service (II)	27%	23%
	Routine non-manual (III)	31%	23%
	Petty bourgeoisie (IV)	9%	14%
	Supervisors etc., skilled manual (V-VI)	13%	14%
	Semi- and unskilled manual (VII)	13%	19%

*Original symbols of Erikson-Goldthorpe schema are provided in parenthesis
**Source: (Erola, 2010)

The survey comprised of questions including basic background variables such as socio-economic information as well as household characteristics. These were complemented by personal mobility-related questions, which included distance from home to city centre, monthly amount of money spent on mobility, car ownership, and distance to nearest public transport stop or station.

The main part of the survey included a set of questions concerning fairness perceptions of urban mobility that inquired about the three mobility redistributions based on, for instance, the results of Jagers et al. (2010): redistribution from high-income households to low-income households, redistribution from households with children to households without children, and redistribution from households in rural and sparsely populated areas to urban households. These redistributions were expected to take place under a PCT scheme as, on average, high-income households generate more transport emissions than low-income households, rural and peri-urban households more than urban households, and households with children more than households without children (Nissinen and Savolainen, 2019). The respondents assessed the fairness of each redistribution on a 5-point Likert scale from 'very fair' to 'very unfair' with an additional option for 'don't know'.

The aforementioned questions of fairness perceptions were supplemented with a set of questions concerning social equity and attitudes towards income inequality as these aspects are likely to have impact on perceived fairness of any redistribution. Social equity is a highly subjective topic and connected to factors such as values, political orientation, and self-interest. Attitudes towards mobility emission reductions are in turn likely to affect the perceived fairness of redistributions under PCT, as they are based on mobility emission levels. The prime attitudes were divided into two alternatives: support for equal responsibility and support for differentiated responsibility for mobility emission reductions. Attitudes towards social equity and income equality were queried through six statements about a just society to which answers were given on a 5-point Likert scale from 'strongly agree' to 'strongly disagree' with an additional option for 'don't know'. The same scale was used to measure attitudes towards transport emission reductions and responsibilities.

To further examine the differences in redistributive fairness attitudes, personal political orientation was surveyed through a question of political party identification. The parties were divided into groups based on a political spectrum with two axes, left-right dimension and GAL (green, alternative, libertarian) - TAN (traditional, authoritarian, nationalist) dimension, according to an analysis of Finnish parties in the 2019 election (Grönlund and Strandberg, 2019). GAL-TAN dimension has been used by political scientists to represent the value conflict between conservative and liberal values in addition to the traditional division between political left and right. These groups allow us to examine whether dimensions of political orientation explain differences in fairness perceptions.

There was an error in the question sheet, including statement "on average, rural households generate less transport emissions than urban households" while the truth is vice versa. Despite the error, the actual question concerned fairness of redistribution from rural to urban people. The error was corrected in the reminder questionnaire sheet but might have affected nearly half of the answers.

3.3 Analysis

The relationships of 15 background variables and six sum variables, related to opinions about income equality and emission reduction responsibility, with the perceived fairness of redistributions were studied. Exploratory factor analysis (EFA) was used separately for question patterns of income equality and emission reduction responsibility, to help to form sum variables. EFA with the maximum likelihood (ML) extraction and the Varimax rotation was used and two factors were found in both cases. The scree test, the proportion of variation explained, and the interpretability of factors were used as criteria, but all of those led to same solution. Instead of using imputation methods the sum variables were used based on those factor solutions. Respondents that missed over a third of answers were omitted to improve the reliability of sum variables.

Statistical significance of background variables was examined using cross-tabulation, and for sum variables a one-way analysis of variance was used, respectively. In the next step, ordinal regression analysis was used to seek the best models to explain response variables (perceived fairness of redistributions). For statistical analysis, the response variables were re-classified to *fair* (1-2), *neutral* (3) and *unfair* (4-5), respectively. The first class was used as response in regression models.

All main effects of the categorical and continuous variables were tested, and all potentially interesting two-way interactions were included in the models. Stepwise selection method was used to explore possible statistically significant interactions. New variables were included in the models based on significance level of 0.25 and kept in the models based on significance level of 0.10, respectively. Multiple significant interactions were found for high vs. low income redistribution, none for households with vs. without children and only one significant predictor for rural-urban redistribution. Thus, ordinal regression model for the last one was not included in results section.

Comparison of categorical variables are presented through odds ratios in the results section. A significance level of 0.05 was used in these comparisons. Statistical analyses were performed with the SAS Enterprise Guide 7.15. (SAS Institute Inc., Cary, NC, USA).

4. Results

4.1 Perceived fairness of expected redistribution under PCT

The only redistribution perceived as fair by majority of the survey participants was from high to low income people (Table 2). Redistribution from rural to urban households was found the most unfair, and redistribution from households with children to households without them was also perceived as unfair by majority.

Table 2. Perceived fairness of three potential redistributions under a PCT scheme for mobility.

Redistribution based on mobility emission levels	Very fair	Quite fair	Neither fair nor unfair	Quite unfair	Very unfair	N
From people with high income to people with low income	15%	38%	24%	14%	9%	310
From households with children to households without children	3%	8%	24%	36%	30%	314
From rural and peri-urban people to urban people	1%	7%	18%	36%	38%	299

4.2 Factors explaining the perceptions of fairness

Statistically significant relations between background variables and perceptions of fairness were found from every redistribution (Table 3). For the simplicity of statistical analysis, the classes of fairness were reduced to three: fair, neutral, and unfair. Total distribution of answers to the two question patterns, from which the sum variables were created, can be found in Appendix II.

Table 3. Statistical significance of factors explaining perceived fairness of redistributions among households. Background variables were compared based on cross tabulation using the Cochran-Mantel-Haenszel (CMH) test statistic, and the sum variables of questions patterns by one-way analysis of variance (ANOVA) using F-test, respectively. P values < 0.05 are bolded.

Explaining factor	High vs. low income	Households with vs. without children	Rural vs. urban households
Gender (Female, Male)	0.263	0.676	0.774
Age (16-34, 35-59, 60-)	0.608	0.106	0.391
Perceived income sufficiency (Sufficient, Insufficient)	**0.004**	**0.046**	0.111
Household size (1, 2, 3 or more)	0.124	**0.000**	0.516
Children in the household (No children, One or more children)	0.487	**0.001**	0.580
Car ownership (No car, One or more cars)	**0.001**	**0.001**	0.117
Distance to city centre (0-1,9km, 2-4,9km, 5+ km)	0.186	0.769	0.950
Social class (Upper class, Middle class, Lower class)	**0.007**	**0.002**	0.482
Distance to nearest public transport stop (Less than 500m, More than 500m)	**0.010**	0.809	0.079
Educational level (Primary school, Secondary school, Tertiary education)	**0.001**	**0.005**	0.248
Share of income spent on transport (Less than 5%, More than 5%)	0.403	0.667	0.426
Political orientation (Left/GAL, Right/GAL, Right/TAN, Floating voters)	**0.000**	0.202	**0.046**
Monthly amount spent on transport (€) (0-49, 50-99, 100-)	**0.020**	**0.008**	0.136
Employment status (Employed, Student/Unemployed, Retired)	0.921	**0.009**	0.279
Annual household income per adult (€) (0-20 000, 20 001-30 000, 30 001-)	**0.004**	**0.002**	0.147
Sum variables:			
Attitudes towards social equity and income equality	0.076	0.630	0.600
Support for income inequality	**0.000**	0.134	0.896
Support for income equality	**0.001**	**0.003**	0.732
Attitudes towards responsibility for mobility emission reductions	**0.000**	0.331	0.678
Support for differentiated responsibilities for emission reductions	0.054	0.290	0.358
Support for equal responsibility for emission reductions	**0.000**	**0.001**	**0.010**

4.2.1 Redistribution from people with high income to people with low income

Support for equal responsibility for emission reductions was found to have the highest explanatory power in a regression analysis for the high to low-income redistribution, while in total the regression model explained 49% of the total variance (Table 4). Higher support for equal responsibility was

associated with higher perceived fairness. Political orientation represented the second highest explanatory power for income level-based redistribution. Voting for a left/GAL party was associated with highest perceived fairness, while right/GAL voters found it the most unfair (Figure 1). 70% of left/GAL voters, 24% of right/GAL voters, and 37% of right/TAN voters found the redistribution fair, while among floating voters the proportion was 52%. Higher support for income equality was associated with higher perceived fairness partly through interaction with perceived income sufficiency, which itself was associated with lower level of fairness and showed a high interaction with many factors. Higher educational level decreased perceived fairness: 66% of those with primary school or lower education found the redistribution fair, whereas 41% of those with secondary education and 30% of those with tertiary education found it fair.

Some background variables showed strong statistical significance in the cross-tabulation but were not included in the regression model. Higher income level and social status were associated with lower perceptions of fairness. Those from car-owning households also showed lower level of fairness, similar to those who spend more money on transport. They were probably outweighed from the regression model by factors with higher explanatory power.

Table 4. Statistically significant predictors for perceived fairness of high vs. low income redistribution based on ordinal regression models. A significance level of 0.10 was used.

High vs. low income - Tests of fixed effects (Type III)				
Effect	**DF**	**Wald χ^2**	**P value**	**Variance explained**
Employment status	2	10.41	0.006	1 %
Perceived income sufficiency	1	0.05	0.826	3 %
Employment status × Perceived income sufficiency	2	8.29	0.016	2 %
Distance to nearest public transport stop	1	6.26	0.012	1 %
Educational level	2	10.78	0.005	3 %
Employment status × Educational level	4	13.41	0.009	2 %
Political orientation	3	13.98	0.003	11 %
Support for income equality	1	0.09	0.769	4 %
Support for income equality × Perceived income sufficiency	1	5.16	0.023	1 %
Support for differentiated responsibilities for emission reductions	1	12.12	0.001	2 %
Support for differentiated responsibilities for emission reductions × Perceived income sufficiency	1	4.11	0.043	1 %
Support for equal responsibility for emission reductions	1	4.53	0.033	16 %
Support for equal responsibility for emission reductions × Employment status	2	6.51	0.039	2 %

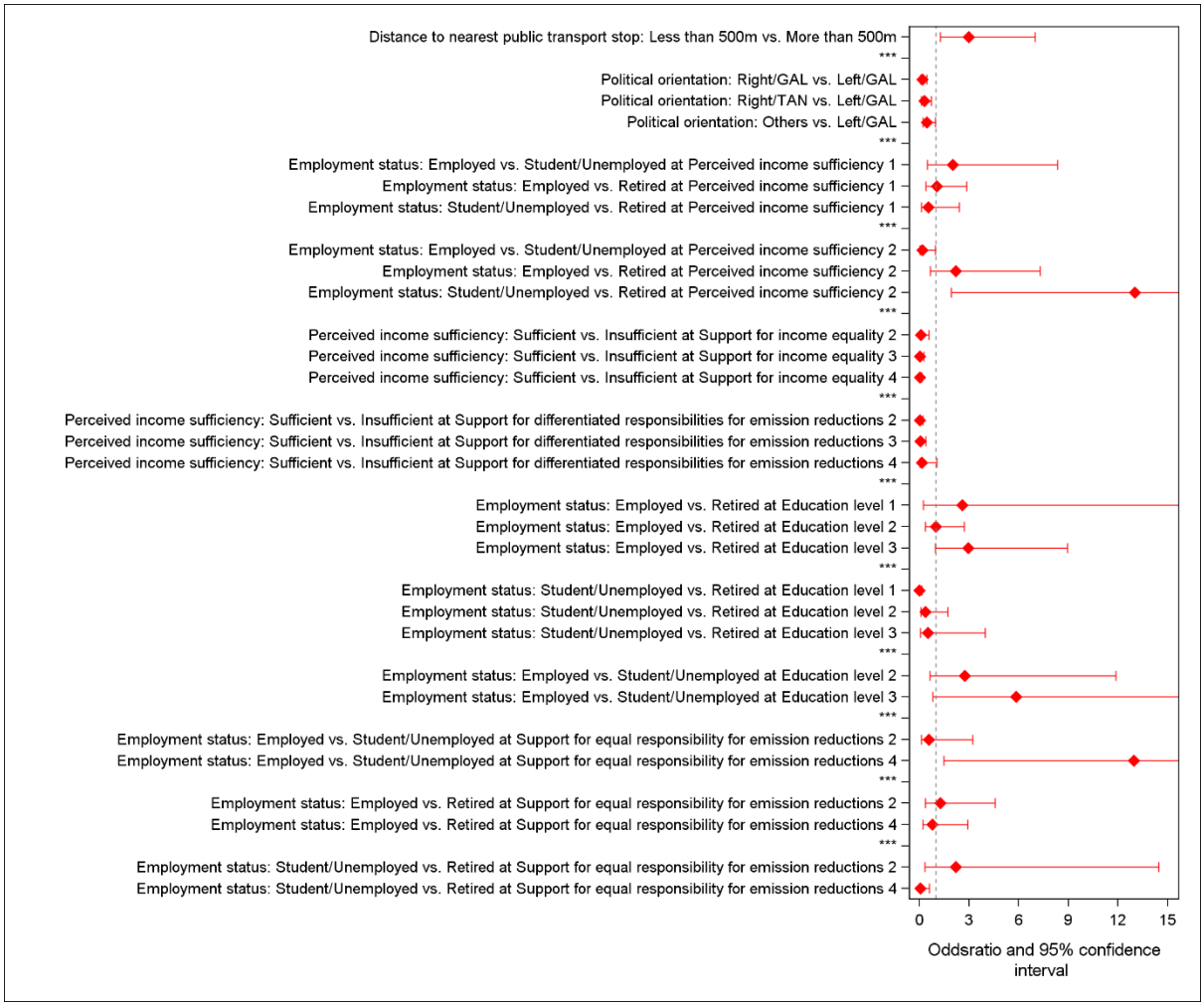

Figure 1. Odds ratios with 95% confidence interval for explanatory variables of perceived fairness of income level-based redistribution. Only partial scales are presented for continuous variables to fit confidence intervals into the figure.

4.2.2 Redistribution from households with children to households with no children

Fewer explanatory variables were found for redistribution from households with children to households without them, and explanatory power of the regression model was 15% (Table 5). Household size, in terms of number of persons in the household, represented the highest proportion of explanatory power, with people in single-person households finding the redistribution more fair than larger households (Figure 2). Higher education decreased perceived fairness: 59% of those with primary school or lower education, 64% of those with secondary education, and 80% of those with tertiary education found the redistribution unfair. Support for income equality and equal emission reductions both increased the perceived fairness.

Similar to the previous redistribution, not all statistically significant background variables in cross-tabulations ended up in the regression model. Differences in car ownership, income level, social class, and number of children in the households showed particularly strong significance.

Table 5. Statistically significant predictors for perceived fairness of children-based redistribution based on ordinal regression models. A significance level of 0.10 was used.

Households with vs. without children - Tests of fixed effects (Type III)				
Effect	**DF**	**Wald χ^2**	**P value**	**Variance explained**
Household size	2	8.76	0.013	7 %
Educational level	2	6.79	0.034	3 %
Support for equal responsibility for emission reductions	1	5.28	0.022	2 %
Support for income equality	1	6.49	0.011	3 %

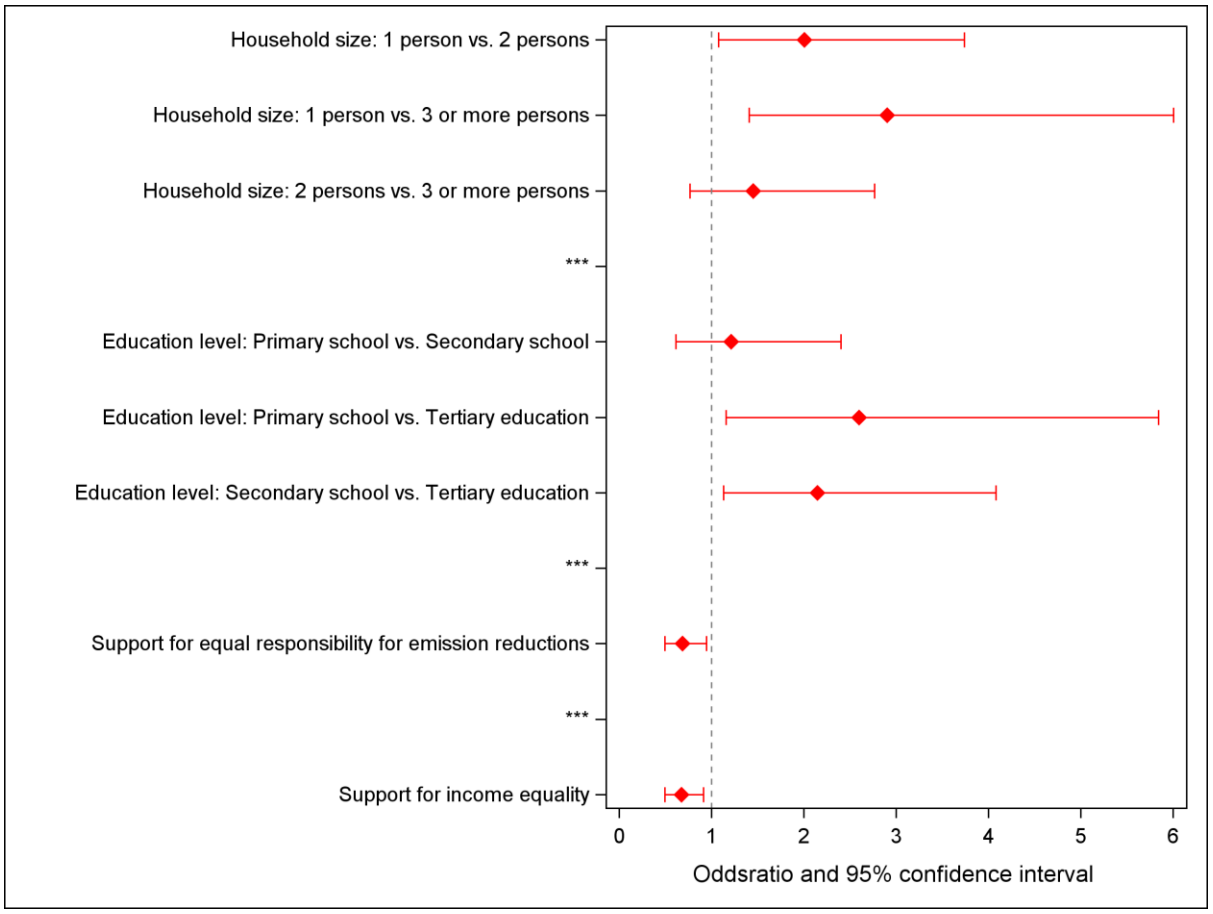

Figure 2. Odds ratios with 95% confidence interval for explanatory variables of perceived fairness of redistribution from households with children to households without.

4.2.3 Redistribution from rural to urban people

A regression analysis was not done for the rural-urban redistribution as support for equal responsibility for mobility emission reductions and political orientation were the only variables to show statistical significance on a 0.05 level. Higher support for equal responsibility and left/GAL political orientation lead to higher perceived fairness of redistribution from rural to urban households. Distance to nearest public transport stop was close to being significant with those who live closer to public transport stop finding the redistribution more fair.

5. Discussion

Overall, redistribution from people with high income to those with low income caused by a PCT scheme for mobility was found fair by majority, while redistributions from households with to households without children and from rural to urban people were considered unfair. Fairness of the first one depended the most on support for equal responsibility for emission reductions and individuals' political orientation. Different perceptions regarding the second redistribution were most explained by household size. The third, which was found the most unfair, depended to some extent on support for equal emission reduction responsibility and political orientation. The results will be discussed and compared to theoretical findings on equity in mobility and the equity and fairness of PCT.

5.1 Reliability and generalizability

Our sample was somewhat representative of Finnish population with only minor deviations (Table 1). The survey focused on perceived fairness of a hypothetical situation where the principles of PCT with equal-per-capita allocation are applied, though there was no mention about any particular allocation methods. Not all research questions were directly considered in the survey, but the results can be compared to theoretical findings on all the topics. Survey results present the perceptions of (peri-)urban people in a Nordic welfare state with traditionally large magnitude of income redistribution. The generalizability of our survey results is rather limited to such countries; however, the survey could well be reproduced in different contexts to analyse whether perceptions of fairness differ.

Questions on redistributions caused by mobility emission levels might have been difficult to understand because the concept is likely unfamiliar to many. Redistribution from rich to poor is familiar to people through taxation, but redistributions based on mobility emission levels are a novel concept. It could have been helpful to provide some information of the concept of PCT. Especially the question of rural-urban redistribution had some issues. First, there was the previously mentioned error on question sheet that might have affected the responses. Second, there were not fully rural people in the sample as the case area was a city consisting of urban and peri-urban areas. However, the mobility emissions of peri-urban households are on average even higher than e.g. households in local centres of rural areas (Nissinen and Savolainen, 2019), and therefore in this matter peri-urban households correspond to rural households as they are more likely to face burdens under PCT than urban households.

5.2 PCT enhancing equity and fairness

There is a highly unequal distribution of benefits and burdens of mobility, such as the distribution of mobility emissions between income groups. Those who emit more gain the benefits of mobility, while the whole society bears the burdens, and disadvantaged population groups are even more exposed to adverse transport externalities. Unequal distribution of benefits and burdens of mobility causes significant social impacts, such as transport poverty. PCT has the potential to address transport poverty by improving transport affordability of disadvantaged groups and by reducing exposure to transport externalities (see Section 2.3). With these effects PCT can promote social equity by making the distribution of benefits and burdens of mobility more equitable. The extent of these effects depends on selected emission right allocation methods and whether the adverse effects on 'low-income loser' groups are mitigated.

Distributional effects of climate policies raise questions on fairness. Our results shed light on perceived fairness of a climate policy instrument such as PCT scheme for mobility. Redistribution based on income level was perceived fairer than redistribution based on other characteristics, such as residential location or having children, although they would all be caused by different mobility emission levels. One interpretation of these results is that these redistributions are perceived unfair because they might place additional burdens on people with low income. Furthermore, this indicates the overall importance of mitigating adverse effects on disadvantaged groups. The results might also be linked to level of carbon literacy and understanding of the principles of carbon pricing.

Carbon intensive dependencies, such as car-dependency have been generated in contemporary societies relying on energy from fossil fuels. The dependencies should be addressed with systems-level changes that do not place excessive burdens on vulnerable groups. Mobility emission reductions themselves have potentially positive equity impacts. Decreased use of conventional private vehicles reduces the adverse effects on the whole society and especially those more vulnerable to transport externalities. PCT is likely to reduce mobility-related carbon inequality by incentivising reductions in mobility emissions.

Distributional issues do not necessarily restrict the choice of climate policy instruments as they can be addressed through separate compensation mechanisms. However, it seems plausible that climate policies that address equity issues themselves are perceived more fair, which increases their public acceptability and chances to be implemented. In the Swedish survey on the expected distributional effects of a PCT scheme with equal allocation conducted by Jagers et al. (2010), the fairness perceptions followed a similar pattern to ours. The two national contexts are quite similar including elements like strongly progressive income taxation. We extend the study by Jagers et al. with an analysis of the factors explaining differences in fairness perceptions.

5.3 Differences in fairness perceptions

The types of factors shown to explain fairness perceptions can be divided into following groups: attitudes towards income equality, environmental attitudes, political orientation, household characteristics, and socio-economic characteristics. Attitudes and political orientation seemed to overweigh other characteristics for the most part.

A combination of support for equal emission quotas, equal emission reductions, higher emission reductions of leisure drivers and overall importance of reducing mobility emissions had the highest explanatory power among the fairness perceptions. They are connected to support for equal or shared responsibility for reducing necessary mobility emission, and higher support is associated with higher fairness of redistributions. It might not be surprising that those who think reducing emissions is not important find the effects of an emission reduction policy to be unfair. Those supporting equal emission reduction responsibilities are likely supportive towards a policy in which an equal emission quota is allocated to individuals. Similarly, the positive effect that support for income equality had on fairness is likely linked to any kind of redistributions promoting income equality.

Political orientation stands out regarding the redistribution based on income level. This seems to be mostly linked to left-right orientation. Right wing/GAL group finding it more unfair than TAN group implies that right-left orientation would overweigh GAL/TAN value conflict. It is unknown whether general support for redistributions outweighs environmental aspects among left/GAL voters. One interpretation is that attitudes towards income equality and redistribution still are the key determinants of political orientation between left- and right-wing parties, even when linked to emission reduction policies. However, the effects of GAL/TAN value conflict in fairness perceptions are difficult to analyse. The Finnish green party is included in left/GAL group, but they are located rather in the middle of left-right axis, whereas most of the right/GAL voters voted for a party located close to the middle of GAL-TAN dimension but farthest to the right (see Grönlund and Strandberg, 2019). Therefore, those who vote primarily for the environment are less likely to vote for that party and thus part of green voters belong to left/GAL group despite their more right-wing orientation. Nearly half of left/GAL group are green party voters.

The concept of self-interest can be identified as one of the main factors on the perceived fairness of redistributions. Effects on personal material welfare can exceed any fairness principles when fairness of policies is assessed (e.g. Hammar and Jagers, 2007). In our results, self-interest seems to affect the perceived fairness of redistribution from households with to households without children, as those in larger households and with children find it more unfair. Self-interest might also explain the different fairness perceptions of those from car-owning households and non-car owning households. Frequent

car users are likely to face burdens under PCT and therefore they might find the redistribution more unfair. Self-interest is likely to be the common factor behind the relationship that income level and social class have on perceived fairness of redistributions. Not all our findings indicated strong effect of self-interest. For example, residential location, in terms of distance from city centre, had no significant effect on perceived fairness of redistribution from rural to urban people. Overall, self-interest seems to be balancing with attitudes towards equity and responsibility, and political ideology, as the explanatory factor of fairness perceptions.

5.4 Practical and theoretical implications

Higher fairness leads to higher public acceptability of policies, and therefore increases their likelihood to be implemented (Bristow et al., 2010; Büchs et al., 2011). Identifying factors that increase fairness is important to design acceptable emission reduction policies. The perceptions of fairness imply that the distributional effects of a PCT scheme for mobility would be perceived fair if they place burdens only on well-off people. This highlights the importance of mitigating the losses of low-income high emitters. As discussed in Section 2.2, this should be considered in the design of the scheme either in emission right allocation or through a separate compensation mechanism.

Equity should be considered in all types of mobility-related policies regarding e.g. public transport services, transport infrastructure or mobility emission reductions. Different kinds of indicators can be used to assess the equity performance of such policies, for example, accessibility levels of disadvantaged population groups and transport poverty indicators. When comparing mobility emission reduction policies, the distributional effects and other equity impacts should be comprehensively assessed. Rapid reductions are needed in mobility emissions, and reductions should be achieved in ways that do not exacerbate inequities. Climate crisis is a global problem that requires global solutions, but local equity impacts cannot be ignored as they raise questions of fairness. Mobility sector poses several local level issues in the form of externalities. Air pollution from conventional vehicles is a local pollutant that is responsible for numerous annual deaths. On the other hand, sustainable transport modes such as biking and walking have positive public health effects. Therefore, a modal shift from private car transport to more sustainable modes causes improvements in public health and reduces the social costs of transport.

6. Conclusions

We conclude based on our survey results that climate policies should not place additional burdens on low-income groups if they are to be perceived fair and achieve public acceptance. PCT has the potential to promote equity with its generally progressive effects but might also make some low-income groups worse off. It seems that mitigating the adverse effects on ‘low-income losers’ is important in order to promote equity and perceived fairness. However, the justification of lower emission reduction responsibilities of low-income high emitting groups should be further studied, for example, through the principles of climate justice.

The findings on the relationship between political orientation and fairness of PCT indicate that redistributions are at the core of ideological differences between political left and right, even in the context of mobility emission reductions. Environmental attitudes also show an impact on fairness through dimensions of political orientation and attitudes towards emission reductions. A more nuanced analysis of the impact of political orientation to perceived fairness of climate policies would help to gain understanding in this matter.

Mobility sector rapidly requires policy measures to cut emissions and to reduce inequities. PCT has the potential to address both issues as long as adverse effects on low-income groups are mitigated. Distributional effects of an implemented PCT scheme should therefore be studied with a focus on identifying low-income losers. Also, the impacts of PCT on transport poverty should be quantified to better address transport poverty issues and therefore make the distribution of benefits and burdens of mobility more equitable.

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References

Bird, J., Lockwood, M., 2009. Plan B? The Prospects for Personal Carbon Trading.
Bobzien, L., 2019. Polarized perceptions, polarized preferences? Understanding the relationship between inequality and preferences for redistribution. J. Eur. Soc. Policy. https://doi.org/10.1177/0958928719879282
Brand, C., Goodman, A., Rutter, H., Song, Y., Ogilvie, D., 2013. Associations of individual, household and environmental characteristics with carbon dioxide emissions from motorised passenger travel. Appl. Energy 104, 158–169. https://doi.org/10.1016/j.apenergy.2012.11.001
Bristow, A.L., Wardman, M., Zanni, A.M., Chintakayala, P.K., 2010. Public acceptability of personal carbon trading and carbon tax. Ecol. Econ. 69, 1824–1837. https://doi.org/10.1016/j.ecolecon.2010.04.021
Büchs, M., Bardsley, N., Duwe, S., 2011. Who bears the brunt? Distributional effects of climate change mitigation policies. Crit. Soc. Policy 31, 285–307. https://doi.org/10.1177/0261018310396036
Bulkeley, H., Edwards, G.A.S., Fuller, S., 2014. Contesting climate justice in the city: Examining politics and practice in urban climate change experiments. Glob. Environ. Chang. 25, 31–40. https://doi.org/10.1016/j.gloenvcha.2014.01.009
Burgess, M., 2016. Personal carbon allowances: A revised model to alleviate distributional issues. Ecol. Econ. 130, 316–327. https://doi.org/10.1016/j.ecolecon.2016.08.002
Chancel, L., Piketty, T., 2015. Carbon and inequality: from Kyoto to Paris. Trends in the global inequality of carbon emissions (1998-2013) & prospects for an equitable adaptation fund. Paris Sch. Econ. 48pp. https://doi.org/10.13140/RG.2.1.3536.0082
Colquitt, J.A., Rodell, J.B., 2015. Measuring Justice and Fairness. Oxford Handb. Justice Work. 187–202. https://doi.org/10.1093/oxfordhb/9780199981410.013.8
Combs, T.S., Shay, E., Salvesen, D., Kolosna, C., Madeley, M., 2016. Understanding the multiple dimensions of transportation disadvantage: The case of rural North Carolina. Case Stud. Transp. Policy 4, 68–77. https://doi.org/10.1016/j.cstp.2016.02.004
Deutsch, M., 1975. Equity, Equality, and Need: What Determines Which Value Will Be Used as the Basis of Distributive Justice? J. Soc. Issues 31, 137–149. https://doi.org/10.1111/j.1540-4560.1975.tb01000.x
Di Ciommo, F., Shiftan, Y., 2017. Transport equity analysis. Transp. Rev. 37, 139–151. https://doi.org/10.1080/01441647.2017.1278647
Durante, R., Putterman, L., van der Weele Joël, J., 2014. Preferences for redistribution and perception of fairness: An experimental study. J. Eur. Econ. Assoc. 12, 1059–1086. https://doi.org/10.1111/jeea.12082
Erola, J., 2010. Luokaton Suomi? Yhteiskuntaluokat 2000-luvun Suomessa.
European Environment Agency, 2019a. Greenhouse gas emissions from transport in Europe.
European Environment Agency, 2019b. Air quality in Europe — 2019 report. https://doi.org/10.2800/822355
European Environment Agency, 2016. Transport and public health.
Fawcett, T., Parag, Y., 2010. An introduction to personal carbon trading. Clim. Policy 10, 329–338. https://doi.org/10.3763/cpol.2010.0649
Finnish Ministry of Justice – Information and results service (2019a). Parliamentary Elections 2019: Results – Electoral Districts, Häme, Lahti. Available at: https://tulospalvelu.vaalit.fi/EKV-2019/en/kutulos_398.html
Finnish Ministry of Justice – Information and results service (2019b). Parliamentary Elections 2019: Results – Whole Country. Available at: https://tulospalvelu.vaalit.fi/EKV-2019/en/tulos_kokomaa.html
Gössling, S., Choi, A., Dekker, K., Metzler, D., 2019. The Social Cost of Automobility, Cycling and Walking in the European Union. Ecol. Econ. 158, 65–74. https://doi.org/10.1016/j.ecolecon.2018.12.016
Gough, I., 2013. Carbon mitigation policies, distributional dilemmas and social policies. J. Soc. Policy 42, 191–213. https://doi.org/10.1017/S0047279412001018
Grönlund, K., Strandberg, K., 2019. Voting and Public Opinion in Finland: The Parliamentary Election of 2019.
Guillaud, E., 2013. Preferences for redistribution: An empirical analysis over 33 countries. J. Econ. Inequal. 11, 57–78. https://doi.org/10.1007/s10888-011-9205-0
Hammar, H., Jagers, S.C., 2007. What is a fair CO2 tax increase? On fair emission reductions in the transport sector. Ecol. Econ. 61, 377–387. https://doi.org/10.1016/j.ecolecon.2006.03.004
IGES, Aalto University and D-mat ltd., 2019. 1.5-Degree Lifestyles: Targets and options for reducing lifestyle carbon footprints. Technical report.
Ivanova, D., Stadler, K., Steen-Olsen, K., Wood, R., Vita, G., Tukker, A., Hertwich, E.G., 2016. Environmental Impact Assessment of Household Consumption. J. Ind. Ecol. 20, 526–536. https://doi.org/10.1111/jiec.12371
Jæger, M.M., 2008. Does left-right orientation have a causal effect on support for redistribution? Causal analysis with cross-sectional data using instrumental variables. Int. J. Public Opin. Res. https://doi.org/10.1093/ijpor/edn030
Jagers, S.C., Löfgren, Å., Stripple, J., 2010. Attitudes to personal carbon allowances: Political trust, fairness and ideology. Clim. Policy 10, 410–431. https://doi.org/10.3763/cpol.2009.0673
Kay, D., 2011. Fairness in a Car-dependent Society, SDC Reports & Papers.
Kenyon, S., Lyons, G., Rafferty, J., 2002. Transport and social exclusion: Investigating the possibility of promoting inclusion through virtual mobility. J. Transp. Geogr. 10, 207–219. https://doi.org/10.1016/S0966-6923(02)00012-1

Klinsky, S., Roberts, T., Huq, S., Okereke, C., Newell, P., Dauvergne, P., O'Brien, K., Schroeder, H., Tschakert, P., Clapp, J., Keck, M., Biermann, F., Liverman, D., Gupta, J., Rahman, A., Messner, D., Pellow, D., Bauer, S., 2017. Why equity is fundamental in climate change policy research. Glob. Environ. Chang. 44, 170–173. https://doi.org/10.1016/j.gloenvcha.2016.08.002

Lahti (2017). Tulonsaajien keskitulo ja tuloluokat suurimmissa kaupungeissa, koko maas-sa, Päijät-Hämeen kunnissa sekä Lahdessa alueittain 2015. Available at: https://www.lahti.fi/TietoaLahdestaSite/Tilastot%20ja%20tilastojulkaisut/Documents/toiminta_tulot_2016.pdf

Lahti (2018). European Green Capital 2020 Application. Available at: http://lahdenvuosi.fi/european-green-capital-2020-application/.

Li, J., Fan, J., Zhao, D., Wang, S., 2015. Allowance price and distributional effects under a personal carbon trading scheme. J. Clean. Prod. 103, 319–329. https://doi.org/10.1016/j.jclepro.2014.08.081

Li, V.O., Han, Y., Lam, J.C., Zhu, Y., Bacon-Shone, J., 2018. Air pollution and environmental injustice: Are the socially deprived exposed to more PM2.5 pollution in Hong Kong? Environ. Sci. Policy 80, 53–61. https://doi.org/10.1016/j.envsci.2017.10.014

Litman, T., 2002. Evaluating Transportation Equity: Guidance for Incorporating Distributional Impacts in Transportation Planning. World Transp. Policy Pract. 8, 50–65.

Lucas, K., 2012. Transport and social exclusion: Where are we now? Transp. Policy 20, 105–113. https://doi.org/10.1016/j.tranpol.2012.01.013

Lucas, K., Jones, P., 2012. Social impacts and equity issues in transport: An introduction. J. Transp. Geogr. 21, 1–3. https://doi.org/10.1016/j.jtrangeo.2012.01.032

Lucas, K., Martens, K., Di Ciommo, F., Dupont-Kieffer, A., 2019. Measuring Transport Equity, 1st ed. Elsevier.

Lucas, K., Mattioli, G., Verlinghieri, E., Guzman, A., 2016. Transport poverty and its adverse social consequences. Proc. Inst. Civ. Eng. Transp. 169, 353–365. https://doi.org/10.1680/jtran.15.00073

Maestre-Andrés, S., Drews, S., van den Bergh, J., 2019. Perceived fairness and public acceptability of carbon pricing: a review of the literature. Clim. Policy 19, 1186–1204. https://doi.org/10.1080/14693062.2019.1639490

Martens, K., 2016. Transport Justice: Designing fair transportation systems, 1st ed. Routledge. https://doi.org/10.4324/9781315746852

Mattioli, G., Lucas, K., Marsden, G., 2017. Reprint of Transport poverty and fuel poverty in the UK: From analogy to comparison. Transp. Policy 65, 114–125. https://doi.org/10.1016/j.tranpol.2018.02.019

Mattioli, G., Wadud, Z., Lucas, K., 2018. Vulnerability to fuel price increases in the UK: A household level analysis. Transp. Res. Part A Policy Pract. 113, 227–242. https://doi.org/10.1016/j.tra.2018.04.002

McNamara, D., Caulfield, B., 2013. Examining the impact of carbon price changes under a personalised carbon trading scheme for transport. Transp. Policy 30, 238–253. https://doi.org/10.1016/j.tranpol.2013.09.017

Meyer, L.H., Roser, D., 2006. Distributive Justice and Climate Change. The Allocation of Emission Rights. Anal. Krit. 28. https://doi.org/10.1515/auk-2006-0207

Nissinen, A., Savolainen, H., 2019. Carbon footprint and raw material requirement of public procurement and household consumption in Finland, REPORTS OF. ed. Finnish Environment Institute.

Oswald, Y., Owen, A., Steinberger, J.K., 2020. Large inequality in international and intranational energy footprints between income groups and across consumption categories. Nat. Energy 5, 231–239. https://doi.org/10.1038/s41560-020-0579-8

Oxfam, 2015. Extreme Carbon Inequality. Oxfam Media Brief.

Pereira, R.H.M., Schwanen, T., Banister, D., 2017. Distributive justice and equity in transportation. Transp. Rev. 37, 170–191. https://doi.org/10.1080/01441647.2016.1257660

Perrels, A., 2010. User response and equity considerations regarding emission cap-and-trade schemes for travel. Energy Effic. 3, 149–165. https://doi.org/10.1007/s12053-009-9067-5

Raux, C., Marlot, G., 2005. A system of tradable CO2 permits applied to fuel consumption by motorists. Transp. Policy 12, 255–265. https://doi.org/10.1016/j.tranpol.2005.02.006

Santos, G., Behrendt, H., Maconi, L., Shirvani, T., Teytelboym, A., 2010. Part I: Externalities and economic policies in road transport. Res. Transp. Econ. 28, 2–45. https://doi.org/10.1016/j.retrec.2009.11.002

Starkey, R., 2012. Personal carbon trading: A critical survey Part 1: Equity. Ecol. Econ. 73, 7–18. https://doi.org/10.1016/j.ecolecon.2011.09.022

Statistics Finland (SVT): Väestörakenne [online publication]. ISSN=1797-5379. Helsinki: Statistics Finland. Available at: http://www.stat.fi/til/vaerak/index.html

Stern, N., 2008. Key Elements of a Global Deal on Climate Change. London.

Thumim, J., White, V., 2008. Distributional Impacts of Personal Carbon Trading: A report to the Department for Environment, Food and Rural Affairs.

United Nations, 2015. Paris Agreement.

Wadud, Z., Noland, R.B., Graham, D.J., 2008. Equity analysis of personal tradable carbon permits for the road transport sector. Environ. Sci. Policy 11, 533–544. https://doi.org/10.1016/j.envsci.2008.04.002

White, V., Thumim, J., 2009. Moderating the distributional impacts of personal carbon trading. Rep. to IPPR, Cent. Sustain. Energy 1–38.

Zachmann, G., Fredriksson, G., Claeys, G., 2018. The distributional effects of climate policies. Brussels.

1. Gender 1 Female 2 Male 3 Other **2. Birth year** _____

4. Number of persons in household
1 Total number_____
2 Number of under 16-year-olds _____

5. Highest completed education
1 Lower than primary school
2 Primary school
3 Secondary school
4 Bachelor's degree
5 Master's degree
6 Licentiate or doctoral degree
7 None of these

6. Employment
1 Employed
2 Unemployed/jobseeker
3 Retired
4 Student
5 On parental leave
6 Homemaker
7 Other:_____

7. Job title *_____
**Former job title if you are retired, unemployed etc.*

8. Total monthly household income before taxes
ca. **_____**€/month

9. Is there a private car in your household?
1 Yes
2 No
3 Number of cars in household _____

10. How long is the distance between your house and city centre of Lahti? _____km

19. How long is the distance to the nearest public transport stop or station?
1 Less than 500 meters
2 More than 500 meters

21. Monthly amount of money spent on mobility (€)? ca._____€/month

43. Do you think your income is sufficient?
1 Yes
2 No
3 Don't know

46. Following statements consider social equity. Circle one option on each statement.

	Strongly agree				Strongly disagree	Don't know
a) Society is just when income and wealth are equally distributed among all.	1	2	3	4	5	6
b) Society is just when hard-working people earn more than others.	1	2	3	4	5	6
c) Society is just when it cares for the poor and needy, regardless of their contribution to society.	1	2	3	4	5	6
d) Society is just when high-ranking families have privileges.	1	2	3	4	5	6
e) Large income disparities are acceptable in order to reward differences in people's talent and performance.	1	2	3	4	5	6
f) Society is just when differences in people's living conditions are small.	1	2	3	4	5	6

47. Following statements consider responsibilities for emission reductions and transport.

	Strongly agree				Strongly disagree	Don't know
a) People who need car more because of poor public transport connections should reduce their transport emissions relatively less.	1	2	3	4	5	6
b) All people should reduce transport emissions by the same percentage from their baseline.	1	2	3	4	5	6
c) If only a limited amount of emissions can be produced in society, one should consider who has a more valid reason for producing emissions.	1	2	3	4	5	6
d) People who need car more to transport children should need to reduce transport emissions relatively less than those without children.	1	2	3	4	5	6
e) Nobody should have the right to produce more transport emissions, but everyone should have the same emission quota.	1	2	3	4	5	6
f) People who need car more because of reduced mobility should not need to reduce transport emissions as much as others.	1	2	3	4	5	6
g) People who need car more because they live far (more than 10 km) from the center should not need to reduce transport emissions as much as those who live nearby.	1	2	3	4	5	6
h) People who use the car for leisure activities should reduce their transport emissions more.	1	2	3	4	5	6
i) Reducing emissions from transport is not important.	1	2	3	4	5	6

48. Imagine a situation where you could make a revenue by reducing mobility emissions. This would generate redistributions from higher emitters to lower emitters. Do you think this is fair? Answer the following questions.

a) On average, people with low income generate less mobility emissions than people with high income. Because of this, people with high income would, on average, have to pay for their high emissions and people with low income would, on average, make a revenue of their lower emissions. This would make an incentive to reduce mobility emissions, and a redistribution from high income high emitters to low income low emitters. How fair do you think this is?

1 Very fair
2 Quite fair
3 Neither fair nor unfair
4 Quite unfair
5 Very unfair
6 Don't know

b) On average, households with children generate more mobility emissions than households without children. Do you think a redistribution from households with children to households without children based on mobility emissions levels would be fair?

1 Very fair
2 Quite fair
3 Neither fair nor unfair
4 Quite unfair
5 Very unfair
6 Don't know

c) On average, rural and peri-urban people generate more mobility emissions than people living in urban areas. Do you think a redistribution from rural and peri-urban people to urban people based on mobility emissions levels would be fair?

1 Very fair
2 Quite fair
3 Neither fair nor unfair
4 Quite unfair
5 Very unfair
6 Don't know

49. If the parliamentary election were held now which party candidate would you vote for? Choose one.

1 Centre Party
2 Social Democratic Party
3 National Coalition Party
4 Left Alliance
5 Green League
6 Finns Party
7 Swedish People's Party
8 Christian Democrats
9 Other:_____
10 I would not vote
11 Don't know or don't want to say

Attitudes towards social equity and income equality:	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**	**N**
Society is just when income and wealth are equally distributed among all.	9.1%	18.5%	25.0%	22.6%	24.7%	340
Society is just when hard-working people earn more than others.	21.8%	31.6%	23.3%	14.2%	9.1%	339
Society is just when it cares for the poor and needy, regardless of their contribution to society.	20.8%	34.4%	23.1%	13.9%	7.8%	346
Society is just when high-ranking families have privileges.	1.7%	3.2%	9.2%	22.4%	63.5%	348
Large income disparities are acceptable in order to reward differences in people's talent and performance.	9.1%	19.7%	22.4%	20.6%	28.2%	340
Society is just when differences in people's living conditions are small.	19.9%	37.8%	25.3%	11.3%	5.7%	336
Attitudes towards responsibility for mobility emission reductions:						
People who need car more because of poor public transport connections should reduce their mobility emissions relatively less.	24.0%	31.4%	26.0%	10.6%	8.0%	312
All people should reduce mobility emissions by the same percentage from their baseline.	7.7%	20.0%	31.9%	22.9%	17.4%	310
If only a limited amount of emissions can be produced in society, one should consider who has a more valid reason for producing emissions.	19.0%	34.0%	23.5%	12.1%	11.4%	306
People who need car more to transport children should need to reduce mobility emissions relatively less than those without children.	10.6%	22.5%	26.9%	21.3%	18.8%	320
Nobody should have the right to produce more mobility emissions, but everyone should have the same emission quota.	13.4%	13.7%	23.6%	23.6%	25.8%	314
People who need car more because of reduced mobility should not need to reduce mobility emissions as much as others.	35.8%	35.2%	16.1%	8.8%	4.2%	330
People who need car more because they live far (more than 10 km) from the centre should not need to reduce mobility emissions as much as those who live nearby.	20.4%	30.9%	27.8%	12.0%	9.0%	324
People who use the car for leisure activities should reduce their mobility emissions more.	21.1%	31.5%	24.8%	11.6%	11.0%	327
Reducing mobility emissions is not important.	6.5%	6.8%	13.9%	18.4%	54.3%	337