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Pathways to stringent carbon pricing: Configurations of political economy conditions and revenue recycling strategies. A comparison of thirty national level policies

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ABSTRACT

There is general agreement among economists and climate policy practitioners that carbon pricing should play a central role among all policies used to tackle climate change effectively. However, in most jurisdictions that have adopted carbon pricing mechanisms, the prevailing price levels remain too low to accelerate decarbonization and drive down emissions. This deficiency can be attributed to numerous political economy constraints, but most pressingly, to the negative distributional effects of the policies combined with the drain they impose on firms' competitiveness. These factors negatively influence the public acceptability of these policies and, thus, the feasibility of introducing ambitious carbon pricing. Recent innovations in the literature suggest that using the revenue from carbon pricing for specific social purposes may ease this political impasse. This study analyzes which revenue recycling strategies are effective, in various political economy environments, to support stringent carbon pricing. Employing the method of fuzzy-set Qualitative Comparative Analysis, this research draws findings from a cross-case comparison of thirty national-level policies. The salient conclusion is that hybrid use of carbon revenue that combines various compensatory schemes and spending on climate projects is the most effective strategy to enhance stringency, while a lack of compensation renders the introduction of ambitious carbon pricing implausible, even in some highly developed countries.

1. Introduction

In the face of escalating climate challenges, only bold, human-centric and far-reaching policies can effectively combat global warming and secure a socially tolerable future. Among the implemented and prospective policies, carbon pricing mechanisms have long been considered by environmental economists and climate policy practitioners to be the most cost-efficient policy instruments to tackle climate change effectively (Baranzini et al., 2017). Carbon pricing theory suggests that crucially needed amendments to current production practices and consumption patterns could be enforced by imposing a fee on emissions (Aldy and Stavins, 2012).

The recent upsurge of global carbon pricing policies is a welcome development in the climate policy landscape (Skovgaard et al., 2019). Carbon markets and taxes have been introduced in various jurisdictions and have proliferated across the globe. Argentina, South-Africa and Singapore all recently joined the group of countries adopting carbon pricing. And China, in terms of covered emissions, introduced the biggest carbon market in the world in 2021. However, carbon prices vary significantly across jurisdictions, and it is generally agreed that the current prices of existing schemes fall below the level needed to drastically reduce emissions, spur technological advancements and keep the rise of global warming under two degrees, as set forth in the Paris Agreement (World Bank, 2017). Therefore, there is a significant gap between the elegant economic theory and the sobering political reality.

A growing body of literature suggests that this gap can be largely attributed to persistent political economy constraints (e.g., Dolphin et al., 2020; Ervine, 2018). Domestic and international climate change mitigation efforts show various paralyzing symptoms of collective action problems and principal-agent failures (Jenkins, 2019; Ostrom, 2010). Crucially, the (re)distribution impact of stringent carbon pricing policies can be substantial, a fact which ignites fierce opposition from energy-intensive industries whose assets and market value are tied to the maintenance of favorable regulatory conditions, and whose leverage in

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redeploying production capacities is very limited (Jenkins, 2014). Firms that are exposed to international trade may find it increasingly challenging to remain cost competitive, both in domestic and international markets, where they must compete with firms selling goods with potentially higher, but unpriced carbon content (Aldy and Pizer, 2015). In a similar vein, environmentally effective carbon pricing entails considerable reductions in private welfare in the short term for households due to the price increase of commodities. Since low-income households spend disproportionately more on energy and basic goods, carbon pricing effects tend to be regressive, and therefore contribute to increasing inequality and energy poverty in a society (Ohlendorf et al., 2021; Wang et al., 2016). Numerous studies show that this regressive effect is perceived as highly unfair by the public, which translates into a lower level of political acceptability and a higher level of opposition (Maestre-Andrés et al., 2019). Lastly, public opposition to high costs is conjoined with a general skepticism about the environmental effectiveness of carbon pricing due to the inelastic demand for basic goods (e.g., motor and heating fuels) and affordability issues with low carbon alternatives. This further erodes support for policy implementation (Carattini et al., 2018).

Despite all these constraints, current innovations in the literature suggest that carefully-crafted policy designs, especially the mechanism through which revenue is ring-fenced and given back to society ('revenue recycling'), may help alter the political dynamics around carbon pricing (Beiser-McGrath and Bernauer, 2019, 1; Klenert et al., 2018). The central theme of this research is to analyze how revenue recycling measures, in various political economy contexts, influence the stringency of these policies. This objective is accomplished by a cross-case analysis of all national-level carbon pricing mechanisms ($N = 30$), using the method of fuzzy-set Qualitative Comparative Analysis (fs/QCA). QCA enables researchers to identify and follow multiple pathways through different constellations of conditions leading to the same outcome. In this research, the intersectional relationships between structural political economy conditions, such as income inequality and various revenue recycling alternatives, and how they affect the stringency of carbon pricing policies, are analyzed. The main finding of the analysis is that a combination of social compensation and spending on climate action is the most effective strategy to implement high carbon prices, while a lack of compensation renders the adoption of ambitious carbon pricing implausible, even in some economically highly developed countries. These findings have direct policy implications, since they indicate that ramping up climate ambitions should be conjoined with adequate social support mechanisms.

The article is structured as follows: The first section presents the novel theoretical framework of this research and highlights the key contributions it makes to the prevailing literature. Following that, identified political economy conditions and revenue recycling strategies influencing the stringency of carbon pricing policies are laid out, along with the resulting theoretical expectations. This second section is followed by the research design, which discusses the scope conditions and the operationalization of the outcome as well as explanatory conditions. The third section presents and interprets the results of the empirical analysis. The discussion section elaborates on possible mechanisms linking revenue recycling to stringency and lays out paths for future research. The conclusion summarizes the main findings of the study.

2. Analytical framework: revenue recycling strategies in different political economy environments

There is an increasing pressure on states around the world to engage in ambitious decarbonization efforts to avoid escalation of the climate crisis. Indeed, the recent global diffusion of carbon pricing policies can be largely explained by the growing climate awareness and concern in the domestic populations, coupled with the international expectation to implement increasingly ambitious abatement measures (Skovgaard et al., 2019; Thisted and Thisted, 2020). Jurisdictions may also have powerful unilateral incentives to adopt strong carbon pricing mechanisms, such as reducing air pollution and energy import dependence, or increasing technological innovation in emerging economic sectors (Dolphin and Pollitt, 2018; PMR 2021a; Parry et al., 2015). However, prevailing price levels in most jurisdictions that adopted carbon pricing are considered to be too low to accelerate decarbonization and drive emissions down drastically. Regarding carbon pricing, the main challenge is how to address distributional issues that can "attenuate or eliminate the ostensible tradeoff in climate policy between present and future welfare," and thus overcome the most pressing political constraints, enabling the realization of the environmental promises envisaged by economic theory (Boyce, 2020, 29; Karplus and Jenkins, 2017). Carbon pricing, as a transparent, cost-increasing form of climate policy, typically faces stronger political opposition from the public and industries than other mitigation measures (e.g., green subsidies), thus significantly constraining the political space for implementing and sustaining effective carbon pricing polices (Dechezleprêtre et al., 2022; Fairbrother, 2022). The theoretical premise of this study suggests that modifying the incentive structure around carbon pricing policies can enhance their political feasibility. This can be achieved by compensating negatively affected social groups, providing immediate local (green) benefits to the public, and bolstering the political coalitions of direct beneficiaries.

Carbon pricing is unique among other climate policies in generating substantial revenue for states. There are myriad paths to spending this revenue in economically, environmentally, and socially productive ways (PMR, 2019; Steenkamp, 2021). As an example, lowering tax rates on employment, financing infrastructure projects (e.g., digitalization or high-speed railway) and reducing national debt, all enhance the macroeconomic performance and competitiveness of a country and offset some of the negative consequences of mitigation policies (an argument put forth in different strands of the 'double dividend' literature, see e.g., Edenhofer et al., 2015; Goulder, 1995; Jakob et al., 2016).

Carbon revenue can also be used to multiply the positive ecological effects of the policy by financing the deployment of renewables, weatherization of buildings, or investing in the development of low-carbon technologies, thus accelerating the decarbonization efforts of a jurisdiction. Furthermore, the revenue can be put towards greater equity in publicly valued domains (e.g., education) and the elimination of rampant climate injustices and social inequality by providing targeted assistance to marginalized groups (low-income households, minorities, elderly, women) (e.g., PMR, 2021b).

As can be seen, carbon pricing revenue can be effectively utilized towards various policy objectives. Crucially, revenue recycling also holds the potential to boost carbon pricing policy towards greater stringency by increasing its political acceptability. Different revenue recycling measures can be implemented that can result in progressive distributional outcome, better environmental performance of policy, and positive effects on people's wellbeing, all of which changes public perception on policy fairness and effectiveness (Beiser-McGrath and Bernauer, 2019; Konc et al., 2022). This modified public perception can foster political acceptability, thus leading to the successful implementation of stringent carbon prices (Maestre-Andrés et al., 2019; Bergquist et al., 2022). However, one of the limitations of the current literature is that it mainly focuses on citizens' perception and neglects private firms, despite the fact that climate policy outcome is influenced by the interests of firms' working through different channels (e.g., competitiveness, aggregate interests of workers) as much as that of the public's interest (Lamb and Minx, 2020). Therefore, revenue recycling options that may make carbon pricing more palatable for private firms should also be researched when examining the nexus between revenue use and stringent policy outcome.

As countries differ significantly from one another in their political economy environments, their use of revenue should also respond to individual local constraints and accommodate differing social objectives. For example, the public may accept higher prices in countries that

are more vulnerable to climate change, if the revenue is spent on adaptation. Alternately, in a socially polarized country where more people are exposed to energy poverty, compensation for poor households will be necessary to avoid equity issues, while in wealthier and more egalitarian jurisdictions, this is less of a concern, and other constraints can be addressed (Andersson and Atkinson, 2020). To make this point more concrete, experimental research shows that a tax rebate scheme in the US that refunds carbon revenue to all families equally was found to significantly increase carbon tax acceptability. However, a similarly proposed scheme in Sweden had negative effects on public support (Kaplowitz and McCright, 2015 and Jagers et al., 2019 as cited in Maestre-Andrés et al., 2019; also see Douenne and Fabre, 2022 for a discussion on the French context). The merits of examining and comparing revenue recycling in different environments is further supported by results from other surveys and experiments that suggest that public preferences for revenue use options might be context-specific (Beiser-McGrath and Bernauer, 2019; Carattini et al., 2018; Dabla-Norris et al., 2023). That is why cross-case analysis is crucial to ascertaining under what structural conditions revenue recycling can support stringent carbon pricing, and which constellation of differing revenue-use schemes is effective in different environments.

This study contributes to current literature in several ways. To my knowledge, this is the first study that systematically analyzes how different constellations of structural political economy factors and revenue recycling strategies can influence carbon pricing stringency. In doing so, the research offers an original theoretical framework for elucidating and examining how policy elements that affect distributional outcomes of carbon pricing interact with the political economy environments in which they are developed and implemented. The results of the analysis corroborate some of the previous findings in the literature by confirming the relationship between structural conditions and carbon pricing stringency (e.g., fossil fuel dependence by Dolphin et al., 2020). However, this intersectional analysis provides additional, crucial insights into a group of countries where the structural conditions militate against higher carbon prices, but which, nevertheless, produce stringent policy outcome. The paper demonstrates that political economy constraints posed by one or two structural conditions (high fossil fuel dependence and/or high income inequality) can be effectively mitigated by targeted revenue recycling measures. Among other successful measures, the analysis reveals that countries applying compensatory mechanisms alongside their policies implement higher carbon prices than those countries with similar structural conditions that do not employ such relief measures.

Furthermore, this study responds directly to calls from scholars demanding comparative analyses of existing revenue recycling systems that tackle real world complex policy designs, in order to ensure greater external validity of findings about the relationship between revenue use and stringency (e.g., Carattini et al., 2018; Carl and Fedor, 2016). To accomplish this research objective, a unique dataset of countries' revenue recycling systems was created. By applying a cross-case analysis to all national-level policies (both carbon taxes and ETSs), which incorporate different revenue recycling options and newly established carbon pricing mechanisms from emerging economies, pressing limitations in the current literature are addressed. These shortcomings include a disproportionate focus on carbon taxes in Western countries, and drawing findings from studies that mainly employ surveys or experiments that can have limited external validity (Maestre-Andrés et al., 2019; Raymond, 2019).

2.1. Explanatory conditions

2.1.1. Structural conditions

The proposed interactive theoretical model consists of three political economy and three revenue recycling conditions, and stringency is assessed through the configurations of these different conditions. Structural conditions were selected based on two key criteria: 1. There is available empirical evidence indicating that they influence carbon pricing policy stringency. 2. They can theoretically interact with revenue recycling measures. There are good reasons why only those conditions should be considered that were found to specifically affect carbon pricing, and not other types of climate policy. Public opinions consistently favor green technology subsidies and regulation over carbon pricing policies. This is especially the case in scenarios without revenue recycling, in relation to domestic mitigation efforts (Dechezleprêtre et al., 2022; Krosnick and MacInnis, 2013). The main reason for the muted public support for carbon pricing, as compared to other mitigation policies, is that the cost of this type of policy tangibly affects consumers and businesses, while the public remains skeptical about the emissions reduction capacity of these policies. On the other hand, the costs associated with green subsidies (increasing taxes and/or lowering spending in other policy domains) might be more hidden, thus less noticeable to the public (Fairbrother, 2022).

Existing large N econometric studies have identified and confirmed three political economy conditions that explain variation in carbon pricing stringency, and which effects might be influenced by revenue recycling (e.g., Dolphin et al., 2020; Furceri et al., 2021; Levi et al., 2020). These are: economic development, income inequality, and fossil fuel dependence. Incorporating these factors into the analysis is essentially equivalent to doing a two-step QCA in which only those remote conditions (macro variables) are analyzed with proximate conditions (policy-specific variables) that presumably have an important effect in explaining outcome (Schneider, 2019). The conditions are introduced in the following subsection.

2.1.1.1. Economic development. As environmentally effective carbon pricing might impose substantial costs on households and private firms, higher income level is an important condition for stringency due to enhanced cost-absorption capacity. Furthermore, there is a great deal of literature that argues that climate change is only prioritized in the public agenda if the basic needs of the citizens, such as job security, are met (e.g., Fankhauser et al., 2015). Economic development enables a higher appreciation of post-material values in society, such as environmental concerns (Inglehart, 1990; Stern, 2000). Finally, countries with higher economic development maybe feel obligated to engage in serious decarbonization efforts, due to their historical emissions records.

2.1.1.2. Income inequality. The regressive, negative distributional impact of carbon pricing is more pressing in countries with higher levels of poverty and existing economic inequalities (Andersson and Atkinson, 2020), a problem which magnifies the political costs of carbon pricing implementation (Furceri et al., 2021). It must be noted that carbon pricing may not necessarily cause regressive effects in various countries (Dorband et al. 2019; Feindt et al., 2021), but some social groups might still be disproportionately affected by stringent policy such as the elderly, or rural households without affordable low carbon alternatives for heating and transport (on horizontal equity issues, see e.g., Cronin et al., 2019; Douenne, 2020). In conclusion, (perceived) inequitable outcome of carbon pricing policies severely affects the political feasibility of implementation.

2.1.1.3. Fossil fuel dependence. The third condition is fossil fuel dependence. Any meaningful climate action thwarts the interests of firms that extract, process and sell hydrocarbons, because their valuation gets depreciated and assets (infrastructure) get stranded in a rapid, clean energy transition scenario (Jenkins, 2019). Similarly, the business model of energy intensive industries such as steel, cement and paper, which rely on cheap fossil fuel, is challenged in a 'greener' world, and this may also have a negative economic impact on (local) governments through employment-and-revenue loss. For these reasons, the fierce opposition from fossil fuel interests against climate policies, and their successful blocking of green initiatives is well-documented in the

literature (e.g., Jenkins, 2014). In essence, the more reliant a country is on fossil fuel resources, the less likely it is that they can introduce meaningful carbon pricing in their jurisdiction.

2.1.2. Revenue recycling conditions

Three main revenue recycling alternatives that theoretically enhance the stringency of carbon pricing are identified, based on the supposition that higher levels of social tolerance and political acceptability enables the implementation of higher carbon prices (Maestre-Andrés et al., 2019). A table showing some forms of revenue recycling in these different categories can be found in the Appendix.

2.1.2.1. Compensation. The first revenue mechanism is compensation. Crucially, by compensating negatively affected social groups and eliminating the possibly regressive effects of carbon pricing, the public's perception on policy fairness can be changed. Using approximately 30% of the revenue from a relatively high to moderate price level to compensate low-income households would make carbon pricing policy outcome progressive (IMF, 2019; Vogt-Schilb et al., 2019). Compensation may come in different forms, such as direct transfer to households, energy bill assistance or tax breaks.

Furthermore, making low carbon technologies more accessible to firms and providing them with assistance to bear the increased costs could help stabilize or even increase their competitiveness, thus diluting their resistance. There are several alternatives to compensating firms that would not compromise the environmental integrity of the policy. For example, reducing existing taxes (e.g., corporate tax) in parallel to introducing carbon pricing ('tax neutrality') could be a politically viable strategy, as was done in Nordic countries as part of a Green Tax Reform agenda (Carattini et al., 2018). Subsidizing the use of clean energy, implementation of energy-efficiency measures, and development of low-carbon technologies may have similarly positive effects on acceptability (Trim et al., 2018).

2.1.2.2. Decarbonization efforts. The second mechanism is to be found in decarbonization efforts, which covers green projects such as renewable energy deployment and energy efficiency programs. The effects through which higher political acceptance can be achieved are twofold. First, such initiatives help to overcome public skepticism concerning the general environmental effectiveness of carbon pricing by demonstrable results through tangible environmental projects (Carattini et al., 2018; Dominioni and Heine, 2019). In countries where the issue of climate change is high on the public agenda, decarbonization projects enjoy obvious public support. This is important, because research shows that public acceptance for command-and-control climate measures, or clean energy incentives, is higher than for carbon pricing (e.g., Krosnick and MacInnis, 2013). Also, green spending may make low carbon technologies (e.g., heat pumps, electronic vehicles) commercially more viable and readily available to citizens. This would enable the financially advantageous behavioral changes that are envisaged by carbon pricing theory. Secondly, from a coalition building perspective, spending carbon revenue on climate action directly benefits and mobilizes clean energy ('sunrise') sectors such as renewables, energy storage and batteries, green hydrogen, or geothermal energy. The more resources green industries acquire through increasing climate action expenditures, the stronger the political coalitions they can develop to pressure policymakers to implement more ambitious and comprehensive regulation on decarbonization (Meckling et al., 2015).

2.1.2.3. Social objectives. The last mechanism, 'social objectives,' refers to spending on policy objectives highly regarded by the public. If public sentiment is focused on a high debt rate, a low level of education, and other needed public services, then "policy bundling" that specifically addresses these concerns, using the revenue generated from carbon pricing, may increase public acceptance of the policy (Bergquist et al., 2020, 1; PMR, 2019; Steenkamp, 2021). For instance, Drews et al. (2022) found that carbon tax revenue proposed to finance Covid-19 expenditures performed well in enhancing public acceptance for the policy, even when compared to other, previously proven, uses of funds, such as on climate projects.

2.2. Theoretical expectations

In most economically developed countries, climate change is a salient issue (UNDP and University of Oxford, 2021), thus in these countries, revenue spending on climate-related projects, to affirm or improve perceptions about the environmental effectiveness of carbon pricing, is the most favorable option from the perspective of political acceptability. However, if high economic development is conjoined with a relatively high level of inequality, some forms of compensatory mechanisms will be inevitable in order to implement more stringent carbon pricing policy. The main reason for this is that growing inequality increases regressivity (Andersson and Atkinson, 2020). When there are more people at or close to their subsistence level of consumption, equity concerns become more pressing, highlighting the need for effective redistribution to counteract negative impacts (Konc et al., 2022). Here, the most effective strategy would be to combine compensation with environmental projects.

It is also expected that no country with a high level of fossil fuel dependence will be able to implement and sustain stringent carbon pricing policy without significant social compensation to support just transition (income support, retraining of workforce, etc.). Additionally, there will need to be environmental spending to lower the costs of technological transition and nurture abatement firms, to fill the void of employment loss in countries with high fossil fuel dependency. In developing countries, climate change is a less salient issue, possibly due to competing developmental objectives and a lower awareness of climate change (Lee et al., 2015). Therefore, spending on compensation and realizing key social objectives may be the most promising revenue recycling strategy. However, even if all revenues are used effectively, it cannot realistically be expected that countries with less advanced economies and high levels of fossil fuel dependence will introduce stringent carbon pricing, because of more pressing socioeconomic objectives (e.g., poverty reduction, industrialization). The expectations, formulated into QCA-conforming Boolean terms can be found in the Appendix.

3. Research design and method

For this research, fuzzy-set Qualitative Comparative Analysis (fs/QCA) is employed. QCA is a *set-theoretic* method that helps us understand social phenomenon in terms of set relations (Ragin, 2008). At the center of inquiry, researchers applying QCA are interested in examining whether certain sets are deemed to be necessary conditions (a superset of outcome) or sufficient conditions (a subset of outcome) to explain social outcome. What fundamentally drives the choice to use QCA, however, is not finding a single necessary/sufficient condition, but exploring different combinations of conditions that are jointly producing an outcome. For example, Ide (2020) shows that countries' insufficient climate policies can be more accurately and comprehensively explained through the intersections of conditions (economic recession and fossil fuel dependence or low level of human development) than by single factors. This is the realm of *causal complexity,* which acknowledges that there can be multiple, non-exclusive pathways to the same outcome (*equifinality),* and that a certain pathway may include a composition of intersecting conditions that jointly exert influence on the outcome (*conjunctural causation*) (Schneider and Wagemann, 2012).

There are well-founded, theoretical and methodological considerations that make QCA employment in this research a promising analytical strategy. As discussed above, contextual differences between countries matter, as they theoretically require the prescription of

disparate revenue recycling strategies. By using QCA we can capture this diverse set of combinations. Equally important is the capability of QCA to detect hybrid revenue recycling strategies. If revenue recycling benefits different social groups across the political spectrum by combining different spending options, we lessen the chance of backtracking on stringent carbon pricing adoption due to public reluctance to give up acquired benefits (Klenert et al., 2018). The more people or social groups benefit from revenue recycling, the more political support can be garnered. Therefore, one of the main theoretical contributions this research makes is an examination of hybrid uses of revenues in all currently implemented national carbon pricing mechanisms, which is a pathway presumably more viable as a political strategy to secure public support. Lastly, it is worth noting that the number of cases ($N = 30$) in this study is well-suited for the method.

This study takes the Paris Agreement as a framework for the systemic comparison of policies, and uses it to determine the unit of analysis and the examined time period (2016–2021) as well. The examined cases are national-level, explicit carbon pricing mechanisms: carbon taxes and emissions trading systems. Although, there could possibly be different political economy dynamics around ETSs and carbon taxes, as ETSs tend to apply to large emitters, indirectly affecting retail prices via carbon pricing, while tax increases tend to be noticed and felt more by voters, it is logical and advantageous to bundle them together for the purposes of research (Aldy, 2017). From a theoretical perspective, the overarching economy principle and expected environmental outcomes of carbon taxes and ETSs are similar (Aldy et al., 2010). Empirically, these instruments interact in numerous ways since some jurisdictions use both instruments to price emissions despite their overlapping emissions scopes, as seen in Finland, and employ policies that resemble policy characteristics of both instruments (e.g., German ETS with fixed price allowances). As Dominioni and Faure (2022) also effectively demonstrate, there is a general trend towards greater similarity in the price stabilizing properties of carbon taxes and cap-and-trade systems, resulting in similar economic and environmental effects. Lastly, by jointly analyzing carbon taxes and emissions trading systems, the empirical results are comparable and build upon those seen in other studies taking similar approach (e.g., Levi et al., 2020). In this way, the data can contribute to the crucially needed knowledge accumulation process in this dynamically evolving field.

All policies that have been operational since the Paris Agreement of 2015 are included in the analysis. However, it is important note that only those EU member states and European Economic Area countries are included that deliberately chose to adopt carbon pricing mechanism in addition to being part of the EU ETS. Countries that have only been participating in the EU ETS are excluded, as the development of the main design elements of the carbon market are outside of their discretion. However, EU ETS prices in countries that use other types of carbon pricing (tax or ETS) are accounted for because they interact with each other in numerous ways. For example, there can be significant overlap between the scope of carbon tax and that of EU ETS (e.g., Finland). In other countries, carbon tax was introduced as a complementary policy instrument to EU ETS (Ireland, Iceland, Portugal), to address emissions in non-ETS sectors or as mechanism to strengthen ETS price signal (the Netherlands, United Kingdom). From a revenue recycling perspective, if EU ETS revenues are spent on climate investments, then carbon tax revenue can possibly be used for compensatory mechanisms or other different social objectives, and the combination of these approaches is theoretically more appealing politically (see above). Therefore, countries employing a carbon pricing mechanism in conjunction with participating in the EU ETS should be part of the analysis, as any examination of the stringency of their carbon pricing framework and revenue recycling strategies would be incomplete without this information.

3.1. Measurement and calibration

Calibration is one of the most decisive parts of QCA research. Calibration is the procedure, by which set-membership scores for cases based on empirical information are assigned, which establishes the qualitative differences between the conditions and outcome under investigation (Schneider and Wagemann, 2012). The process includes the identification of a suitable measurement that reflects the social science concepts we want to capture, and determines the qualitative anchors defining: the crossover point (0,5) (a case is more in or out of a set); full membership (1); and full non-membership (0). In this research, fuzzy-set analysis that allows assigning partial membership scores from 0 to 1, is used, in contrast to crisp sets that are dichotomous (e.g., High Income/Not High-Income countries). Using fuzzy sets allows the research to show empirical diversity among cases (High-, Middle-, Low-Income countries). Raw data is calibrated by using the *direct method of calibration* that applies a logistic function to transform raw data into calibrated scores between the qualitative anchors (Schneider and Wagemann, 2012). Calibration and all other analytical steps are performed in *R* (Dusa, 2018; Oana and Schneider, 2018; Oana et al., 2021). Used data, codes and developed formulas (calibration functions, data diagnostics, robustness tests, solution formulas, etc.) can be found in the online data repository and the Appendix.

3.1.1. Outcome measurement and calibration

The focus of this research is to analyze which constellation of conditions produces the most stringent environmental outcomes. In carbon pricing, this outcome is best represented by price level, since the higher the emission prices are, the more incentive actors have to reduce their carbon footprint and to invest in low-carbon technologies. However, which economic sectors and fossil fuel types are included in the policy (called "coverage") is at least as important as the price level, because the broader the coverage, the more sectors are compelled to engage in decarbonization efforts. Therefore, this research combines the price level and coverage to calculate the so-called "emissions-weighted carbon price" (ECP) (after Dolphin et al., 2020, 480).

This is how the basic formula looks:

$$\text{PRICE}^{*}\ \text{COVERAGE}\ (\%\text{SHARE OF GHG}) = \text{ECP}$$

However, for most countries, price calculation is more complex because some countries have adopted both carbon tax and an emissions trading system, have implemented different rates for different greenhouse gases, or the scope of their carbon pricing mechanisms partially overlaps. To overcome these challenges, all these unique differences were taken into account when the effective price was calculated for each country (see Appendix, where calculated prices for each country are also depicted). As an example, the Danish emissions-weighted carbon price developed as follows:

$$\underbrace{\underbrace{(24*0.018)}_{\text{F-gases}} + \underbrace{(28*0.332)}_{\text{'other GHG'}}}_{\text{carbon tax}} + \underbrace{(68.95*0.3125)}_{\text{ETS}} = \underbrace{31.27\ \text{USD}}_{\text{ECP}}$$

where, 24 is the carbon tax rate for F-gases; 28 is the carbon tax rate for other greenhouse gases; 0.018 (1.8%) and 0.332 (33.2%) are the respective shares of GHGs emissions covered by the carbon tax for these gases; 68.95 is the ETS price level in USD; 0.3125 (31.25%) is the share of GHG emissions covered by the ETS in the country.

The data used for calculating carbon prices are from World Bank (2021): April 2021 for carbon taxes, and October 2021 for emissions

trading systems, which was the cut-off point before COP26. To decide which carbon prices are considered stringent, the 'safety criterion' is applied, a principle which is also embodied in the Paris Agreement (Boyce, 2018). This entails that climate policies should be primarily assessed against how well they perform to keep global warming at a safe, socially tolerable level of increase. To define full membership, the most-cited price range in the literature is used, a level that was developed by the High-Level Commission on Carbon Prices in 2017, led by Joseph Stiglitz and Nicholas Stern. They argue that a minimum price of 40–80 USD/t CO_2 by 2020 would be needed to achieve the Paris Agreement's temperature goals (World Bank, 2017). The 30 Euro benchmark (USD 34.26 in 2020 prices), developed by OECD (2021a), is used as the crossover-point for the minimum carbon price level required for meaningful decarbonization efforts, which is optimistically still aligned with the Paris Agreement's temperature goals. Full non-membership is set at USD 10.

3.1.2. Conditions measurement and calibration

High Economic Development (HED) is measured by GNI per capita, and the World Bank's income classification system, the Atlas Method, is applied for defining qualitative anchors, with the further qualitative distinction made between Western European and Eastern European countries to reflect differences in terms of cost absorption and technological capacity between them. Therefore, non-membership (0) is set at 4095 USD (the difference-maker between lower-middle income- and upper-middle income countries); the crossover point (0,5) is at 12695 USD (threshold for high income countries) and full membership (1) is at 35000 USD. For economic development, data from 2020 were used. The set of Low Income Inequality (LII) is measured by the Gini index with the following calibration thresholds: non-membership: 0.4 (high income disparity), crossover point: 0.3 (relatively reasonable income gap), and full membership: at 0.2, corresponding to near-perfect income equality (Lin et al., 2017). Low Fossil Fuel Dependence (LFD) is measured by the share of fossil fuels taken up by primary energy consumption; 0.8 (80%) is taken as the cross-over point, in reference to the EU's relatively ambitious climate objective of increasing the proportion of renewable energy use to 20% by 2020—seen as a realistic goal that can be achieved by additional efforts from countries. Full membership is set at 0.6, whilst full non-membership is 0.9. To measure income inequality and fossil fuel dependence, the mean value between the years 2015 and 2019 is taken for each country, corresponding to the time period examined in the course of this research. Further details on data collection and an explanation on calibration can be found in the Appendix. The following table provides an overview of the measurements of conditions and the calibration of their thresholds (Table 1).

The data collection on countries' revenue recycling measures is a result of extensive desk research. Information was collected through publicly available governmental and policy reports on revenue recycling (e.g., OECD, 2019; PMR, 2019). To reflect the examined time period of this research, revenue recycling measures introduced between 2016 and 2021 were considered. Information on the revenue usage of different countries was checked against at least two sources. These efforts resulted in a unique dataset of all national level carbon pricing revenue recycling systems. The dataset, along with all used sources, is available in the online repository.

The compiled dataset reveals that, out of thirty countries, twelve countries do not link revenue to any specific purposes. Eleven countries apply hybrid revenue recycling, combining different spending options. For example, Ireland compensates vulnerable social groups and invests in low-carbon transition using funds from carbon taxes, or Norway, which uses all three revenue recycling channels by reducing taxes, putting a portion of the revenue into a pension fund and financing renewable energy and energy efficiency programs. One country, Colombia, spends carbon revenue solely on social objectives (supporting the peace process in post conflict zones), whilst the remaining six countries, including Japan and Latvia, use carbon pricing proceeds towards decarbonization efforts. In general, most earmarked ETS revenues are spent on environmentally friendly projects, whilst carbon tax proceedings are used towards more diverse objectives, such as tax-shifting, but great variation exists among countries. For example, Germany uses most its domestic ETS revenue for relief measures to households and industry, whilst 50% of the Luxembourgian carbon tax revenue is spent on climate action.

Table 1
Measurement and thresholds of membership scores for explanatory conditions.

Conditions/sets	Measurement and data source	Calibration (all with direct method)
High Economic Development (HED)	GNI/capita (World Bank)	Non-membership: 4095 USD/capita Crossover point: 12695 USD/capita Full membership: 35000 USD/capita
Low Income Inequality (LII)	GINI index (OECD and World Bank)	Non-membership: >0.4 corresponding with high income disparity Crossover point: 0.3 corresponding with a relatively reasonable income gap Full membership: <0.2 corresponding with perfect income equality
Low Fossil Fuel Dependence (LFD)	Share of fossil fuels in primary energy consumption (BP Statistical Review of World Energy)	Non-membership: 90% (0.9) or more Crossover point: 80% (0.8) Full membership: 60% (0.6)
High Compensation (HCO) High Decarbonization Efforts (HDE) High Social Objectives (HSO)	Share of revenue spent on the three different conditions (multiple sources, see dataset)	Non-membership: 0 Crossover point: 0.25 (0.3 for compensation – 'progressive outcome') Full membership: 0.5

The share of the revenue spent on the three different conditions is taken into account when calculating revenue recycling conditions. For example, if 60% of the revenue is spent on social cushioning (e.g., transfers to low-income households) and the rest on energy efficiency programs, then the value of 0,6 is assigned to 'Compensation' and 0,4 to 'Decarbonization Efforts.[1]' Both legally earmarked (ring-fenced) revenue and politically committed (hypothecated) spending are taken into account. Regarding calibration, non-membership is set at 0; full membership set at 0.5; the crossover point is 0.25, but 0.3 for compensation, because most studies suggest that approximately 30% of the revenue should be repaid to low-income households to make carbon pricing progressive (see above).

It is important to note that the calibration of the explanatory conditions is highly robust (see the results of different robustness tests: sensitivity ranges and also fit-and-case-oriented robustness in the Appendix).

4. Results

4.1. Analysis of necessity

As a first step, the analysis of necessity is performed for both the outcome (stringent carbon pricing) and its non-occurrence (not having a stringent policy, referred to as "lax carbon pricing"). No single condition

[1] For a better understanding of the calibration process used to analyze revenue recycling data, an example of a complex case (Portugal) is provided in the Appendix, page 9–10.

or disjunction of conditions has been proven to be necessary for stringent carbon pricing. However, not introducing compensatory mechanisms (~HCO) along with carbon pricing has been found to be necessary for the absence of an outcome. This is an important finding from a revenue-recycling perspective because it shows that countries that have lax carbon pricing policies, also do not provide compensation for households or firms (~HCO). In other words, whenever we see low carbon prices, a lack of compensation is also present.

4.2. Analysis of sufficiency

Two separate analyses are run, and the intermediate solutions are interpreted for both cases in which the outcome was present (high stringency) and absent (not high stringency). First, the conditions sufficient for stringent carbon pricing mechanisms are presented (Table 2).

The solution formula shows three sufficiency paths to stringent carbon pricing. 1. HED*LII*LFD demonstrates that a combination of favorable political economy conditions (high economic development, low income inequality, low fossil fuel dependence) enable the implementation of ambitious carbon pricing. 2. HED*HCO*HDE shows that developed countries that are constrained by one or two structural political economy conditions (having higher income inequality and/or greater reliance on fossil fuels in their energy mix) can still implement stringent carbon pricing if they use a hybrid revenue recycling strategy. Lastly, HED*~LFD*HDE*HSO indicates that even high economic development and fossil fuel dependence conjoined with high decarbonization efforts and spending on social objectives can produce stringent carbon pricing.

Table 2
Solution formula for stringent carbon pricing (HS).

HED*LII*LFD + HED*HCO*HDE + HED*~LFD*HDE*HSO - > HS[a]					
Sufficiency Paths	inclS	PRI	covS	covU	Cases
High Economic Development AND Low Income Inequality AND Low Fossil Fuel Dependence (HED*LII*LFD)	0.910	0.863	0.550	0.279	Iceland, Norway, Germany, Slovenia, Finland, Sweden, Denmark, France
High Economic Development AND High Compensation AND High Decarbonization Efforts (HED*HCO*HDE)	0.841	0.731	0.413	0.124	Luxembourg, Portugal, Switzerland, Ireland, Denmark, France
High Economic Development AND High Fossil Fuel Dependence AND High Decarbonization Efforts AND High Social Objectives (HED*~LFD*HDE*HSO)	0.852	0.724	0.121	0.045	Estonia
	0.868	0.810	0.737		

inclS: sufficiency inclusion score.
PRI: proportional reduction in inconsistency.
covS: raw coverage.
covU: unique coverage.
[a] '*' is the logical operator for AND;'+' is the logical operator for OR; '~' is the logical operator for NOT, used in Boolean algebra. 'inclS' shows the extent to which the sufficiency path is consistent with the empirical data. More deviant cases imply lower inclS scores. The obtained inclS scores imply a very high consistency (Schneider and Wagemann, 2012). PRI demonstrates simultaneous subset relations, meaning a path is sufficient for both the outcome (stringent carbon pricing) and the negated outcome (lax carbon pricing), which is illogical. PRI score close to or lower than 0.5 should be avoided, in order to consider the path sufficient. The obtained PRI scores imply no issue with simultaneous subset relation. covS and covU show the empirical relevance of sufficiency paths. covS demonstrates to what extent a single sufficiency path (e.g., HED*LII*LFD) can explain outcome. The closer covS is to 1, the more cases are covered by the solution formula. CovU demonstrates the amount of coverage that is attributable to only one sufficiency path (removing empirical overlap with other paths). (Oana et al., 2021)

Second, the condition sets that result in lax carbon pricing developed as follows (Table 3):

This solution formula is more complex than the previous one. As the first solution formula shown above only applies to highly developed economies, it is worthwhile to begin interpretation with the last sufficiency path, which applies exclusively to them. HED*~LII*~HCO*~HSO suggests that highly developed countries with higher levels of income inequality cannot implement stringent carbon pricing if they do not employ compensatory mechanisms and spend on socially beneficial programs. The first path, ~LFD*~HCO*~HSO, shows that higher fossil fuel dependence conjoined with a lack of social compensation also produces lax carbon pricing. ~HED*~LII*~HCO*~HDE and ~HED*~HCO*~HDE*~HSO both demonstrate that unfavorable political economy conditions (not having developed economy and having higher income inequality) conjoined with a lack of revenue recycling lead to low carbon prices.

One of the fruitful outcomes of the obtained solutions is the ability to construct a typology that elegantly encapsulates the main argument of this study, concerning how stringency is affected by the interaction between structural political economy conditions and revenue recycling strategies. Additionally, this typology enables the interpretation of the obtained solution formulas to proceed in a more substantial and systemic way (Table 4).

Explaining from right to left, we find the first category comprised of countries with enabling political economy conditions and stringent carbon pricing mechanisms. Basically, they are affluent countries with low income inequality and low fossil fuel dependence. These are the Nordic countries (Finland, Iceland, Norway, Sweden), France, Germany, and Slovenia. Most of these countries also use various revenue-recycling strategies, but model results suggest that implementing these is not necessarily needed to adopt stringent carbon pricing mechanism (see Appendix). These findings are in line with the literature for studies using quantitative methods to assess stringency according to structural political economy factors (e.g., Dolphin et al., 2020; Levi et al., 2020), and with the theoretical expectations of this study, with the exception of green spending as being a necessary condition for stringency.

The second group consists of countries that deviate from the enabling political economy environment (high economic development but also higher income inequality and/or higher fossil fuel dependence). The model results show that if these countries use hybrid revenue recycling strategies, meaning a combination of compensation and climate change mitigation efforts, they can overcome challenges posed by structural conditions and implement stringent carbon pricing policies. The countries in this group include Luxembourg, Portugal, Switzerland, Ireland and Estonia. This finding supports the core argument of this study that, under constrained political economy conditions, effective revenue recycling may well be a prime contributing factor in adopting stringent climate policy.

The third group stands in stark contrast to the previous one from a revenue recycling perspective. These countries have similarly constrained political economy environments, but they do not provide any compensation to negatively-affected social groups (households, firms) and their carbon pricing rate is considered low. The data from these countries contradicts that of the previous group, reinforcing the evidence that revenue recycling, especially compensatory mechanisms, is an important policy feature that can push carbon pricing policies towards higher stringency.

The last group includes countries with a 'highly constrained' political economy environment. These are less-developed countries with a higher level of inequality and/or fossil fuel dependence, which implement or perpetuate lax carbon pricing policies. These results confirm the

Table 3
Solution formula for non-stringent carbon pricing (~HS).

~LFD*~HCO*~HSO + ~HED*~LII*~HCO*~HDE + ~HED*~HCO*~HDE*~HSO + HED*~LII*~HCO*~HSO - > ~HS					
Sufficiency Paths	inclS	PRI	covS	covU	Cases
High Fossil Fuel Dependence AND No Compensation AND No Social Objectives (~LFD*~HCO*~HSO)	0.869	0.832	0.665	0.064	Argentina, China, Mexico, South Africa, Kazakhstan, Korea, United Kingdom, Japan, Singapore, Netherlands, Poland
Low Economic Development AND High Income Inequality AND No Compensation AND No Decarbonization Efforts (~HED*~LII*~HCO*~HDE)	0.976	0.974	0.332	0.053	Argentina, China, Mexico, South Africa, Colombia
Low Economic Development AND No Compensation AND No Decarbonization Efforts and No Social Objectives (~HED*~HCO*~HDE*~HSO)	0.977	0.975	0.349	0.035	Argentina, China, Mexico, South Africa, Kazakhstan, Ukraine
High Economic Development AND High Income Inequality AND No Compensation AND No Social Objectives (HED*~LII*~HCO*~HSO)	0.813	0.738	0.492	0.081	Korea, United Kingdom, Japan, Singapore, Chile, New Zealand, Latvia, Spain
	0.845	0.812	0.835		

inclS: sufficiency inclusion score.
PRI: proportional reduction in inconsistency.
covS: raw coverage.
covU: unique coverage.

Table 4
Typology on political economy environments and revenue recycling.

	Highly Constrained Environment	Constrained Environment without Compensation	Constrained Environment with Hybrid Revenue Recycling	Enabling Political Economy Environment
Sufficiency paths (nr. of cases)	Low Economic Development *High Income Inequality * No Compensation * No Decarbonization Efforts (5) Low Economic Development * No Compensation * No Decarbonization Efforts * No Social Objectives (2)	High Economic Development * High Income Inequality * No Compensation * No Social Objectives (8) High Fossil Fuel Dependence * No Compensation * No Social Objectives (2)	High Economic Development * High Compensation * High Decarbonization Efforts (4) High Economic Development * High Fossil Fuel Dependence * High Decarbonization Efforts * High Social Objectives (1)	High Economic Development * Low Income Inequality * Low Fossil Fuel Dependence (7)
Outcome Cases	Lax Carbon Pricing Argentina, China, Mexico, South Africa, Kazakhstan, Colombia, Ukraine	Lax Carbon Pricing Korea, United Kingdom, Japan, Singapore, Chile, New Zealand, Latvia, Spain, the Netherlands, Poland	Stringent Carbon Pricing Luxembourg, Portugal, Switzerland, Ireland, Estonia	Stringent Carbon Pricing Iceland, Norway, Germany, Slovenia, Finland, Sweden, France

theoretical expectations and corroborate the assessments that carbon pricing implementation will be exceedingly challenging in emerging economies where political economy constraints are greater than in more developed countries (Finon, 2019). We do not know whether effective revenue recycling, especially compensatory mechanisms, could foster more stringent policies, as none of these countries apply any redistributive measures.

The only country that does not fit into this classification is Denmark, which has an enabling political economy environment for stringent carbon pricing and employs a hybrid revenue recycling strategy, yet it still fails to introduce a meaningfully high carbon price. However, the country already has one of the highest tax rates on energy in OECD countries, and it recently reached a political agreement to introduce the world's highest corporate carbon tax (OECD, 2021a).

5. Discussion

When we analyze specifically the empirical importance of revenue recycling, the main focus of this research, we can make some crucial observations. Compensation is the most significant form of revenue recycling to enhance carbon pricing stringency. This statement is buttressed by the necessity claim for the non-occurrence of outcome (~HCO - > ~HS) and is further supported by the fact that all countries that implemented compensatory mechanisms also have stringent carbon pricing. While the decarbonization effort is the most popular form of revenue recycling (seventeen countries out of thirty employ it), it is, in itself, insufficient to produce stringent policy, as indicated by numerous countries who spend revenue solely on green causes and not having high carbon prices (e.g., Poland, Japan, Singapore). Building on the assumption that public support is a prerequisite for stringent policy outcome, it must be noted that this result casts a shadow on the findings in the literature that suggest the most effective way to enhance public acceptability for carbon pricing is to use the revenue for environmental projects (for meta-analyses, see: Carattini et al., 2018; Maestre-Andrés et al., 2019). Rather, the results support more recent findings in the literature asserting that social transfers are a more constructive means to secure public support for stringent climate policy, because they contribute to the population's overall wellbeing and have positive distributional effects (Konc et al., 2022). One possible explanation for this discrepancy is provided by Sommer et al. (2022). They have found that people who chose green investments as a preferred form of revenue recycling are more likely to support a carbon tax, but their support is reduced when confronted with more stringent policy outcomes, whilst the public's demand for social cushioning increases. Therefore, public's preferred method of revenue recycling may change with increasing stringency, which explains why compensation is more important for implementing ambitious carbon pricing than green spending, which generally remains the most popular measure.

Although compensation appears to be the most important single revenue recycling measure, model results suggest that hybrid revenue use (compensation plus green spending) is even more favorable for stringent policy outcome, especially in constrained political economy environments. This finding is in line with the theoretical literature suggesting that: 1. The larger the share of the population that directly benefits from carbon pricing, the more likely it is that meaningful carbon prices can be introduced and perpetuated (Klenert et al., 2018). 2. The possible combination of public benefits such as improving the environmental conditions for low-income/marginalized communities

(insulating their homes from state funds) can be a more viable political strategy to secure political acceptance than single benefits such as energy bill assistance (Raymond, 2019).

A recent case where such hybrid revenue recycling strategy was pursued is the Irish carbon tax reform. Ireland faced serious political economy constraints for implementing ambitious carbon tax, such as using the highest share, among European OECD countries, of fossil fuels (coal, peat, oil) for home heating and its notoriously high-emission transportation sector (OECD, 2021b). The Irish government took a comprehensive approach and compensated for both the horizontal (within income groups) and vertical (among income groups) distributional impact of an increasingly stringent carbon pricing policy, legislated to reach 100 EUR/tCO_2 by 2030. Therefore, compensatory measures targeted poor households, as well as certain vulnerable groups (big families, elderly), through increasing existing welfare transfers (Department of Public Expenditure and Reform, 2020). Approximately 30% of their revenue was ring-fenced for social cushioning and the rest on green spending. The biggest share of green spending went to energy efficiency programs and the development of a low carbon transport system. These decisions on revenue allocation for specific social protection measures and green spending, directly addressed the expressed preferences of the public and those of powerful interest groups, such as business associations, to secure political support for reform (Citizens' Assembly, 2018; Department of Finance, 2019). Karapin's (2020) illuminating process tracing analysis also shows that the revenue neutral design of British Colombia carbon tax, handing the entire revenue back to businesses and consumers through corporate and income tax reductions as well as tax credits for low-income earners, helped this climate policy to survive the political backlash during implementation. This move also strengthened its acceptance over time by securing consent from businesses and subsidizing poor households which diluted public opposition to perceived increasing inequality resulting from the implementation of the tax. Raymond's (2019) case studies throw additional insights into the causal mechanisms linking hybrid revenue recycling and stringent policy outcome. He explained how increased political legitimacy, and support for ETS implementation and reform, could be forged in California and the Northeastern states in the US by paying for tangible, salient public benefits from carbon revenues, such as subsidizing renewable energy installations for consumers, and funding zero-emissions housing for disadvantaged populations, which effectively addressed specific local conditions like pressing economic inequality. These cases demonstrate that a hybrid use of revenue can simultaneously serve the objectives of enhancing public acceptability, reversing negative distributional impact, and furthering climate change mitigation efforts.

There are numerous avenues for further research that can go beyond the limitations of this study and provide additional insights into the relationship between revenue recycling and carbon pricing stringency. First, important theoretical lessons can be gained by breaking down the broad revenue recycling categories used in this research (e.g., Compensation) into more specific measures (Bourgeois et al., 2021). Green spending and/or compensatory schemes targeting different socioeconomic groups can be examined, such as low-income households and energy-intensive industries, to assess whether these different approaches lead to different outcomes. For instance, the support-increasing effect of compensation might be different if provided in form of tax breaks which, in general, tend to be regressive (Fremstad and Paul, 2019; Murray and Rivers, 2015). The literature could also benefit from the study of comparative, qualitative analyses of revenue usage for different carbon pricing instruments in distinct political economy contexts, and from investigations into the underlying causal mechanisms linking revenue recycling and stringency.

6. Conclusion

This study presents a novel theoretical approach to analyzing the stringency of carbon pricing through a constellations of political economy conditions and revenue recycling measures. The empirical results obtained from the comparison of thirty national level carbon pricing mechanisms indicate that compensation is a critical measure for the implementation of ambitious policy. Furthermore, a key finding of this research is that applying a hybrid use of revenue, combining compensation and green spending, enables the implementation of stringent carbon pricing, even in constrained political economy environments. Examining stringency in constrained environments is particularly relevant because this is the current situation of most countries in the world today. Using the obtained results, substantial empirical evidence is provided to support theoretical claims about the relationship between enhanced carbon price level and effective redistributional policy choices. It is hoped that this evidence can serve as an essential indicator to policy makers on how these policies should be designed to be politically acceptable, socially tolerable, and fulfill their environmental purposes. The main policy recommendation that might be drawn from this analysis is that the combination of compensation and climate investments can be a particularly effective strategy to secure political support for ambitious climate policy, even in countries that face considerable structural obstacles to their decarbonization path. It appears that social protections and/or preserving firms' competitiveness are prerequisites for stringent policy. Once these needs are effectively addressed by policymakers, significant fiscal resources can be directed towards furthering climate change mitigation efforts, moving the world economies in a direction that also reflects the preferences of the general public.

Declaration of Competing Interest

The author reports there are no competing interests to declare.

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Appendix A. Supplementary data

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