



Procedural climate justice: Conceptualizing a polycentric solution to a global problem

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ABSTRACT

This article introduces a conceptual framework for climate governance. It provides an insight into how a system of governance can cope with the uncertainty and pluralism that are prevalent in climate governance. In our framework, we combine polycentric climate governance, procedural climate justice and directed technical change policy. We show that following norms of procedural justice can enhance the desired properties of polycentric systems. In turn, polycentric systems are a suitable environment for fulfilling procedural justice norms. As to the policy dimension: There is reason to assume that innovation and adaptation policies work well in polycentric systems, while carbon pricing relies more strongly on a global treaty to be effective. And innovation and adaptation profit from procedural justice norms being followed. Polycentrism, procedural justice, and innovation and adaptation policy all possess specific properties that can cope very well with a complex environment where there is positive uncertainty about the future and many parties with different normative outlooks. They combine to a system that is flexible and adaptable over time. This constitutes the particular strength of our conceptual system as a framework for climate governance, policy, and research.

1. Introduction

Actors concerned with *climate governance* have discussed a wide range of governance models. Some have put hope on a global top-down treaty, others have discussed polycentrism as a model for climate governance (see e.g. Ostrom, 2009; Rayner, 2010 for comments on this debate). The latter can be traced back to Elinor Ostrom's concept of polycentrism and suggests a bottom-up and decentralized governing of climate change. Likewise, in the discussion on *climate justice*, many different types of justice have been discussed. A widely used approach is to apply distributive norms to a global carbon pricing regime (see, e.g., Gardiner, 2010; Kortetmäki, 2016 and Schlosberg, 2013 for an overview). An alternative to this is procedural climate justice (e.g., Brandstedt and Brülde, 2019; Grasso and Sacchi, 2015). Besides justice and governance, *climate policy* has been a contested field. While carbon pricing is still a popular route, adaptation (e.g., Biesbroek and Lesnikowski, 2018) and a focus on renewable energy innovation policy (a paradigmatic example is Acemoglu et al., 2012) have been identified as important complements to the carbon pricing policy route.

Only few scholars have aimed at connecting the concepts of

procedural climate justice, *polycentric climate governance*, and *adaptation and innovation policy*. Although each of these concepts has been well investigated on its own, little has been done to systematically connect the three ideas. Yet, it is a worthwhile endeavor combining them to a common conceptual system. This is for the following reason: Any interesting climate governance framework must show how it responds to the specific governance challenges of the climate crisis. Two very prominent challenges are those of *positive uncertainty* and *reasonable disagreement*. There is uncertainty about the exact future development of climate change and its impact on human beings. And there is a wide range of actors with different normative outlooks trying to agree on some way of addressing climate change. The conceptual system developed in this article holds interesting insights into how one can cope with these challenges. It can therefore be understood as a useful “governmental thought experiment”.

Our argument will proceed as follows: We provide a detailed list of elements of procedural climate justice. We then argue that the normative elements of procedural justice match very well with the positive elements of polycentric climate governance. Polycentric systems facilitate the fulfillment of norms of procedural justice. And procedural norms

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in turn make polycentric systems more effective and legitimate.¹ We also add the policy dimension to investigate how different policy options work in a polycentric framework. In a polycentric system, unilateral carbon taxes risk being ineffective. In contrast, adaptation and renewable energy innovation policy (or so-called direct technical change) could effectively reduce the risks climate change poses to sustainable development. Finally, we discuss the benefits of our framework of justice, policy, and governance. In particular, a procedurally just polycentric system may prove helpful where approaches focused on top-down governance, price-based policies or on distributive notions of justice struggle to cope with uncertainty and pluralism. This article does not aim to substitute carbon pricing policies that follow distributive justice goals, or top-down approaches. In contrast, we attempt to complement pricing policies with the aim to catalyze sufficient climate action soon.

The article is organized as follows: We propose our method of research in [Section 2](#). We provide the theoretical background in [Section 3](#). There we identify the main properties of the concepts of polycentric climate governance, procedural climate justice, adaptation as well as directed technical change policy as they are described in the respective literature streams. Our main argument as described in the preceding paragraph is presented in [Section 4](#). We discuss some implications and limitations of our approach in [Section 5](#). Finally, we provide concluding remarks.

2. Methodology

Following [Gilson and Goldberg, 2015](#), the purpose of a conceptual article is to propose new relationships between constructs and concepts. We rely on the definition by Meredith stating that concepts are “a bundle of meanings or characteristics associated with certain events, objects, or conditions” ([Meredith, 1993](#), p. 5). We aim to aggregate the three concepts of a polycentric climate regime, procedural climate justice, and a climate policy focused on adaptation and especially on innovation, to a conceptual system. Such a system “is characterized by the many interactions occurring among the elements of the conceptual framework. That is the conceptual system consists of multiple concepts with many interrelated propositions” ([Meredith, 1993](#), p. 10). Therefore, we do not construct a predictive theory, but we clarify and bridge existing theoretical approaches ([Gilson and Goldberg, 2015](#)). We investigate how the elements and aspects of the three concepts interact with each other. And we show how they can be combined within an integrative framework that may prove useful for (research on) climate policy making and climate governance.

The advantage of considering the chosen concepts together is that one can better understand some proposition or concept if we understand a) the reasons for adopting it and b) the implications of adopting it ([Brandom, 2000](#)). Only in the integrated view can one understand the implications and consequences of the use of some concept.

To base the work done in this article, we will introduce our main concepts in [Section 3](#). We take the concepts of “polycentric climate governance”, “procedural climate justice”, “climate adaptation” and “directed technical change” as our starting point. [Section 3](#) serves the purpose of identifying the main properties of these concepts as described in the literature. To this end, we draw from articles that introduce our central concepts in an abstract, high-level way. Moreover, [Section 3](#) shows that the three concepts have not yet been linked sufficiently. This legitimizes our analytical endeavor. To do this, we identify articles that touch on all three concepts simultaneously. The aim of this section is not to conduct a comprehensive literature review. We intend only to provide the theoretical background for our conceptual work done in later sections.

¹ Yet, we do not think local governance per se is guaranteed to be procedurally just. It can, e.g., be captured by local economic or political elites.

In [Section 4](#), a list of elements of procedural climate justice is provided. These elements directly spring from the literature on procedural climate justice we have mentioned in [Section 3](#), especially from the sophisticated concepts of [Brandstedt and Brülde, 2019](#) and [Grasso and Sacchi, 2015](#). The elements are selected so that they aggregate to a sound and plausible conception of procedural climate justice that can be endorsed by all people subject to climate governance. It shall be possible to endorse them in their own right and they shall be instrumental to effectively reducing the risks climate change poses to humanity. It is also important that our concept of procedural justice is only so normatively demanding that it is still possible for a wide range of actors to endorse it ([Grasso and Sacchi, 2015](#)).

We investigate how the descriptive elements of polycentric climate governance match with the normative requirements of procedural justice. We consider what are the prospects for the fulfillment of procedural justice norms in polycentric governance. And, in turn, we analyze how following procedural norms will affect the functioning of polycentric governance systems. We then use game-theoretic considerations to illuminate the consequences of adopting different unilateral climate policies in a procedurally just polycentric climate regime. Where it improves the understanding of our framework, we compare the ideas of governance, justice, and policy used in our framework to other frequently discussed concepts in these domains.

3. Theoretical background

3.1. Introducing three dimensions

Governing polycentrically means that “political authority is dispersed across separately constituted bodies with overlapping jurisdictions” ([Skelcher, 2005](#), p. 89). Polycentricity is different from fragmentation since there is still a common frame of rules and a degree of cooperation between political units ([Bäckstrand et al., 2018](#)). Several scholars have shown the advantages of polycentric systems over systems ruled top-down by one sole authority. Multiple layers of political authority, e.g., municipal, county and state governments, allow citizens to choose the right level and the most competent authority for provision of public goods ([Cole, 2015](#); [Ostrom, 2009](#)). Benefits at multiple scales of cooperation can be reaped ([Ostrom, 2010](#)). Many jurisdictions experimenting with policy allow mutual *learning*, more so than if there is just one overall policy approach ([Cole, 2015](#)). This also increases *resilience* ([Jordan et al., 2018](#)). Additionally, polycentrism includes the idea of *subsidiarity* ([Cole, 2015](#)). This increases legitimacy and *inclusiveness* of decisions ([Jordan et al., 2018](#)), as political preferences are likely to be more homogenous the smaller the group is ([Ostrom, 2010](#)).

Some studies have applied polycentrism to climate governance, beginning with [Ostrom, 2009](#). [Dorsch and Flachsland, 2017](#), show that in decisions on smaller scales and with direct pragmatic benefits, free riding can be less prevalent. They find that there are site-specific co-benefits of climate action to be reaped. These co-benefits range from improved health by less air pollution ([Prins et al., 2010](#)), to increased energy security by using clean energy sources ([McCollum et al., 2013](#)), to using proper insulation and photovoltaic on an individual level ([Ostrom, 2009](#)). Hence, there are synergies between climate action and other policy issues. [Prins and Rayner, 2007a](#), conclude that there are already powerful political forces that one can leverage for climate policy.

The second introduced concept is that of **procedural climate justice**. *Substantive* notions of justice make statements about what constitutes a just final allocation of advantages and disadvantages. *Procedural* justice on the other hand formulates criteria for rules of interaction and decision-making ([Miller, 2021](#)). In the case of *pure procedural justice*, no external criterion is available to evaluate the outcome. There is a procedure that is determined as just, and any outcome is just if and only if the required procedures have been followed properly ([Rawls, 1999](#)).

Some authors have fruitfully applied the notion of procedural justice

to climate justice. In a paradigmatic article, Paavola and Adger, 2006, note the unequal ability of *participation* for developing countries in the UNFCCC. Tomlinson, 2015, provides an impressive survey of procedural justice in the UNFCCC, with similar results. Likewise, Biermann and Gupta, 2011, emphasize the importance of the legitimacy of rule-setting processes. *Transparency* is frequently brought up as a procedural norm (Biermann and Gupta, 2011; Brandstedt and Brülde, 2019; Grasso and Sacchi, 2015). Another element is *voice*, that is, the capability to politically articulate ones views and interests (Grasso and Sacchi, 2015). Grasso and Sacchi, 2015 and Brandstedt and Brülde, 2019, have to be highlighted. They provide one of the rare developments of an explicit and detailed notion of procedural climate justice.

Two further concepts important for our analyses are **climate adaptation** and **innovation policies**. In the last years a substantial amount has been written on adaptation (Alves and Mariano, 2018). Still, adaptation measures receive too little funding in practice (Intergovernmental Panel on Climate Change, 2022; Kortetmäki, 2016). Adaptation is said to have two central advantages above mitigation. It helps the affected people in a much quicker and more direct way. And it is partly a private good (Prins and Rayner, 2007b; Stern, 2007) or a public good that can be provided at a much lower scale than mitigation. Adaptation thus requires less cooperation. Therefore, it is less difficult to implement than a global mitigation treaty.

A further concept is innovation policy consisting mainly of clean energy R&D subsidies, or so-called directed technical change. This has been dubbed by some the central climate policy, instead of the conventional approach of carbon pricing. Acemoglu et al., 2016, Acemoglu et al., 2012, Aghion et al., 2019, Aghion et al., 2009, and Hémous, 2016, suggest the following. They build on endogenous growth theory, as proposed by Romer, 1990. There, firms decide on their innovation based on profit expectations from temporary monopoly (Romer, 1990). Where a technology is lagging, incremental innovation will not lead to temporary monopoly profits. This leads to path dependencies. Path dependency means that there are multiple possible outcome equilibria. Some of these might be better for all than others, that is, they are pareto-superior to others. Which path is ultimately chosen depends on initial conditions and expectations (Aghion et al., 2019). This can lead to pareto-inferior paths to be chosen. As profits from innovation and production in fossil technology are currently larger than from clean technology, there is a path dependency in fossil technology. Yet, it is possible to switch to a clean energy path by heavy temporary subsidization of clean energy R&D. A terminological note: We use the terms “directed technical change”, “innovation policy” and “clean energy R&D subsidization” mostly interchangeably in this text. This is well in line with the before-mentioned literature. “Directed technical change” means state-funded research to influence the direction of innovation. This general term best suits a high-level conceptual paper like this one. It would not be appropriate to specify the exact policy, be it R&D tax cuts, or R&D wage policies, or further options.

3.2. Links between the three dimensions

Some articles have come close to linking the three concepts: Schlosberg, 2012, employs procedural elements and considers adaptation. Gwyn Prins and Steven Rayner have supported a bottom-up approach including adaptation and innovation (Prins and Rayner, 2007a, 2007b), and consider inclusiveness as a norm (Prins et al., 2010). Dorsch and Flachsland, 2017, consider polycentrism, the norm of non-domination, and adaptation.

These are valuable contributions. Yet, they rarely adopt even two of the concepts explicitly and investigate their interrelations. Thus, they do not treat the connections between policy, governance, and concepts of justice comprehensively. Alves and Mariano, 2018, note that procedural norms receive too little attention in the adaptation literature. Furthermore, the adaptation literature rarely consciously adopts a polycentric approach (Biesbroek and Lesnikowski, 2018), as Elinor Ostrom calls for

(Ostrom, 2010). The polycentrism literature focusses on effectiveness and not on justice (Bäckstrand et al., 2018). And to our knowledge it has never been shown how a combination of the three streams copes with uncertainty and pluralism. As Drupp et al., 2020, p. 14, notes: “The research landscape of sustainability economics is quite fragmented, with several clusters having no overlap with each other in terms of their conceptual vocabulary”, so that “contributions would benefit from a better integration and systematic links among each other”. This missing link between the three streams we shall tackle.

4. The conceptual system

4.1. Uncertainty and reasonable disagreement

Any interesting suggestion for a climate governance model must suggest some way in that it responds to the specific context of climate change. While there are many problems in climate governance – far too many for us to list them – we believe that there are two concepts that subsume many of these challenges. These are uncertainty and reasonable disagreement.

The uncertainty regards the future development and impacts of climate change. For example, when constructing carbon pricing policies, policy makers need to calculate the social cost of carbon (SCC) to impose the efficient Pigouvian tax on carbon emissions. The problem is that currently available models for calculating the SCC, so-called Integrated Assessment Models (IAMs), are quite weak and respond strongly to arbitrary choices of parameters (Aghion et al., 2019). Uncertainties involve the response of temperature to higher atmospheric concentrations of CO₂, i.e. climate sensitivity (Pindyck, 2021; Pindyck, 2013). Furthermore, they involve the economic impacts of higher temperatures, which are estimated largely made up damage-functions (Pindyck, 2013). A third difficulty of IAMs is the discount rate. The discount rate is at heart a normative parameter responding to the question of how much society values the welfare of future generations (Hampicke, 2011). Different discount rates yield highly different SCC (Pindyck, 2013), typically ranging from \$15 to \$300 (Prins et al., 2010). In short, policymakers move on thin epistemological ice when determining the amount of effort they should put into climate policy.

Another source of uncertainty are the bio-physical tipping points. If tipping points are triggered, strongly non-linear responses of the earth system may occur (Lenton, 2011). And for some tipping points, it is uncertain at which temperature they will be triggered (see, e.g., Duffy et al., 2021). This makes navigating and predicting the future development of climate change even harder.

Even if climate scientists and climate economists delivered a waterproof and unchanging *descriptive* decision basis, there would remain ample room for *normative* disagreement. Climate change impacts differ between world regions, because of different geographic preconditions on the one hand and unequal adaptive capacity on the other hand. That different countries might prefer different temperatures makes global negotiations on temperature targets more difficult. And normative disagreement not only concerns the desired end state but also the distribution of contributions to reaching this state. This becomes explicit in the debate about the initial allocation of emissions certificates in a potential global ETS. In these negotiations, one can observe the phenomenon of *reasonable disagreement* (Brandstedt and Brülde, 2019). *Opinions about what is a good and just outcome and burden distribution diverge* not only because of country-specific political and economic interests. They may also diverge because of different values and world views (Grasso and Sacchi, 2015). Even if states offer terms of cooperation they see as fair in their own light, and that can be said to be reasonable, there may still be disagreement between states (Tomlinson, 2015).

Researchers and policy makers are, practically speaking and for all purposes, left without an agreed-on specific external criterion that could determine what constitutes a good outcome or a just distribution (Tomlinson, 2015). And because of uncertainty, they would not even

know the exact way to get to that outcome. These challenges must be responded to by a model of climate governance. We should notice, then, that reasonable disagreement about outcomes and distributions leaves open the possibility of agreeing to certain just *procedures* and thus to a notion of pure procedural justice.

4.2. The procedurally just polycentric climate regime

We offer four elements of procedural climate justice. We posit that all norms need to be fulfilled by a climate regime for the decisions taken within such a regime to be adequately called procedurally just: (1) self-determination; (2) transparency; (3) equal participation; (4) voice. We presuppose here that the participants of the climate governance regime are reasonable, so that their claims can be reconstructed from reasonable moral views and accurate information (Brandstedt and Brülde, 2019).

(1) *Self-determination* can be split into the two principles of sovereignty (or non-domination) and subsidiarity. Self-determination is an important good for peoples. It is one of the fundamental principles of liberal-democratic foreign policy to accept the independence of other states. This includes accepting that they act with the goal of ensuring their citizens well-being (Rawls, 2001). Self-determination also has instrumental value. Climate policy needs to be reliable in the long-term. This is most unlikely if agreement is only coerced (Tomlinson, 2015). The principle is especially addressed to the Global North to remind it that climate policy should not be a neocolonial project imposing the North's interest on the South (Muradian, 2019). The principle of self-determination provides a first link to polycentrism. The norms of *sovereignty* and *subsidiarity* are found again in polycentrism's emphasis on *subsidiarity*. That is: a polycentric system may better fulfill this procedural norm than a global top-down governance scheme would.

(2) *Transparency* (as also proposed by Brandstedt and Brülde, 2019 and Grasso and Sacchi, 2015, entails collecting data, analyzing and evaluating policy related to climate change (Aldy, 2018)), and providing free access to this knowledge (Grasso and Sacchi, 2015). This matches well with the *mutual learning* characteristic for polycentric systems. Transparency is valuable in itself as well as instrumental to accountability, legitimacy (Biermann and Gupta, 2011), learning and flexibility. This demonstrates how following a procedural norm can enhance the desirable aspects of polycentric governance.

(3) *Equal Participation*. This cannot mean that all affected by one decision should have a seat at the table (Tomlinson, 2015). This would be practically inapplicable and would interfere with the sovereignty principle. But where an actor is potentially coerced by some outcome, she should have an equal ability to participate in the decision process (Tomlinson, 2015). We admit this is vague, but so is the "all affected principle", and only because of vagueness one should not just discard the principle of participation. Just like the preceding elements, participation has instrumental value. This we will see in our elaborations on inclusive adaptation policy. It also is intrinsically desirable as an expression of political equality. And not only does it make polycentrism more effective, like in adaptation, but it is in turn facilitated by polycentrism. Polycentrism's element of *subsidiarity* facilitates inclusive *participation*.

(4) *Voice* (as also proposed by Grasso and Sacchi, 2015, or part of the political freedoms in Sen, 1999 – Everyone affected should be able to contribute their knowledge (Grasso and Sacchi, 2015). This principle is connected to transparency and participation, though we find it worthwhile to include it in our list as an explicit and distinct element. After all, frequently the most vulnerable have the least voice (Paavola and Adger, 2006). Surely, it is easier to lend marginalized groups a voice if political units are smaller. Again, the procedural norm profits from the polycentric regime.

We hold that these values are morally appealing in and as of themselves. And we think that they are *less controversial than strong distributional norms and therefore easier to agree to* (Brandstedt and Brülde, 2019; Tomlinson, 2015). Furthermore, we hold that all of these elements have

significant instrumental value to all potential participants in a polycentric climate regime. In climate governance, society is confronted with a context where it does not know the desired end state nor the exact way to some outcome (Prins and Rayner, 2007a). And there is a reasonable pluralism of values and interests. Here, polycentric governance as a learning, flexible and pluralistic system may in some cases be more suitable than a preconceived one-shot solution centrally implemented from the top down. And a version of justice which is not as rich in presuppositions and less demanding than substantive and distributive notions seems appropriate. Moreover, it is suitable that procedural justice does not focus on end states but on pathways and procedures (Grasso and Sacchi, 2015). The commonly accepted norms of procedural climate justice can provide climate governance with a consensual frame, without which there would not be polycentrism, but fragmentation. This gives us a first idea of how procedural climate justice and polycentric climate governance are adequate for a context of uncertainty and reasonable disagreement. This idea is illustrated in Fig. 1. The elements of procedural climate justice and polycentric climate governance are listed. The dashed lines between them show which of these elements possess synergies. The thick black lines identify which elements help in responding to contexts of *uncertainty* and *disagreement*.

4.3. Climate policy in a procedurally just polycentric climate regime

We now analyze the *effectiveness* of different climate policies that are adopted unilaterally. We need to understand their workings in a polycentric system and how these policies relate to our elements of procedural climate justice. Now, the term "effectiveness" is meaningless without a specified goal which can effectively be reached. Yet, we said we operated under purely procedural norms. We suggest the following: Our approach of procedural justice shall not substitute but complement substantive visions of justice. This is well in line with the literature (Brandstedt and Brülde, 2019; Grasso and Sacchi, 2015; Paavola and Adger, 2006; Samarakoon, 2019). Then, we can choose some substantive goal, which is more or less uncontroversial, such as: preventing serious harm from later generations (Hampicke, 2011), or lowering the overall cost associated with climate change. Here we suppose no *reasonable* disagreement. This assumption suffices for some general evaluative insights about policy mechanisms. Besides investigating effectiveness, we aim to show that the policies found to be effective interact productively with the norms of procedural climate justice we have offered in the preceding chapter.

4.3.1. Carbon pricing

To begin with, unilateral carbon pricing will not be a sufficient route in a polycentric setting. The main reason is that one country's emissions are in some part endogenous to those of other countries. Firstly, insofar as the supply of fossil fuels is inelastic, if one country unilaterally reduces demand by taxing emissions, the price of fossil fuels will fall. Then, the other countries will consume more fossil fuels (Wiener, 2007). Secondly, countries trade with each other. They export those goods where they have a comparative cost advantage. If a country domestically taxes carbon emissions, the production of goods which involve large emissions is likely to be transferred to non-taxing countries where the goods can be produced at relatively lower cost (Aghion et al., 2009; Wiener, 2007). This is bad for a nation's industrial base, but not good for global emission levels. Furthermore, production reallocation often is accompanied by innovation reallocation (Hémous, 2016). And innovation reacts positively to increases of the market size (Acemoglu et al., 2012). As a result, one can expect that non-taxing countries accelerate their innovation in emissions-intensive goods (Hémous, 2016). Using emissions-intensive production techniques will then get more and more profitable. In this way, unilateral taxation of emissions may even contribute to overall environmental degradation (Hémous, 2016).

This whole phenomenon is called carbon leakage (Aghion et al., 2009; Antimiani et al., 2016). Carbon leakage not only occurs when a

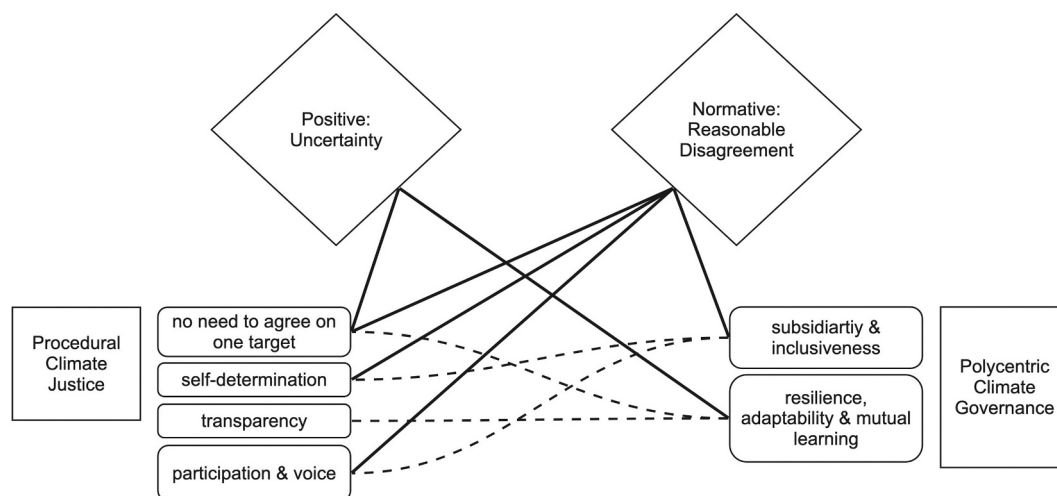


Fig. 1. Polycentric climate governance and procedural climate justice. (Own illustration).

single country adopts a carbon tax. It also occurs if a group of countries (Tomlinson, 2015) like the European Union acts unilaterally.

One possible response to this is a carbon border adjustment, where a tariff is put on products imported to the taxing country. The tariff shall act as a carbon tax on these imported products. This can mitigate some of the adverse effects of unilateral carbon pricing, though likely not all of them. Other consuming countries will continue to buy from abroad, so that fossil production and innovation will still move to other countries, as domestic firms importing intermediates will lose competitiveness (Antimiani et al., 2016). And retaliatory measures could also follow. Then, a non-comprehensive emissions pricing policy might not have the desired effects.

4.3.2. Directed technical change

Taxing aims at reducing emissions by raising their price. The reduction can also be achieved by inducing a fall in prices of substitutes through innovation, i.e. by making available cheap clean energy (Acemoglu et al., 2016). *Subsidies for clean energy R&D* can be used to accelerate the rate of innovation and thereby to give the decisive impulse for a transition to clean energy. We already noted that the path dependency in fossil technology can be broken by governments via heavily subsidizing clean energy R&D (Aghion et al., 2019). They have several options for intervention. They can directly pay researchers as in state-financed universities for basic research. Or they can increase profit expectations of firms. This can be done either by subsidizing R&D and thereby reducing costs of innovation, or by implementing lotteries or price competitions in clean energy R&D. What is fascinating about this intervention is that it only needs to be temporary. Once enough research has been done in the clean sector, so that clean technology has an edge over fossil technology, it will be rational from the individual firm's point of view to allocate researchers to clean innovation (Acemoglu et al., 2012; Aghion et al., 2009; Hémous, 2016). Consequently, it will then no longer be profitable to innovate in (and produce with) fossil technology.

Notice that relying only on taxation of emissions might theoretically also induce innovation and technology because it reduces profit expectations from fossil technology. Yet, empirically, no such link has been found (Lilliestam et al., 2021). And there is a central difference between the direct effects of carbon taxation and research subsidies. While both render clean energy relatively cheaper, the price signal sent by a locally restricted tax is locally restricted, too. In contrast, *the price signal sent by locally restricted research is global*.

This very important asymmetry makes *clean energy R&D subsidies a highly attractive climate policy in a polycentric system*. Not all countries need to subsidize R&D. There is no need to coordinate globally. Technology as knowledge is not physically bound by national frontiers. If

clean technology is the most advanced technology and this knowledge or technology is diffused to other countries, then also in these countries it will be profitable for firms to produce with clean technology and to innovate in clean technology.² So, it would suffice if a small group of countries adopted this policy of subsidies (Aghion et al., 2019; Aghion et al., 2009). Indeed, this is why most innovation happens in a very few countries anyways (Prins and Rayner, 2007a). If they innovate, the rest can imitate (Aghion et al., 2019, Aghion et al., 2009). An absolutely necessary condition for this to be an effective mechanism for fighting climate change is technology transfer (Aghion et al., 2021).

Furthermore, recommendations for research subsidies do not change significantly in reaction to small parameter changes, as is clearly the case for carbon taxes (Acemoglu et al., 2012). Here the strong message for rich western countries is: the longer they wait, the larger the gap between fossil and clean technology will become, and the more they will invest in infrastructure that is useless later (Aghion et al., 2021), so the more costly will become their later policy intervention. Even with a low discount rate like the one chosen by Nordhaus, they should rigorously and immediately intervene with subsidies (Aghion et al., 2021), while optimal subsidies do not vary greatly with different discount rates (Acemoglu et al., 2012). Thus, *uncertainty is not as great a problem for directed technical change policies as it is for carbon pricing*.

Research subsidization and technology transfer are also in line with the elements of procedural justice. It is in the self-interest of industrialized countries to have sizeable government investment in research. This is because in contrast to developing countries, the economic model of industrialized countries relies heavily on their own frontier innovation activity (Aghion et al., 2021). Shifting parts of their research budgets into clean energy and energy efficiency research will reap co-benefits. Energy efficiency is of interest in itself for energy-intensive economies (Prins and Rayner, 2007a). Clean energy furthermore improves energy security, on the one hand through diversification of energy sources, and on the other hand, and most importantly so, through higher energy sovereignty (McCollum et al., 2013). Industrialized countries have a geostrategic and economic interest in becoming independent from, e.g., autocratic regimes to provide them with energy, especially with fossil fuels (Prins and Rayner, 2007a).

The element of transparency matches with research subsidies, too. When multiple countries adopt green innovation policies, exchange about which policies work well and which do not can enhance mutual

² Although it should be noted that investor-state dispute mechanisms may well interfere with governmental support for technology development and diffusion (Tienhaara and Cotula, 2022).

learning (Aldy, 2018). And as transparency is understood as free access to knowledge, it matches with the technology transfer condition. Technology transfer will work if barriers to knowledge are removed, e.g. if regimes of intellectual property rights are designed to promote diffusion of knowledge.

The path of directed technical change policies is also compatible with self-determination and sovereignty of developing countries. It does by no means impose growth restrictions on them. They can, as they do, continue to pursue growth strategies. Their economic model already relies heavily on adapting technologies developed by others (Aghion et al., 2021). Therefore, they will voluntarily take the green growth path as soon as the industrialized North has made clean technology cheaper and more profitable to use (Acemoglu et al., 2016).

4.3.3. Adaptation

Adaptation is essentially a bottom-up, polycentric response (Rayner, 2010): e.g., developing warning and response systems against heat waves or building up water storage and irrigation systems to cope with droughts (Intergovernmental Panel on Climate Change, 2022). Following the principles of procedural climate justice listed above becomes extremely valuable in matters of adaptation (Schlosberg and Collins, 2014). Polycentric subsidiarity, supported by the norm of self-determination, gains its importance through the fact that vulnerabilities are different in different localities. Each community often knows best what the local problems are and what might be effective coping strategies. So, the community should be able to decide on measures taken, not some higher governance level (Jordan et al., 2018).

The elements of participation and voice are necessary to map and treat vulnerabilities (Schlosberg, 2012). At times, local problems are not known on a higher level. Not all local values can be captured in economic terms or some other scale that then might be used to make policy decisions (Adger et al., 2011). These issues of invisibility and of incommensurability are only solvable through participation and voice. This means constructing institutions that ensure inclusion of relevant actors in political decisions and providing opportunities for articulating views and suggestions (ibid.). Inclusive decision making is integral to successful adaption (Intergovernmental Panel on Climate Change, 2022).

Transparency matches finely with adaptation in a polycentric system. One of the virtues of polycentric systems is mutual learning between jurisdictions. This applies particularly to adaptation. There is no precedent for adapting to such large-scale changes in climate patterns as are and will be occurring. Therefore, it can be regarded (and instrumentalized) as an advantage that many regions are simultaneously

adapting and can learn lessons from the efforts of others. This increases resilience in comparison to a monocentric system where only one solution is implemented at a time.

Adaptation policy is flexible, even in the short run. This is suitable for a context of great uncertainty concerning the exact effects of climate change and of alternative policy responses (Bernstein and Hoffmann, 2018). *Adaptation and research subsidies share advantageous characteristics: Both need no global treaty, no monocentric solution.* This is because both policies exhibit complementarities. They are unlike carbon taxation, where one country's taxation makes it less attractive for other countries to mitigate. Indeed, one country's clean research makes it more attractive for others to mitigate. As to adaptation, multiple local adaptation experiments provide valuable lessons to future adaptation projects, making them more successful. It should, though, be kept in mind that adaptation is far from being a general solution. The higher the temperature, the more difficult and ineffective adaptation becomes (Intergovernmental Panel on Climate Change, 2022).

Our argument is visualized in Fig. 2. The grey lines show how policies aiming at adaptation and directed technical change are enhanced by elements of polycentrism and procedural justice, or how they fulfill norms of procedural justice.

5. Discussion

Two qualifications should be added to the preceding elaborations. (1) We identified a conceptual system that may help climate policy makers and researchers to navigate the specific challenges of climate change. But this system does not substitute ideas of distributive climate justice or carbon-pricing-based policies, it rather aims at complementing them. (2) We comment on potential weaknesses and limitations of our approach.

- (1) Distributive injustices often root in procedural injustices (Schlosberg, 2012). Then, accepting a common frame of procedural rules might help finding an acceptable substantive and distributive outcome where one cannot directly agree to one. Procedural justice therefore complements substantive justice. Likewise, clean energy R&D follows the same object as carbon pricing, that is, emissions reduction. Furthermore, the subsidiarization of clean energy research may increase the probability that a globally harmonized carbon pricing scheme is adopted at a later point in time. This is because the availability of technical substitutes makes mitigation less costly. Take the example of the Montréal Protocol on Substances that Deplete the Ozone Layer.

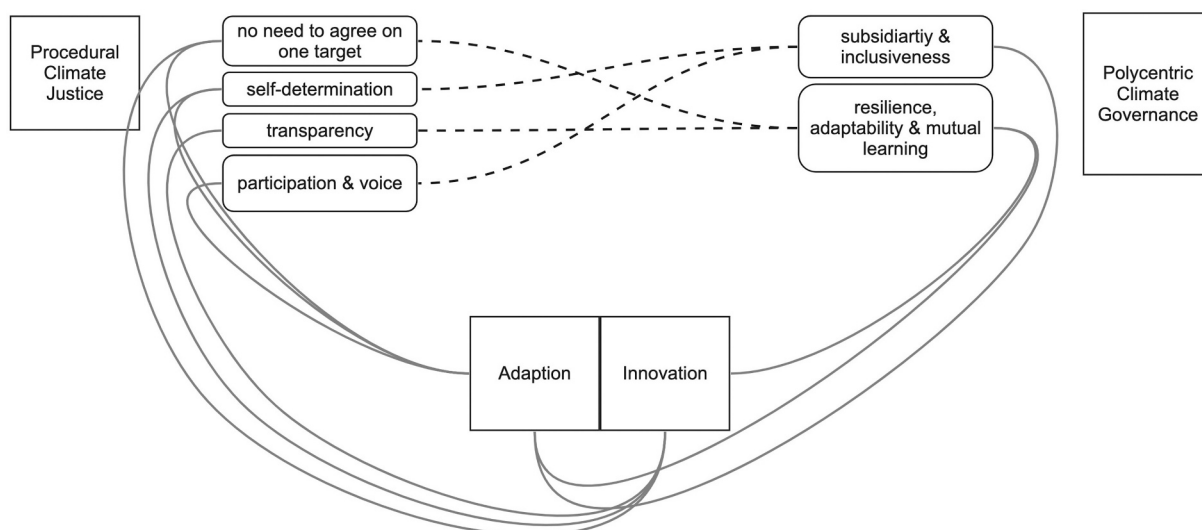


Fig. 2. Economic policy in a procedurally just polycentric climate regime. (Own illustration).

There, global coordinated action was quickly taken. This can be explained with the availability of cheap technological substitutes (Prins and Rayner, 2007b). In sum, our approach does not aim to replace top-down approaches but to complement them. Yet, we have provided reasons why our approach is likely to be a productive framework at this very moment of climate governance.

- (2) The weakness and limitation of pure procedural justice is the “possible acceptance of any type of outcome” (Grasso and Sacchi, 2015, p. 783). We cannot call all outcomes just. This is a compromise we have to make. We are practically left without a criterion for what is just, so we will call just only what has been produced under a procedurally just regime. We suggest to stop calling an outcome just if it fails to fulfill such uncontroversial substantive requirements as avoiding serious harm from future generations or “bequeath[ing] our descendants the conditions for a good life” (Hampicke, 2011, p. 51).

Our framework is not at all meant to be a comprehensive solution to climate governance. And there are reasons why our framework would not be adopted, or where it would fail to deliver on solutions to the climate crisis. E.g., polycentric systems risk redundancy or coordination failures in policy. And even following procedural justice norms may end up in obvious distributive injustices. Additionally, some actors in the global climate governance environment may reject any norms of procedural justice, e.g., because they are too costly to adopt. Hence, our framework is useful as a “thought experiment” or a frame of thought, and surely not as a panacea.

6. Conclusion

Let us recap concisely: *Positive uncertainty* and *reasonable disagreement* are key features with which climate governance must cope. There are many other challenges, of course, but these two might subsume many of them and without responding to these, climate governance will struggle to make progress. We found a procedurally just polycentric climate regime to respond well to these challenges. It is suited for a pluralistic context. And it is very adaptable and flexible, which is apt for an environment of uncertainty.

The suggested elements of procedural climate justice are: self-determination, transparency, equal participation, and voice. We showed that procedural climate justice and polycentric climate governance match well. Positive elements of polycentrism facilitate the fulfillment of normative elements of procedural justice. For example, polycentric subsidiarity facilitates self-determination, participation and voice. The normative elements in turn make the polycentric system more effective: As a case in point, transparency enhances mutual learning. We have emphasized that policy in such a system should not rely solely on fragmented carbon pricing regimes. It should focus more on bringing about a clean energy transition by subsidizing green technology R&D. The new combination of polycentrism, procedural justice, as well as adaptation and innovation policies has also been shown to respond adequately to the features of *positive uncertainty* and *reasonable disagreement*. Therefore, it can be a productive framework for inspiring climate governance, policy, and research.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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