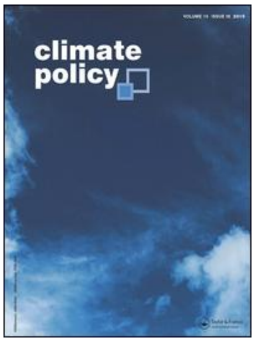

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A dual-track transition to global carbon pricing

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ABSTRACT

Unilateral climate policies have been unable to achieve intended emissions reductions. We argue that international harmonization of climate policy beyond the Paris Agreement is the only way forward and that global carbon pricing, either through a tax or market, is the best available instrument to manage this. A foundation has already been laid, as current carbon pricing initiatives cover about 20% of global CO_2 emissions. Since it limits free-riding by countries/jurisdictions, global carbon pricing is, in principle, behaviourally easier to negotiate than other instruments, such as emission targets or technical standards. To overcome political resistance, we propose a dynamic strategy consisting of two parallel tracks and five transition phases. The first track entails assembly of a carbon-pricing coalition that expands over time and exerts moral and economic pressure on non-members to join. The second track involves refocusing UN intergovernmental climate change negotiations on carbon pricing, potentially involving initially heterogeneous prices reflecting distinct income levels of countries, which then gradually converge. The dual tracks are designed to reinforce one another, increasing the likelihood of a successful outcome. The proposal results in a transition trajectory consisting of two interactive tracks and five phases, with specific attention to inequity within and among countries. We illustrate how such an approach could function with either a carbon tax or market.

Key policy insights

- International harmonization of climate policies is required to achieve the deep cuts in emissions needed to meet the Paris Agreement's 2°C or 1.5°C target.
- A focus on carbon pricing – either through taxation or emissions trading – has multiple strengths: it can be easily compared and harmonized among countries; it can be gradually strengthened over time; it moderates freeriding and fear of competitiveness losses; and it automatically generates revenues to compensate low-income households and countries.

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- Formation of a carbon-pricing coalition would enable such a group to speak with a single, powerful voice at UN climate change conferences. It would put economic and moral pressure on non-members, stimulating them to join and show a constructive attitude in ongoing UN climate change negotiations.

1. Introduction

While many regard the Paris Agreement to be a major step forwards in international climate cooperation (e.g. Kinley, 2017), others warn that it is too weak to bring about the deep decarbonization required to avoid dangerous climate change (e.g. Clémençon, 2016). Four main shortcomings have been emphasized: (1) Currently, the Nationally Determined Contributions (NDCs) do not add up to anything even close to the 2°C target, let alone the more ambitious 1.5°C target (Rogelj et al., 2016a; Schleussner et al., 2016; UNEP, 2017; Watson et al., 2019). (2) Their voluntary character allows countries to develop weak national policies that do not even meet their pledges. (3) A lack of global policy coordination has resulted in very distinct ambitions of national NDCs, allowing countries to potentially free ride on the stronger action of others. This is reflected by highly divergent implicit carbon prices (from close to zero to well above US$200/t$CO_2$, according to Aldy et al., (2016)), giving rise to a considerably higher global cost of emissions abatement than necessary. (4) Heterogeneity of national climate policies also contributes to adverse systemic effects that reduce overall emissions reduction, notably the potential for carbon leakage (Fowlie, 2009; Peters et al., 2011); and rebound of energy conservation (Brockway et al., 2017; Saunders, 2014; van den Bergh, 2011).

Weak national policies can only be definitively overcome through a global agreement that binds countries/jurisdictions to implement consistent climate policies. One way to accomplish this is by upscaling carbon pricing through international policy coordination, removing competitiveness concerns (Carbone & Rivers, 2017) that currently preclude high unilateral carbon prices and coverage of export sectors.

In view of this, we propose a strategic plan for moving towards strong climate policies worldwide, achieved through policy harmonization by way of carbon pricing. This involves two mutually reinforcing tracks along multiple phases: (1) founding a ‘carbon-pricing coalition’ among the most ambitious nations to implement a uniform carbon price, as either a carbon tax (Nordhaus, 2015) or emissions trading through carbon markets (Keohane et al., 2017); and (2) reorienting UN intergovernmental climate change negotiations (referred to hereafter as ‘UNFCCC negotiations’) to a focus on global carbon pricing. The guiding principle behind the multiphase structure is that, if one cannot reach a political goal immediately, a gradual, step-wise procedure should be tried out (Kern & Rogge, 2018; Koreh et al., 2019). The focus on carbon pricing is motivated by the fact that it is already applied in many countries (Haites, 2018), is an effective but not overly invasive instrument for emissions reduction (Best et al., 2020), can be easily compared and harmonized among countries/jurisdictions, can be gradually strengthened over time, potentially improves negotiation outcomes by moderating free-riding and fear of competitiveness losses, and automatically generates revenues, which can be used for multiple purposes, including compensation of low-income households and countries (see Table A1 in the Appendix for a more complete list of strengths and additional references).

The intention is that the proposed carbon-pricing coalition would create economic, moral and political pressure on non-members to join the coalition. In addition, the coalition could speak with one powerful voice at climate conferences so as to redirect these negotiations towards a global carbon price. The resulting harmonization of national policies would level the playing field, in turn allowing countries to escape the limits of unilaterality and, in coordination with others, strengthen their climate policies. The dual, parallel tracks would define a transition trajectory along which the international community could gradually overcome political obstacles and achieve globally consistent and high carbon prices, promoting effective and affordable emissions reduction. This is visually illustrated in Figure 1. The details of the proposal are elaborated in subsequent sections, including how to overcome key political barriers at national and international scales, interactions between the first and second track, and the five distinct transition phases.

While a majority of us authors prefer a global carbon tax to a carbon market, opinions on this are divided. It is relevant to note that carbon markets are more common in current efforts to integrate carbon pricing among

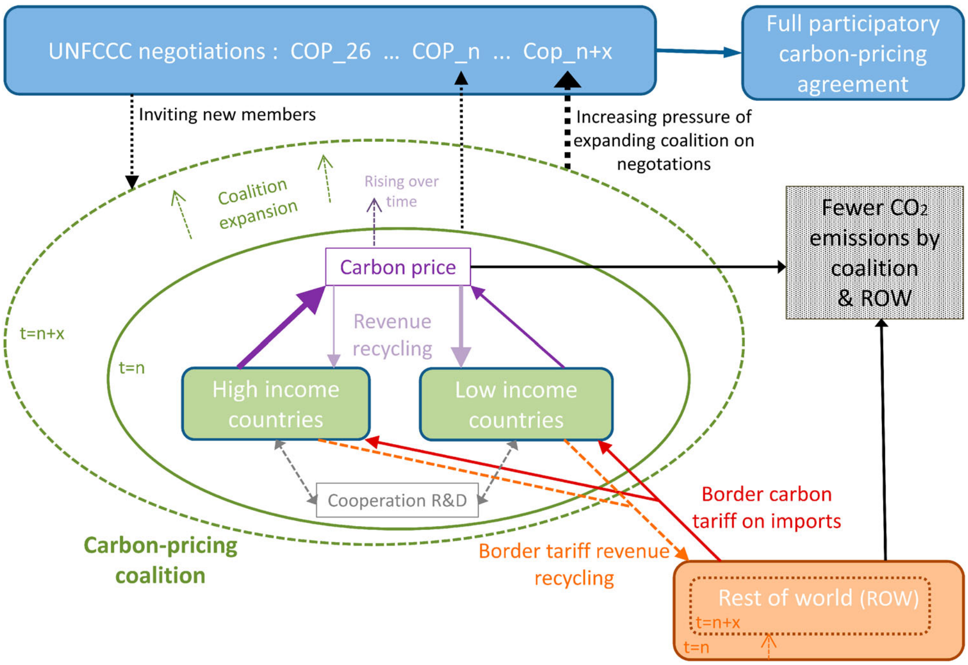

Figure 1. Parallel tracks to achieve effective climate policy in all countries.

regions (Haites, 2018). In line with this, some authors propose to aim for a global carbon market (Pollitt, 2016; Keohaneet al., 2017). In this respect, the integration of the two largest emissions trading systems in the world, namely the EU emissions trading system (EU-ETS) and China's national emissions trading system (C-ETS), would be a good and far-reaching initial step (Gulbrandsen et al., 2019; Li et al., 2019; Zeng et al., 2018). Rather than making a definite choice, we will argue that the dual-track transition can be operationalized with either a global carbon tax or a global carbon market.

2. Track I: an expanding carbon-pricing coalition

2.1. Motivation

The experience of almost three decades of UNFCCC negotiations suggests that it is very unlikely all countries would agree to open negotiations about a global carbon price. The UNFCCC parties include large and small states, importers and exporters of high-carbon goods, developed and developing countries, and fossil fuel rich and poor nations – representing a range of interests. Past climate negotiations have clearly shown the barrier role played by hesitant (e.g. Australia, China, Russia), and even unwilling countries (e.g. Saudi Arabia, USA).

One promising route towards a carbon-pricing agreement, which could overcome many political barriers, is to establish a 'carbon-pricing coalition' among countries/jurisdictions with an ambition to implement effective climate policies. This was first proposed for a carbon tax by Nordhaus (2015) and for carbon markets by Keohane et al. (2017). Both are special cases of the general idea of climate clubs[1] to frame climate deals, regardless of the policy instrument, in smaller groups (Gampfer, 2016; Victor, 2011).

2.2. Basic features of the coalition

The coalition or club would coordinate or integrate carbon taxes (Nordhaus, 2015) or markets (Keohane et al., 2017) to achieve a uniform carbon price across member states. It would cover all energy-related emissions and possibly even other sources, to ensure that few emissions escape regulation and that economy-wide emissions reduction is cost-effective. The coalition could also opt for a minimum rather than a uniform carbon price, to allow participating countries who already have a relatively high unilateral carbon price to maintain it.

The club would apply a uniform border carbon tariff (or border carbon tax/price adjustment), with a rate no higher than the carbon price, on imports of goods and raw materials from non-members. Non-members would then feel economic pressure to join the club, and possibly even moral pressure if many countries already participate, as then non-members would be perceived as free-riders. A trade adjustment of this kind would align national interests of non-members with carbon pricing since their exports would be taxed/priced in accordance with carbon content, which could encourage them to join the coalition in order to access the carbon tax or market (e.g. permit auction) revenues and other club advantages (Victor, 2015), as further discussed below. Coalition members would, under such a tariff, minimize competitive disadvantage from carbon pricing in domestic and world markets vis-à-vis competitors from countries outside the coalition (Böhringer et al., 2012). Moreover, if a coalition were to include the main mutual trade partners, a large share of exports by coalition members would be subject to the joint carbon price. Finally, to further limit competitive disadvantage, the coalition could use part of the revenues of carbon border tariffs to reimburse carbon expenses of exports from member to non-member countries through rebates to the exporting firms. Such 'full border adjustment' is an additional tool for protecting and expanding the coalition (Fischer & Fox, 2012).

History offers successful cases of coalitions expanding to a global agreement. The General Agreement on Tariffs and Trade (GATT) included 23 members at its start in 1947, and subsequently transformed into the World Trade Organization (WTO) with 164 country members (Aakre et al., 2018). International coalitions of like-minded countries have repeatedly proven their effectiveness and ability to expand in the past, such as NATO and the EU. A carbon-pricing coalition could stimulate citizens, environmental NGOs and even firms in non-member countries to lobby their government to join the coalition (Marchiori et al., 2017).

2.3. WTO legality and implementation of border carbon tariffs

Opinions differ regarding legal feasibility of border carbon tariffs under WTO-GATT rules (Brewer, 2010; Charnovitz et al., 2009; Cottier, 2009). However, Article XX in principle permits border tariffs to conserve 'natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption' (Fischer & Fox, 2012, p. 201). One way to resolve WTO legality is allowing a WTO panel to settle a dispute which would translate in a case law on a border carbon tariff by a carbon-pricing coalition (Bhagwati & Mavroidis, 2007). This would generate media and political attention, which as a beneficial side effect might stimulate international debate on how to align WTO rules with environmental/climate protection more generally.

Designing an effective border tariff is a challenge. It should account for total emissions associated, directly and indirectly, with the production of imported goods. Ideally, their carbon intensities should be estimated based on the technology applied in the foreign sectors. However, calculating emissions based on similar domestic technologies is easier and compatible with WTO rules (Rocchi et al., 2018).

To circumvent the complexity of designing carbon border tariffs in this way, Nordhaus (2015) proposed a uniform percentage tariff on all imports from non-participants, which would serve as a sanction on non-participation. His model simulations indicate that a sufficiently high tariff would provide incentives for many countries to join the coalition. However, his sanctions may have a harder time passing WTO scrutiny than carbon-specific tariffs.

One might wonder why border carbon tariffs have not been tried yet. The simple answer is that countries are understandably fearful of this, and, aside from a handful of major players such as the USA, China and the EU, few have the economic and political power to do it on their own: a coalition is needed to create a critical mass. The EU is, nonetheless, considering implementing a carbon tariff at its joint border, prompted by President Macron from France. This would serve as a litmus test of its legality under WTO rules.

2.4. Coalition expansion and stability

The larger the coalition – in terms of people, trade volume and emissions – the more attractive non-members would find it to enter. Coalition membership could be further encouraged by creating specific membership benefits, as far as allowed under WTO rules, such as mutual financial support and cooperation in trade, low-carbon innovation and science – creating positive spill-overs across members. A coalition would also allow countries to learn from each other about their institutional design or to link national regulatory systems, creating larger and thus more effective and efficient systems. California and Québec, and Switzerland and the EU, have, for example, linked their emissions trading schemes (California ARB, 2018; Federal Office for the Environment, 2019). Benefits include greater liquidity, lower volatility and higher cost-effectiveness, due to greater variation in marginal abatement options (Doda & Taschini, 2017).

To preclude trade wars and otherwise promote coalition stability, it should be signalled clearly that carbon border tariffs are motivated by climate change concerns and do not serve as a disguised protectionist measure or a source of public revenue. To this end, they could be temporarily complemented with partial or complete 'revenue recycling offsets' (van den Bergh, 2017): border tariff revenues would then be returned to non-member countries from whence the imports originated. These countries could use the returned money to assist industries in adopting low-carbon production technologies (Grubb, 2011). The offsets could function during a transition period; once the coalition reaches a critical minimal size, they could be removed to maximize the incentive for countries to join the coalition. An alternative option would be to place the revenues from border carbon tariffs into a global climate fund aimed at supporting developing countries. The literature on climate finance offers suggestions on how to operationalize this (Steckel et al., 2017).

2.5. Likely members of an initial coalition

The coalition and its goals could be promoted, and new members invited, during the annual climate change conferences. Like individual countries, a coalition could make a (joint) pledge, as well as put moral pressure on the UNFCCC negotiations to give serious attention to carbon pricing in an effort to harmonize national policies. Border carbon tariffs would likely also pressure non-members to take the negotiations more seriously. As a result, the parallel tracks might exert mutual positive feedback.

Perhaps the best starting point for a coalition would be countries that already have some form of carbon taxes or emissions trading with considerable coverage and a relatively high price (Haites, 2018). Others might be motivated to participate because of co-benefits (Edenhofer et al., 2015). An agent-based model simulation of climate clubs suggests that a coalition initiated by the EU and USA would be likely to grow to a size that reduces emissions effectively (Hovi et al., 2017). Early participation of China and Japan would then almost guarantee success. Given the rejection of the Paris Agreement by the US government, the possibility of the USA committing to an ambitious climate policy is currently very unlikely. It is noteworthy, though, that one study finds that coalitions can function even without the participation of the USA, as long as other major emitters show leadership (Sprinz et al., 2018). Participation by the USA in some form, next to the EU and China, would, nevertheless, represent an ideal starting point for a carbon-pricing climate club. A recent study proposes a multi-level climate club that can also include sub-national states, with differentiated responsibilities. Empirically elaborating this idea, it finds that 31 American states already show great ambition in climate policy, or rely heavily on international trade with Europe and China, and thus would be sensitive to club pressure through a border carbon tariff. In this way, an estimated 70% of US emissions could become part of this climate club (Martin & van den Bergh, 2019). In fact, several north-eastern states in the USA already participate in the Regional Greenhouse Gas Initiative (https://www.rggi.org), suggesting they might be interested to join a multi-level coalition.

3. Track II: challenges and opportunities for UNFCCC negotiations

3.1. Integrating the carbon-pricing coalition in the UNFCCC

Building a carbon-pricing coalition does not mean that the UNFCCC process becomes useless for mitigation policy negotiations. On the contrary, these can be positively influenced by a successful coalition (Falkner, 2016). Coalition members could share their experiences with carbon pricing, and provide arguments and data to encourage non-member countries/jurisdictions to join.

A carbon-pricing coalition matches the current UNFCCC approach, which formally recognizes that countries participate in specific coalitions to achieve bargaining power; e.g. the Umbrella group, Alliance of Small Island States, and Group of 77 (UNFCCC, 2019). Article 6.2 of the Paris Agreement also welcomes 'cooperative approaches'. Hence, the proposed carbon-pricing coalition could represent the objective of implementing harmonized, effective policies and facilitate consensus formation on matters relating to carbon pricing (Weischer et al., 2012). Further negotiations could, moreover, integrate it into possible future trading mechanisms within the UNFCCC framework, as is currently being negotiated under Article 6.4.

3.2. Negotiating a carbon price

Negotiating a carbon price is likely to be easier than reaching agreements on climate technology standards or very ambitious country-specific targets. Countries try to weaken standards for sectors important to their economy, such as emission norms for cars. A focus on binding national quotas motivates countries to seek stronger commitments from others than from themselves. In contrast, when negotiating a unique global carbon tax or carbon market, countries would know that a strong policy in the form of a carbon price would equally apply to all sectors and all other countries. This would then reduce the incentive to free ride, making it possible to achieve a reasonably high carbon price (Cramton et al., 2015).

As already discussed above, supra-regional and supra-national carbon markets already exist, while academics have put forward options for integrating the two largest markets, the EU-ETS and C-ETS. One should not, therefore, consider the negotiation of a global carbon market as an impossible task. In addition, negotiating a global carbon price is, in theory, simpler than negotiating global non-pricing climate policies as it comes down to a one-dimensional negotiation challenge (Weitzman, 2014, 2017). On the contrary, aiming for national quantity emission targets among some 190+ countries means dealing with a much larger dimensional coordination problem. It is therefore surprising that the carbon-price approach has not been seriously and persistently explored, leaving us instead with the voluntary approach of the Paris Agreement. Negotiating technical standards implies an even more difficult n-dimensional challenge with n denoting the huge number of carbon-intensive technologies in the world. Moreover, if not all n technologies were part of the agreement, market distortions and rebound would result, hampering its effectiveness. In addition, technology standards would be prone to lobbying and resistance from sectors and countries most affected, and need continuous updating and hence renegotiation to account for technological change.

Consistent carbon pricing in all countries would also make it easier to compare the stringency of policies in different countries, which is currently almost impossible, given the complicated and often unclear mix of instruments in climate policy. Dominance of carbon pricing would therefore improve transparency, in turn allaying governmental fears that strong domestic climate policy would harm national industrial competitiveness and exports.

3.3. Intermediate steps

Despite all the advantages, it is unlikely that an international carbon price will soon get full support at UNFCCC negotiations. Suppliers of fossil fuels, such as Saudi Arabia and Russia, are expected to strongly resist. Therefore, parallel to the first track of a carbon-pricing coalition, the UN could consider the option of an incomplete-participation sub-agreement to the Paris Agreement, as a politically more feasible intermediate step. Sub-agreements among the most ambitious countries under the UNFCCC umbrella could create pressure on other countries to join. The difference with a carbon-pricing coalition as discussed in Section 2 is that the UN umbrella could send a stronger signal to non-participants to join. For this reason, an external coalition might over time be transformed into a UN sub-agreement.

Another potential intermediate step, if political resistance remains strong, is temporarily settling for a heterogeneous set of carbon prices adapted to the income level of countries (Bataille et al., 2018). This would recognize global inequity as a barrier to striking an effective climate agreement. Different carbon taxes could converge over time, depending on, e.g. economic growth in poorer countries or a rise in international climate transfers from donor countries. Alternatively, if a carbon market is adopted, poorer nations could receive extra permits as a form of compensation during some period. Such second-best transition scenarios would sacrifice some effectiveness and efficiency for the sake of political feasibility. The effectiveness loss might be limited as low income countries tend to have cheaper emission reduction options, and behavioural responses may be relatively strong already for low price signals. To maximize effectiveness and minimize carbon leakage, however, this transition phase should apply temporarily and evolve into a uniform carbon price along with compensation for low-income countries out of generated revenues (Section 3.5).

As a first step, negotiators might garner broad support for carrying out an experiment during a few years with a uniform carbon price among willing countries. This can then subsequently be evaluated and adjusted. Opposition from some countries against carbon pricing is likely to diminish once it is shown to work effectively and with limited economic impairment.

3.4. Carbon price level and dynamics

Finally, with regard to the level of ambition, if opting for a carbon tax, a carbon-pricing schedule could start with a global carbon price that is at least as high as the minimum of the carbon taxes or carbon market prices in the member economies. The starting price could then be increased regularly with an announced amount (e.g. US $5–10 every year), until emissions reduction conforms to a plausible pathway to the 1.5 or 2°C temperature target. The Swiss CO_2 Law, for example, has implemented this type of design, in which the carbon price is automatically revised if the emission targets are not reached. A gradually rising schedule gives investors time to anticipate long term decisions. The 2017 Report of the High-Level Commission on Carbon Prices suggests the carbon price needed to reach the Paris Agreement goals to be in the US$40–80 range in 2020, rising to US$50–100 by 2030 (HLCCP, 2017; IMF, 2019 proposes similar ranges). Other reference points can be derived from studies estimating the social cost of carbon, indicating a lower bound of US$125/t$CO_2$ (van den Bergh & Botzen, 2014). A study by Dietz and Venmans (2019) recommends starting with a global carbon price of $44/t$CO_2$ and gradually increasing it over time with initially 3% a year.

When opting for a global carbon market, the carbon budget consistent with the accepted climate target should be the guide.[2] Starting with a lax global cap, e.g. implying a carbon budget broadly consistent with an increase in global temperature of 3°C above pre-industrial levels, the cap would then be gradually tightened over time to one consistent with 2 or even 1.5°C warming, resulting in a rising price schedule as well. Finally, while changing political winds may make it difficult for individual countries to stay on a rising-tax or tightening-cap schedule, this may become easier once they have committed to a common carbon tax or market, along with a temporal adjustment schedule, through a coalition or global agreement.

3.5. Equity concerns

If carbon pricing is well designed, it can be one of the most equitable instruments of climate policy (Klenert et al., 2018). This should provide another motivation for redirecting UNFCCC negotiations towards this instrument. Contrary to other regulatory instruments like quotas or technology standards, carbon pricing generates revenues that permit compensation for inequitable consequences of the policy. This holds true not only for carbon taxation, but also for emissions trading, as revenues can be raised by selling or auctioning permits. Experience with carbon pricing in British Columbia shows that redistribution of revenues can also enhance public support (Murray & Rivers, 2015). The broader literature on equity perceptions underlying public support for carbon pricing confirms this (Carattini et al., 2017, 2018, 2019; Maestre-Andrés et al., 2019).

Regarding inequitable effects of climate policy at an international level, international redistribution of revenues from a global carbon price is desirable. One study finds that a global tax of US$30/t$CO_2$ would generate revenues of about US$1 trillion, roughly 1% of Gross World Product (GWP), while another estimates revenues of carbon taxation to be as high as 6% of GWP (Davies et al., 2014; IEA, 2017). Hence, carbon pricing can potentially deliver large funds for reducing inequality and energy poverty. In practical terms, the revenues of a global carbon tax or market (permit sales) could be collected by an international organization, such as the IMF, and redistributed according to an agreed rule among individual countries, while accounting for inequity compensation. In the case of a carbon market, the initial permit distribution could be negotiated so as to account for inequity; contrary to a carbon tax, revenues to reduce inequities are not automatically collected, unless the

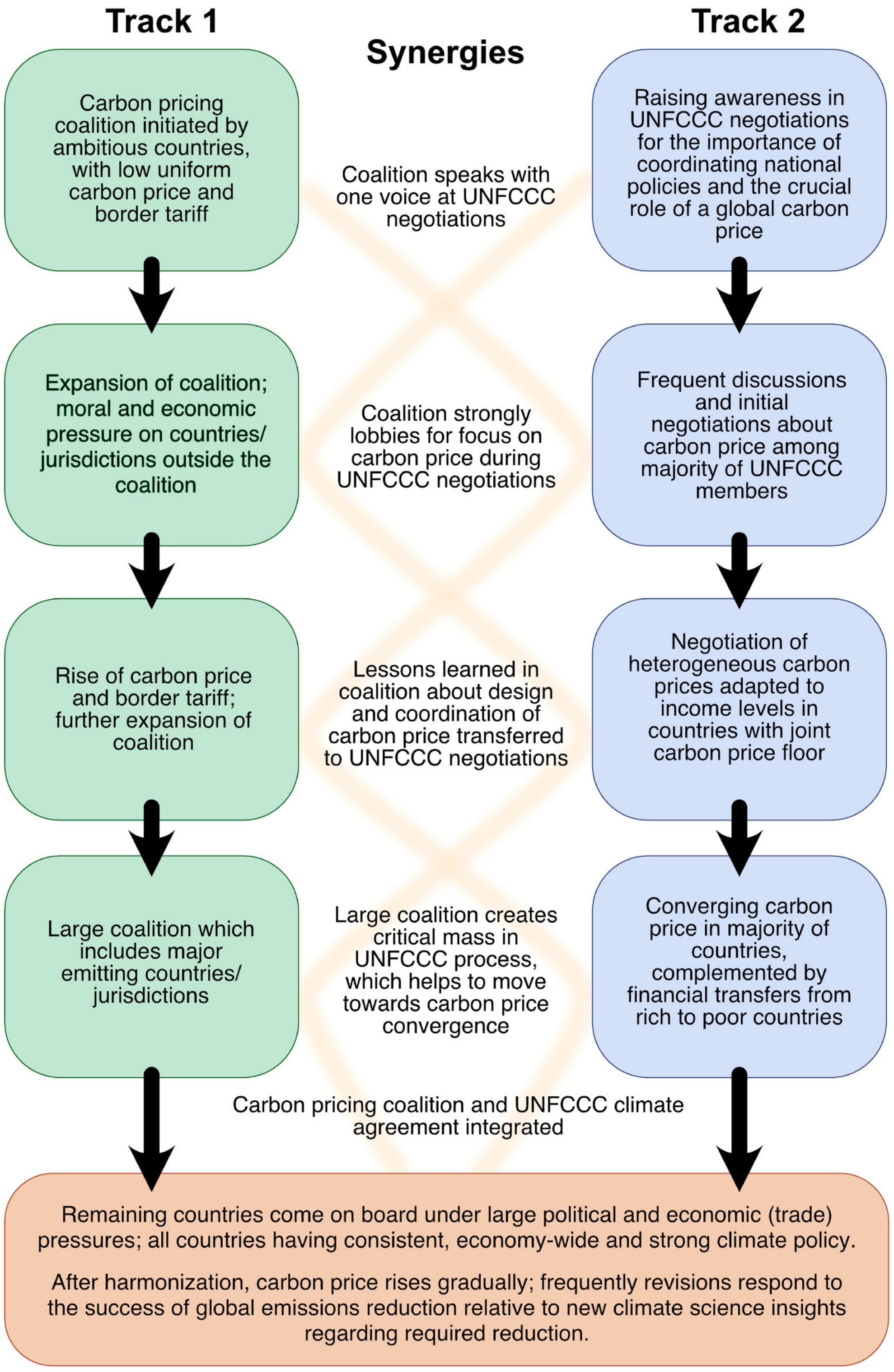

Figure 2. A dual-track transition to global carbon pricing.

permits or part of them are sold. While we admit that this will not be easy, one should realize that a similar distributional equity challenge is faced by any climate policy that pretends to be globally feasible and effective.

In judging distributional effects of carbon pricing, one should recognize that other policy instruments can have considerable inequitable consequences. Technical standards make products more expensive for all consumers, and relatively more so for low income groups. Untargeted subsidies for solar PV result in a transfer of income from society to relatively well-off home-owners (Allan and McIntyre, 2017; Borenstein, 2017). Similarly, adoption subsidies for wind energy favour landowners holding large parcels of land suitable for wind turbines. Subsidizing the purchase of electric vehicles disproportionately benefits well-off households. Unlike carbon pricing, these policy instruments do not generate revenues to compensate for their inequitable impacts. This does not deny that there are good reasons to combine such other instruments with carbon pricing into a more complete policy package (van den Bergh et al., 2020).

4. Interactions between the two tracks over five phases

Combining the two tracks – a carbon-pricing coalition and a refocusing of UNFCCC negotiations onto carbon pricing – gives rise to a dual-track transition to global carbon pricing as illustrated in Figure 2. Based on the suggestions made in Sections 2 and 3, this transition is conceptualized as consisting of five main phases, expressing its gradual character to overcome political barriers. In the ultimate phase, the two tracks are integrated into a global agreement on a uniform carbon price. The figure highlights the actions that need to be taken in the various phases for each track as well as their interactions. Note that carbon pricing would initially be negotiated in the coalition, then at some point would enter the UNFCCC context, and finally the two would be fully integrated through a complete global agreement on carbon-pricing.

It is likely that carbon pricing will, in many countries, substitute for existing energy and fuel taxes. As the effective or nominal tax on energy may not alter much, one should consider this as an inevitable and positive development, for two reasons. First, the carbon price achieves greater fine-tuning in terms of emissions reduction than energy/fuel taxes, and hence is more effective in reducing emissions. Second, this substitution would simplify the complex policy mix, translating into more international transparency about effective carbon prices (OECD, 2018). This, in turn, would facilitate harmonization of nominal carbon prices and increased stringency of national climate policies. In addition, finance ministers would no doubt appreciate the reliable nature of carbon tax revenues (Franks et al., 2015) which can be used for many purposes (Carl & Fedor, 2016; Klenert et al., 2018; Postic & Métivier, 2019); moreover carbon tax evasion is difficult since the tax basis, fossil fuel consumption, is easily monitored.

5. Conclusions

We have argued that carbon pricing offers our best chance to achieve global policy coordination, which is required to strengthen climate policy and effectively confront climate change. Negotiating global carbon pricing is very likely to prove politically easier than negotiating binding country-level targets – and more so if it includes equitable revenue recycling. However, heterogeneous national interests make a full-participatory agreement unlikely in the short run.

To overcome political barriers, we have proposed to advance on two parallel tracks: countries with the most ambitious climate goals and policies initiate a carbon-pricing coalition, while a reorientation of UNFCCC negotiations creates room for talking seriously about a global carbon price schedule, including redistribution-of-revenues rules. As the UNFCCC negotiations increase interest in the coalition, membership grows over time, placing further pressure on the UNFCCC negotiations to focus seriously on carbon pricing. Whereas each track on its own may be unlikely to achieve the end goal of global carbon pricing, their synergies greatly increase the chance of establishing this essential pillar of climate policy.

Notes

1. Theoretical and experimental studies provide arguments and evidence that a club structure increases average contributions to public goods (Cornes and Sandler, 1996; Swope, 2002).
2. While noting that the calculation of carbon budgets involves many uncertainties and is subject to debate (Rogelj et al., 2016b).

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Appendix

Table A1. Main reasons for adopting carbon pricing as the core instrument of climate policy

(1) Carbon pricing assures that all economic agents internalize climate change externalities in their decisions. A single carbon price will consistently modify uncountable decisions by consumers, producers, investors and innovators. This will quickly and effectively alter the composition of market-based consumption and production, the main sources of CO_2 emissions, from high- to low-carbon goods and services.
(2) Carbon pricing will steer the direction of innovations towards low-carbon production life cycles and low carbon technologies in transport, electricity generation and household consumption. This will further enhance a low-carbon economy in the medium to long run.
(3) Implementation is simple: rather than levying hard-to-monitor CO_2 emissions, fossil fuel inputs are levied in relation to their carbon content as this translates proportionally, through their combustion, to CO_2 emissions. Pricing needs to be applied only where fossil fuels – whether coal, oil or gas – are taken out of the ground or imported from a country that does not charge a carbon price. In this way, only a moderate number of firms need to be regulated and controlled.
(4) The systemic nature of global carbon pricing, i.e. its ability to cover the entire economic system, guarantees maximum effectiveness of emissions reduction as it avoids excessive leakage and rebound. In addition, it contributes to a gradual and smooth transition to a low-carbon economy.
(5) Since carbon pricing accounts for heterogeneity of abatement opportunities and costs among polluters, it further minimizes society's overall cost of pollution control. In addition, carbon pricing is a form of decentralized public policy, implying low information needs and costs for governments.
(6) Carbon pricing does not rely on environmental consciousness or altruism of consumers and firms as price incentives automatically steer them towards low-carbon options.
(7) Cost-accounting by firms assures that the cost of carbon is straightforwardly included in the price of intermediate and final goods and services and passed on through existing markets, from firm to firm and to final consumers. Hence, no additional, separate carbon accounting system is required.
(8) Carbon pricing offers a uniquely flexible device to keep emission reductions in tune with advances in natural climate sciences, namely through adaptation of the level of a carbon tax or of an emissions cap in a carbon market.
(9) Carbon pricing – notably a carbon tax but also selling or auctioning emission permits – generates revenues that can be redistributed, within or between countries, to compensate for any inequitable impacts.
(10) A carbon price can be globally up-scaled relatively easily to overcome competitive concerns, permitting more stringent price levels. In addition, unlike other instruments such as national emission targets or technological standards, it reduces free-riding in climate negotiations.

Sources: Aldy et al. (2010), Nordhaus (2010), Tirole (2012), Cramton et al. (2017) and Baranzini et al. (2017).