The Optimal Design of Climate Agreements

Inequality, Trade and Incentives for Climate Policy

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Thomas Bourany*

The University of Chicago

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Abstract

Fighting climate change requires ambitious global policies, which are undermined by free-riding incentives. Multilateral agreements and trade policies are usually proposed to address this issue, c.f. Nordhaus (2015). Moreover, climate policy has strong redistributive effects across countries due to inequality in income, climate impacts, effects on energy markets, and trade leakage, which exacerbate non-cooperation. In this context, how can we design a climate agreement that accounts for all these different channels to fight climate change? Through the lens of an Integrated Assessment Model (IAM) with heterogeneous countries and international trade, I study the "climate club" design to maximize world's welfare, choosing carbon and trade policies when countries can exit climate agreements. Participation constraints create a policy tradeoff between an intensive margin – a climate club with few countries implementing large emission reductions – and an extensive margin – accommodating a larger number of countries at the cost of lowering the carbon tax. I solve for the optimal climate club, which consists of all the countries at the exception of Russia, where the members impose a \$100 tax per ton of CO_2 and a 50% tariff on goods from non-members. Despite full discretion in the choice of carbon tax and tariffs, one cannot achieve the world's optimal policy, \$150 tax/ton CO_2, with complete participation. The tax is reduced to encourage participation but lowering it to include Russia would compromise climate action. I explore how additional instruments, such as transfers, as proposed in the COP's "loss-and-damage fund", or fossil-fuel specific tariffs, can increase abatement and welfare by mitigating the adverse redistributive effects of climate change and carbon taxation.

*Thomas Bourany, *thomasbourany@uchicago.edu*. I thank my advisors Mikhail Golosov, Esteban Rossi-Hansberg, Lars Hansen and Michael Greenstone for valuable guidance and advice. I also thank Jordan Rosenthal-Kay, Tom Hierons, Aditya Bhandari and other seminar participants at UChicago and Booth for stimulating discussions. All errors are mine.

1 Introduction

Fighting climate change requires ambitious global policies. Carbon emissions must reach net zero in the next decades, and our economies need to phase out fossil fuels in a concerted effort to keep temperature under $2°C$ and avoid catastrophic consequences of global warming c.f. IPCC et al. (2022). However, we are currently facing climate inaction, and the main reason behind this lack of cooperation is the presence of free-riding in climate policy. The benefits of fighting climate change are global while the costs of reducing emissions, in particular with carbon taxation, are local. Individual countries have incentives to free-ride on the rest of the world's reduction in emissions without implementing costly carbon abatement themselves.

Moreover, taxation of carbon and fossil fuels have strong redistributive effects, changing the willingness of countries to implement climate policy. First, emerging economies may face challenges in reducing fossil fuel consumption necessary to continue their economic development. Second, carbon taxation has substantial impacts on energy markets, between of fossil fuels exporters and importers. Finally, imposing a carbon tax in one country reallocates economic activity, and carbon emissions, toward other countries through international trade – known as the "carbon leakage". All these effects reinforce free-riding incentives and climate inactions.

Multilateral climate agreements have been the traditional answer to address climate inaction, as the United Nations Conference of the Parties (COP) for example. More recently, trade instruments have been the focus of policy discussions as trade policy offers the potential to give incentives to other countries to reduce emissions. In particular, Nordhaus (2015) proposes the idea of "climate club", which are voluntary agreements where members implement carbon taxation as well as retaliatory tariffs on countries that do not participate in the club. In this context, trade sanctions are necessary to foster participation to a club and reduce free-riding incentives.[1]

In this context, what should be the design of a climate agreement that accounts for free-riding incentives as well as redistributive effects? What is the optimal climate club? This paper addresses this question by examining the conditions necessary to construct a universal climate agreement with globally optimal carbon tax and tariffs. I explore which factors incentivize countries to join such an agreement, and I investigate how carbon and trade policy needs to be implemented to promote participation, maximize welfare and fight climate change.

In this project, I tackle these policy questions in a Climate-Economy framework augmented with heterogeneous countries and international trade. I build a multi-country Integrated Assessment Model (IAM), extended with trade in goods à la Armington and energy markets in fossil fuels. Individual countries differ in their vulnerability to climate change, income levels, energy mix as well as their positions as exporters or importers of goods and energy. In this framework, I account

[1] Another notable example is the European Union's Carbon Border Adjustment Mechanism (CBAM) which is proposed to address the climate leakage. This policy is a "carbon tariff" – i.e. a tariff whose rate increases with the carbon content of the good imported. This also has the potential to generate incentives for trade partners to implement climate policy in order to lower the carbon footprint of their exports.

for the multifaceted redistribution and leakage effects that arise in general equilibrium as a result of climate policy. This serves as a laboratory for evaluating the welfare effects of different agreement designs.

With endogenous participation, countries have differing incentives to join a climate agreement. As a result, the decisions on the optimal levels of carbon tax and trade tariffs, as well as the choice of participants in the club should be made jointly. Indeed, the optimal design reveals a tradeoff between an intensive and an extensive margin. At the intensive margin, an agreement could gather a small set of countries, which can individually implement large emissions reductions with high carbon taxes. However, this may be hardly satisfying to reduce global emissions and combat climate change effectively. In contrast, building a more extensive climate club requires to accommodate the participation of a larger number of countries, which can only be done at the cost of lowering the carbon tax.

In this context, I address the policy problem where a global social planner maximizes the world's welfare by designing a climate agreement that consists of three elements: (1) the set of countries that are included in the agreement – also called "climate club" or "climate coalition" – and that are subject to the climate and trade policies, (2) the level of the carbon tax that club members set on their oil, gas and coal energy consumption and (3) the level of the trade tariffs that the members impose on the goods imported from non-member countries – either uniform tariffs as in Nordhaus (2015) or carbon-border adjustment mechanisms (CBAM) as proposed in the European Union.

Countries make an individual choice to join or leave the agreement, and such strategic participation needs to be accounted for in the design of the agreement. I consider Nash equilibria where countries take participation decisions either unilaterally, or with "coalition deviations", i.e. when a subset of countries decide jointly to deviate and leave the agreement. The policy thus mirrors an optimal taxation and trade policy problem with limited instruments, assorted with a choice of countries. Given policy instruments, the coalition choice resembles a combinatorial discrete choice problem (CDCP) that can arise in trade economics. I propose different numerical solution methods to tackle this problem in presence of participation constraints.

I contrast this framework with global policy benchmarks absent endogenous participation. First, I consider the optimal carbon policy when the coalition gathers the entire world, without participation constraints. I show that the choice of the carbon tax depends crucially on the availability of redistribution instruments in the First-Best allocation. Without such instruments, such as lump-sum transfers, I show how the choice of the carbon tax accounts for distributional motives. Indeed, the carbon tax accounts for income inequality and its effect on trade leakage, as well as demand distortions and supply redistributions through fossil fuels energy markets. As a result, the optimal carbon tax is \$150 per ton of CO_2, and is lower than the Social Cost of Carbon, i.e. the marginal cost of climate change, a result that contrast with the standard Pigouvian recommendation.[2]. Second, I also compare the "climate club" framework to the non-cooperative Nash equilibrium, in which each individual countries choose their "unilaterally optimal" carbon taxation and trade tariffs. The unilateral carbon tax policy becomes a subsidy to increase production and revenues and tariffs are used for terms-of-trade manipulation.

In comparison, climate agreements provide an "issue linkage", c.f. Maggi (2016) by coupling the implementation of climate policy with a reduction in tariffs, as there would be free trade among coalition members. We see that the countries' participation choice depends on the balance between two effects: the distortionary cost of carbon tax against the cost of tariffs, which is related to gains from trade. To choose whether to exit the agreement, individual countries consider if the first outweighs the second. This is the case for fossil-fuel producers or several developing economies. Consequently, they would not participate in a climate agreement unless the carbon tax is decreased.

As a result, the optimal climate club consists of all countries at the exception of Russia and the agreement imposes a moderate carbon tax of \$100 per ton of CO_2, and a 50% tariff on traded goods of non-participants. The optimal climate agreement cannot achieve the world's optimal policy with complete participation – an agreement with a \$150 carbon tax and all the countries – despite full discretion on the choice of the carbon tax and tariffs.

First, to increase participation, it is beneficial to reduce the carbon tax. Several Middle Eastern countries, and several developing economies in South-Asia and Africa would not join an agreement with high carbon tax, and this for any tariffs. It is therefore optimal to lower the tax by 35% to include those countries, and share the "burden" of carbon abatement across more countries.

Second, it is beneficial to leave several fossil fuels producing like Russia and former soviet countries outside of the climate agreement. Indeed, they suffer large welfare costs from carbon taxation, being relatively cold, closed and exporters of oil and gas. They would never join an agreement, unless the carbon tax would be very small, which is not optimal from a global perspective.

Third, trade policy is a key strategic instrument to undermine free-riding and incentivize countries to join the agreement. All the countries for which the cost of large tariffs outweighs the distortionary cost of carbon taxation are willing to participate in such climate club. That is especially the case for countries in Europe, East Asia and South-East Asia, like China, which trade internationally a large share of goods production, and have hence large gains from trade. Absent tariff retaliation, free-riding prevails over the cost of climate actions, as discussed in Nordhaus (2015). However, if moderate tariffs spur participation for low carbon tax, this incentive effect vanishes quickly as the carbon tax increases and larger emissions reduction are required. The gains from trade are bounded – and small for some countries like Middle-East and Russia – and therefore, there is a limit to what carbon policy can be achieved.

[2]The optimal policy problem with limited instrument is treated extensively in Bourany (2024) in a large class of climate-macroeconomic models. In the present paper, I draw a particular emphasis on international trade and leakage effects, a novel channel that needs to be accounted for in optimal carbon taxation.

Additional policy instruments – such as transfers with a "loss and damage" fund, or fossil-fuel-specific tariffs – improve the climate agreements and increase the carbon tax closer to the second-Best allocation. Indeed, these two instruments addresses two channels to incentivize participation. First, redistributing part of revenues from the carbon tax to poorer economies like South-Asia and Africa – who consume less fossil fuel per capita – improve their welfare much more than the loss incurred by the richer economies of North America, Europe and East-Asia. Second, fossil-fuel-specific tariffs have strong effects on the energy rents of oil-exporting countries. This increases the retaliatory power of the climate club and is more influential to promote participation.

Lastly, I compare how these results on the optimal agreement can change depending on the impact of climate change or the gains from trade. First, I change the damage function and follow the specification of Weitzman (2009), which features larger curvature in temperature warming. This raises the cost of climate change, especially for very warm countries, increases the optimal carbon tax, but also amplifies free-riding incentives. Second, I change elasticity of substitution across goods, which decreases the gains from trade. This reinforces the trade leakage effects and dampens the power of trade instruments as a policy channel for participation. Both reasons lower the optimal carbon tax that can be achieved with an agreement. In this context, additional instruments like transfers or fossil-fuel-specific tariffs are particularly important to broaden participation.

Literature

This works relates to a large literature on the economics of climate change and bridges a gap with both the international trade policy and the game theoretical literature. First, I contribute to the debate on the formation of Climate Club, following the pioneering contribution of Nordhaus (2015). The implementation of climate policy suffers from a free-riding problem and Nordhaus proposed a simple framework to evaluate the principle of issue linkage, i.e. linking the enforcement of a climate policy with trade tariffs. He shows with the C-DICE model that for different – exogenously set – carbon prices and tariffs rates, we can achieve varying participation to a climate club. With low carbon price – up to $25\$/tCO_2$ – and high tariffs – above 10%, the climate club can achieve a club with all the 15 regions he considers.

I depart from Nordhaus' Climate Club framework in three directions. First, I show that when a Social Planner chooses endogenously and optimally both the carbon tax, the tariffs and the club members, we observe an intensive margin - extensive margin tradeoff. Lower tax and higher tariffs increase participation, and conversely. Second, I depart from the C-DICE model that use ad-hoc functions for the carbon abatement – inspired from DICE – and the gain from trade and costs of tariffs – a quadratic approximation of the results of Ossa (2014). I show that modeling the energy market – both with heterogeneity in demand and supply of fossil energy – and trade in goods, accounting for leakage effects and terms-of-trade manipulation, highlight the tradeoff between the cost of carbon taxation and the cost of tariffs. In particular, in this micro-funded setting, gains from trade are bounded, which makes some countries unwilling to join an agreement, if the loss from phasing out fossil fuels is too large, and this *for any tariffs*. Third, I model the cost of climate on production as endogenous to policy, which makes the optimal carbon tax account for redistributive effects through income inequality, trade leakage and energy markets.

Farrokhi and Lashkaripour (2024) also study how climate policy can be conducted with trade instruments. They solve for the optimal trade policy in a rich multi-industry trade model, inspired by Copeland and Taylor (2004), and show that unilateral policy accounts for carbon leakage when setting tariffs. In this setting, they explore the sequential construction of a climate club, where European Union starts a coalition, implements the unilaterally optimal trade-climate policy and iteratively grows the participation to the club. In contrast, I show how should the club *design* the trade-climate policy *strategically* to spur participation. My framework also incorporates several redistribution channels absent from their framework, related to non-linear damage, making the cost of climate change endogenous to policy, or inequality across countries that create differences between policies maximizing output, reducing emissions and improving welfare.

This project lies at the intersection of three literatures, one on trade policy, one the game-theoretical aspects of climate policy cooperation, and one macroeconomic models of climate change,

First, the interdependence between climate, environmental and trade policies is explored extensively in Kortum and Weisbach (2021), Barrett (2001), Bohringer et al. (2016), Bohringer et al. (2012) or Hsiao (2022).These articles explore the differences between unilateral policies implemented at the country level and the potential for climate cooperation using trade policies. Other articles in this trade literature explore the underpinnings of optimal trade policies, e.g. Costinot et al. (2015), Ossa (2014), Adao et al. (2023), Antras et al. (2024), more specifically the choice of trade tariffs for different objectives, like terms of trade manipulation for example. I show how these policy instruments can be used for issue linkage and climate policy.

Moreover, I also borrow from the theoretical literature on climate cooperation, with classical references such as Barrett (1994), Harstad (2012), Barrett (2003), Barrett (2013), Nordhaus (2015) or the older literature collected in Batabyal (2000) or summarized in Maggi (2016). There is also a large literature on dynamic games and coalition formation games, that focus on the building of agreements, either through coordination games or through bargaining procedures, or summarized in Ray and Vohra (2015), or Okada (2023) more recently. Iverson (2024) and Hagen and Schneider (2021) are more recent references in static settings, exploring the stability result and the set of supportable climate coalitions with different feature of climate clubs, where trade policies are crucial. Similarly, Nordhaus (2021), Harstad (2023), or Maggi and Staiger (2022) study those questions as well as other dynamic features, such as technical change, the path of climate dynamics or intertemporal decision-making. I draw inspiration from many of these references. I allow the trade framework I study to be extended to dynamic settings, and I explore the dynamic implications of climate agreement in the near future.

Third, I also draw heavily on a more quantitative literature on the macroeconomic implications of climate change and carbon policy. Indeed, in the continuity of Bourany (2024), I show that the optimal carbon policy should account several general equilibrium channels, as well as macroeconomic dynamics – in the spirit of IAMs. Starting from a static version of the classical DICE/RICE models, c.f. Nordhaus and Yang (1996), Barrage and Nordhaus (2024), I study an extension with optimal fossil fuel taxation, as in Golosov et al. (2014) and with heterogeneous countries/regions, c.f. Krusell and Smith (2022), Cruz and Rossi-Hansberg (2024, 2022), Kotlikoff, Kubler, Polbin, Sachs and Scheidegger (2021), Kotlikoff, Kubler, Polbin and Scheidegger (2021).

When the policy instruments are limited – as in our setting we only consider one uniform level of carbon and penalty tariffs against non-members and no transfer instruments – we need to change endogenously the choice of these instruments, like Hassler et al. (2021), Belfiori et al. (2024), or Douenne et al. (2023), in the case of climate policy, Davila and Walther (2022) or Chari et al. (2023) in more general cases. This follows a large literature on optimal policy in heterogeneous agents models, c.f. Bhandari et al. (2021*a*,*b*), Le Grand et al. (2024) or Davila and Schaab (2023) among many others.

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