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# Climate and international trade policies when emissions affect production possibilities

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ABSTRACT

In this paper, we develop a model of international trade and climate change in which emission discharges arising from production have a feedback effect on national production sectors by impacting upon effective factor endowments. With this context, the objectives are, first, to provide a general characterization of Pareto-efficient climate and trade policies and, second, to examine the possibility – starting from non-Pareto-efficient equilibria – for Pareto-improving environmental policies. We provide conditions under which several particular reforms of carbon taxes are welfare improving.



## 1. Introduction

The theoretical literature addressing the linkages between climate and trade policies (either from a cooperative or non-cooperative perspective) has predominantly paid attention to the analysis of optimal policy when emission discharges (a by-product of the production process) affect consumers' utility directly.[1] Although this is, clearly, an important perspective, it is perhaps not the most empirically compelling assumption in the context of climate change. Indeed, there is strong evidence that climate change largely impacts the planet and its biosphere in ways that ultimately impact the production sectors of countries (for example, [19,21]).[2] These production externalities, which may affect factor endowments or technology, have received relatively little attention in the literature.[3] Analyzing these externalities is important, not least because they affect the sustainability and competitiveness of environmentally sensitive industries.[4]

Accordingly, it is the objective of this paper to explore the interaction between climate and trade policies from a cooperative perspective when emissions (such as carbon dioxide) arising from production activities accumulate in the atmosphere and lead to climate change, which, in turn, adversely affects the effective factor endowments of

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[1] See, among others, Baumol and Oates [2], Markusen [17,18], Rauscher [20], Copeland [5], Copeland and Taylor [6,7], Turunen-Red and Woodland [24] and Keen and Kotsogiannis [15].

[2] Indeed, many production sectors, such as agriculture and fisheries, are highly dependent on specific climate conditions. Increases in temperature and carbon dioxide ($CO_2$) can be beneficial for some crops in some places, but changes in the frequency and severity of droughts and floods could adversely affect farming production in others. Changes in temperature are likely to cause the habitat ranges of many fish and shellfish species to shift, which could disrupt ecosystems. For a brief, but informative, discussion on these effects see http://epa.gov/climatechange/impacts-adaptation. Deschênes and Greenstone [10] and Felkner et al. [12] provide empirical analyses of the effects of climate change on South-East Asian and US agricultural production.

[3] Important earlier contributions in the international trade literature include [8,3], both of whom consider externalities through productivity effects of emissions.

[4] For an insightful discussion on these issues see Copeland and Taylor [9]. See also Aldy et al. [1], Jones et al. [14] and Chen and Woodland [4].

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countries.[5] Our focus on the impact of climate change on the world economy manifesting itself through factor endowments and their productivity requires some comment. First, as briefly discussed above, such impacts are empirically compelling and have been the subject of many studies in the climate change literature. It is therefore important to draw out the implications of this particular channel of impact of climate change for policy, which we define here to be the cooperative reform of carbon taxes. Such implications for carbon tax policy (and other issues) have been the subject of research by many others for the case where the climate change impacts are directly on the utility functions of households and by a few for the case of impacts on sectorial productivity. Our focus on factor endowments is meant to partially fill this research gap. Second, the formulae for directions of carbon tax reforms that are welfare increasing are crucially dependant on the way that climate change impacts the economy. While many of our reforms are specified in terms of what we call world shadow prices for goods and world shadow taxes for carbon, concepts that may also arise in the analysis of utility function impacts, these shadow prices and taxes will depend on the nature of climate change impacts. Thus, instead of being dependant on the structure of household preferences, they will depend on how climate change affects endowments of various factors of production in different countries and then on the different production technologies that relate factors to outputs. Third, and related to this point, policy makers will need knowledge of the quantitative measures of these impacts through the production sector to be able to properly set policies. Information on climate change impacts on household preferences will be insufficient for policy making if impacts through the production sector are empirically relevant.

Accordingly, our model structure and theoretical analysis focus on this particular channel whereby climate change impacts the economy through its effect on effective factor endowments. To isolate and highlight the implications of this channel of climate change, we abstract from other channels via technologies and preferences. It has to be emphasized that although the model (and the issues it addresses) is structurally similar to existing models that discuss efficient policies (and the existence of Pareto-improving reforms) when pollution affects welfare through preferences (such as in [24]), the underlying mechanism of climate change impacting the economy – through its effect on effective factor endowments – is not. It is this precise mechanism – and the policy implications underlying it – that is the focus of this paper.

To address these issues, we construct a model that is sufficiently flexible and general to determine the general equilibrium implications of climate change without reliance on specific production structures and specific preferences. Our results are correspondingly general and have wide policy implications.

Our primary concern is with the welfare aspects of trade tax and carbon tax policies of governments in the context of a model involving factor endowment impacts of climate change. At one level, we address the Pareto-efficient design of climate and tariff policies from the perspective of production externalities. An understanding of cooperative policies is important as (but not only as) it provides a central benchmark for policy evaluation. In this context, we are interested in characterizing the nature of trade and carbon tax settings required to obtain a Pareto-efficient world outcome when transfers are, and are not, permitted. At another level, and of particular policy interest, we address the possibility of identifying, starting from a Pareto-inefficient equilibrium, practical carbon tax reforms that can deliver strict Pareto improvements in welfare. Interestingly, as it will become clear shortly below, such reforms do exist and their structure depends crucially on the way in which climate change impacts the world economy through the production sector.

It is shown that Pareto optimality of international trade and carbon taxes requires special conditions to be met. When international transfers are available policy instruments, carbon taxes are of Pigouvian form and uniform within sectors of the economy and over all countries. These taxes depend on the impact of climate change on effective factor endowments in each country and how these effective endowment changes impact on production and, hence, on the net revenue earned by production sectors, aggregated for the world as a whole. Pareto optimality requires that trade tax vectors be the same for each nation, thus ensuring that domestic prices are common across nations. When international transfers are not available, however, Pareto optimality requires domestic prices and carbon taxes (that are of an adjusted-Pigouvian form) to be collinear across nations, national differences being needed to ensure that national budget constraints are satisfied.[6]

We also obtain results concerning the possibility of using carbon tax reforms to generate Pareto improvements in welfare starting from a Pareto-inefficient initial trading equilibrium. We first provide general theoretical results establishing necessary and sufficient conditions for the success of such carbon tax reforms, expressed in terms of income effects and a measure of efficiency. Second, we provide welfare results for several specific carbon tax reforms, establishing sufficient conditions for their success. These reforms include reducing the gap between existing and conditionally Pareto-optimal carbon tax vectors and reducing the gap between existing and world shadow carbon tax vectors.[7]

## 2. Description of the model

The model is the standard competitive general equilibrium model of international trade, appropriately modified to deal with pollution (a by-product of production) affecting production possibilities of countries through changes in their

[5] This is a feedback effect upon the production sector by altering either the quantity of factors (for example, loss of land through rising sea levels) or their productivity (for example, through land degradation).

[6] Thus, the collinearity of taxes obtained by others for a model involving pollution externalities affecting consumer preferences survives in our model involving externalities that impact on the production sector. The collinearity property of Pareto optimality has been demonstrated in the context of consumer preferences by Keen and Kotsogiannis [15].

[7] The proofs for the various propositions make use of theorems of the alternative, which are provided and discussed by Mangasarian [16].