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Strategic effects of future environmental policy commitments: Climate change, solar radiation management and correlated air pollutants

Jingwen Qu [a, 1], Emilson Caputo Delfino Silva [b, *]

[a] School of Economics, Georgia Institute of Technology, 221 Bobby Dodd Way, Atlanta, GA 30332-0615, USA
[b] Department of Marketing, Business Economics and Law, Alberta School of Business, University of Alberta, 3-40N Business Building, Edmonton, AB T6G 2R6, Canada

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ABSTRACT

We study the effects of environmental policy commitments in a futuristic world in which solar radiation management (SRM) can be utilized to reduce climate change damages. Carbon and sulfur dioxide emissions (correlated pollutants) can be reduced through tradable permits. We show that if nations simultaneously commit to carbon permit policies, national SRM levels rise with carbon quotas. Alternatively, if they simultaneously commit to SRM policies, the global temperature falls with each unit increase in the global SRM level. A nation always wishes to be a leader in policymaking, but prefers carbon to SRM policymaking. The globe prefers SRM policy commitments.

1. Introduction

If in the near future multiple instruments are available (e.g., carbon pricing and solar radiation management) and governments are able to commit to a particular type of policy instrument, which instrument will they prefer? Are there clear game theoretic predictions of play? This paper is an attempt to answer these questions.

There is not much reason for optimism with respect to the prospects of implementation of an effective, cooperative, international agreement to curb the evils produced by climate change. The Kyoto protocol has not produced enthusiastic results and a post-Kyoto agreement does not promise to be much different.[2] The high national costs associated with mitigation of greenhouse gas emissions appear to be the main culprit. Such high costs were the main motivation for the US government to reject Kyoto, and may again be the main argument utilized by powerful nations, such as the USA and China, to reject a post-Kyoto agreement.

Revealed preference informs us that some nations prefer the status quo of no significant mitigation of greenhouse gas emissions to a commitment to reduce greenhouse emissions by a significant percentage amount relative to 1990 levels. However, this fact does

* Corresponding author. Tel.: +1 780 248 1312.
E-mail addresses: jqu8@gatech.edu (J. Qu), emilson@ualberta.ca (E.C.D. Silva).
[1] Tel.: +1 404 725 8936.
[2] Caplan et al. (2003) demonstrate that the Kyoto Protocol contained all the necessary ingredients to yield an efficient allocation of resources provided there was full participation. However, they show that a nation has a strong incentive to opt out if it anticipates that the other nations will participate and effectively reduce their emissions of greenhouse gases.

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not rule out the possibility that governments, which have rejected Kyoto as well as those that may reject a post-Kyoto agreement, are currently contemplating adopting cheaper alternatives to mitigation of greenhouse gas emissions in order to reduce their potential damages caused by climate change. In fact, there appears to be credence in the scientific community that some nations are seriously considering producing climate change engineering products – such as solar radiation management (SRM) generated by injections of sulfate aerosols into the stratosphere – that may effectively control the global temperature (see, e.g., the discussion of the scientific findings in Moreno-Cruz (2011)). One must also account for some of the potential negative effects associated with climate change engineering. SRM, for example, is expected to produce droughts, ozone depletion and to change the color of our blue skies.

This paper studies some of the effects associated with uncoordinated policy commitments with respect to provision of SRM relative to policy commitments for mitigation of greenhouse gas (e.g., carbon dioxide) emissions. We envision environmental policy making in a future global economy in which SRM is a proven and mature technology, which can be deployed at will and unilaterally by any nation. Among other things, we analyze whether there will be an incentive for a nation to be a policy leader in mitigation of carbon dioxide emissions or SRM provision, where the nations are perfectly informed about the benefits and costs of providing SRM.[3] Solar radiation management is expected to produce droughts, ozone depletion and to change the color of our blue skies.

The fact that SRM may soon prove to be a cheaper and effective alternative to mitigation of carbon dioxide emissions implies that unilateral action in SRM will not only be credible (see, e.g., Barrett (2008)), but also that nations may then wish to commit to SRM policies and subject their carbon mitigation policies to SRM policy commitments. Recent and noteworthy contributions to the literature have considered some of the potential reactions we may observe with future implementation of geoengineering technologies (e.g., Goeschl et al. (2013), Millard-Ball (2012), Moreno-Cruz (2011), Moreno-Cruz and Keith (2012), Moreno-Cruz et al. (2011), Urpelainen (2012)). Moreno-Cruz (2011) examines non-cooperative games in which two nations are either symmetric or asymmetric with respect to drought damages. In the symmetric game, he finds that the prospect of SRM will create greater incentives for free riding on carbon mitigation. When nations are asymmetric, he finds that SRM provision can induce inefficiently high levels of mitigation. Millard-Ball studies the impact of geoengineering deployment on the formation of a mitigation agreement. He shows that a credible unilateral threat of utilizing geoengineering may strengthen global abatement and lead to a self-enforcing climate treaty with full participation. Urpelainen shows that geoengineering may induce significant reductions in emissions in the present if it produces severe negative externalities, since the latter may lead to a very harmful geoengineering race in the future. If the externalities are not overly severe, unrestricted utilization of geoengineering can be globally beneficial.

Our paper contributes to this literature in at least three significant ways. First and foremost, we examine the effects associated with strategic environmental policy commitments, whereby SRM policy may precede carbon policy. This may indeed occur in the future when SRM technology is mature. SRM policy may be (politically or even socially) cheaper and easier to implement than carbon policy. Our motivation here is therefore to consider a likely future event and then make a prediction concerning the equilibrium policies. As in the papers cited above, we assume that SRM provision generates global damages - in our setting SRM produces drought damages and the drought damage function is increasing at an increasing rate.

Second, our model accounts for the fact that emissions of carbon dioxide are correlated with emissions of sulfur dioxide due to important common sources, such as energy production. Our model builds on Caplan and Silva (2005).[4] As in Caplan and Silva, sulfur dioxide emissions cause acid rain damage in the emitting nation. We show that the instruments a nation utilizes to control carbon and sulfur dioxide emissions are strategic complements. Hence, whenever SRM provision leads to an increase in carbon emissions, it also leads to an increase in sulfur emissions, with a resulting increase in acid rain damage. Finally, unlike the cited papers, we examine environmental policy making within a general equilibrium framework. This will enable us to see how consumers and industry emitters respond to strategic policy choices made by the governments.

2. Modeling strategies and brief discussion of main results

We consider a global economy consisting of two nations, which are identical in all respects, except for the drought and acid rain damage functions.[5] This is a modeling strategy. We wish to highlight the effects that differences in both drought and acid rain damages may promote in the formulation of non-cooperative carbon and SRM environmental policies and on the incentives for policy commitments.

Each nation has three policy instruments at its disposal; namely, SRM provision and carbon and sulfur pollution permits. Our choice of pollution permits as the means to price emissions is motivated by the Kyoto Protocol, the European Union Emissions Trading System and the 1990 US Clean Air Act Amendments, which created a national program in tradable sulfur dioxide emission permits.

Although we consider the making of uncoordinated environmental policies in a future time when policy makers have SRM at their disposal, our analysis involves a single period. The various timings of the games examined in this paper are strictly motivated by individual costs and benefits of policy commitments. We wish to predict which timing is likely to emerge in equilibrium. The timings are not motivated by the historical evolution of the utilization of environmental policy instruments. An alternative and interesting avenue for research is to explicitly consider an intertemporal model in which the sequence of policy instruments mimics the historical evolution of environmental policy, with sulfur pollution permits preceding carbon pollution permits and the latter preceding SRM. In such a case, the sequencing is exogenous and one considers the

[3] Policy leadership in transboundary pollution contexts has been studied in the literature. See, for example, Caplan and Silva (1999) and Nagase and Silva (2007, 2007) show that the policy effects produced by China's first-move advantage seem to be consistent with the policy choices made by China and Japan to address their acid rain problems. To our knowledge, however, the impacts of policy leadership in a setting in which the nations have instruments to reduce carbon emissions and produce SRM have not yet been examined in the literature.

[4] See also Silva and Zhu (2009). Our framework can also be seen as an extension of the impure public good model studied in the literature (see, e.g., Cornes and Sandler (1994) and Silva and Yamaguchi (2010)) to a context in which there are two impure public goods, namely, SRM provision and mitigation of carbon dioxide emissions. SRM provision yields global pure public good benefits, but entails national-specific drought damages. Reduction of carbon emissions also yields global pure public good benefits, but entails national-specific costs in terms of reduction of the consumer surplus associated with energy consumption. Our analysis makes a contribution to the public goods literature in that we consider both simultaneous and sequential strategic interactions between these two types of impure public goods.

[5] For an analysis in which there is strategic policymaking concerning greenhouse gas emissions in the presence of asymmetric damages and benefits of greenhouse gas emissions, see Caplan et al. (1999).