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Non-cooperative pollution control in an inter-jurisdictional setting

Robin Boadway [a,*], Zhen Song [b], Jean-François Tremblay [c]

[a] Department of Economics, Queen's University, 94 University Avenue, Kingston K7L 3N6, Canada
[b] CEMA & CIAS, Central University of Finance & Economics, 39 College South Road, Beijing 100081, China
[c] Department of Economics, University of Ottawa, 120 University, Ottawa K1N 6N5, Canada

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ABSTRACT

This paper examines various circumstances under which decentralized pollution policies can be efficient both in federal settings and in multi-region settings with labor mobility. We consider a model in which pollution control policies are set by regional governments non-cooperatively and pollution damages are borne by the residents of all regions. We characterize the efficiency of pollution policies, and of population allocation among regions, in a variety of scenarios, including when pollution policies are enacted before interregional transfers are determined by the federal government and before migration occurs; when migration decisions are taken before policy decisions; in the absence of a central government if regional governments can make voluntary interregional transfers; when decisions over pollution control policies are followed by voluntary contributions by regions to a national public good; when regions can commit to matching the abatement efforts of each other; and when regions can commit to specific levels of abatement contingent on the emissions of other regions not exceeding some maximum level.

1. Introduction

Policies for controlling emissions of pollutants are sometimes enacted by subnational governments in a federation. In Canada, various provinces have implemented either carbon tax schemes or versions of cap-and-trade, more or less to the exclusion of the federal government. Similarly, in the USA, several states have engaged in carbon pricing or regulatory schemes. There may be political economy reasons for this, especially since sub-national jurisdictions — or regional governments, as we shall call them — rely to very different extents on carbon-generating industries. However, there may be reasons based on standard assignment of functions arguments for decentralizing pollution control, given that regulators and enforcers need local information about producing and consuming agents. As well, economic unions typically rely on member nations to undertake pollution control policies.

Given that pollution crosses borders freely, it is natural to assume that decentralized provision will lead to inefficiently low levels of emission control, unless policies can be cooperatively implemented. There is, however, a literature that suggests that decentralized provision of a national public good can be efficient if regional governments are first-movers and the central government implements an optimal redistributive interregional transfer or equalization system. The literature is associated with Silva and Caplan (1997) and Caplan et al. (2000), it has been carefully surveyed by Akai and Sato (2008), and recently extended by Naoto and Silva (2008), Silva and Yamaguchi (2010) and Caplan and Silva (2011). This literature is the starting point for our paper.

There exist two other branches of literature that investigate circumstances under which non-cooperative behavior can lead to efficient outcomes even when the behavior involves the potential for free-riding. One applies to models of voluntary contributions to public goods. Guttman (1978) showed that if all agents contributing to a public good could commit to matching the contributions of others, an efficient level of contributions would result. Danziger and Schnytzer (1991) and Althammer and Buchholz (1993) showed that voluntary matching contributions may lead to a Lindahl equilibrium, and Boadway et al. (2007) generalized this analysis to other forms of commitment. They showed that if only one agent could commit, it could implement a scheme that would also be Pareto efficient. This scheme, referred to as a quantity-contingent mechanism (QCM), involves one agent committing to a contribution level contingent on a minimum level of contribution by another. Buchholz et al. (2011) characterize the conditions under which matching equilibria are interior; Guttman and Schnytzer (1992) and Altemeyer-Bartscher et al. (2010) extend the use of matching contributions to externalities; and Boadway et al. (2011) explore its application to international pollution control. In the latter case, when countries are able to match the abatement of each other, an efficient outcome will result, including in a multi-period setting. Boadway et al. also showed that this result applies even if countries' emissions are not perfect substitutes. Buchholz et al. (2012) consider a matching mechanism for climate protection where a subset of countries can form a coalition within which both positive and negative matching rates can emerge. This

* Corresponding author. Tel.: +1 613 533 2266; fax: +1 613 533 6668.
E-mail address: boadwayr@econ.queensu.ca (R. Boadway).

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literature is for the case when there is no central (or world) government. There are other approaches that require some central coordinating agency to operate simple mechanisms for enforcing efficient regional choices, such as deposit-and-refund schemes proposed by Gersbach and Winkler (2007) and Gerber and Wichardt (2009).

In a federal context, fiscal decision-making can generate interregional spillovers that generally cause inefficient choices. However, efficient regional decision-making can be induced by interregional migration, as shown by Boadway (1982). Regional governments, facing an equal-utility constraint because of migration, implicitly behave in the national interest when they maximize per capita utility, a phenomenon that Myers and Papageorgiou (1993) refer to as 'incentive equivalence'. The incentive-equivalence result applied mainly to the efficiency of regional fiscal decision-making when regions provide local public goods for which there is no spillover. However, even if fiscal choices are efficient, migration can be inefficient, as shown by Buchanan and Goetz (1972) and Flatters et al. (1974). One important rationale for federal equalization transfers is to correct this inefficiency of migration. But, as Myers (1990) shows, inefficient migration can, in simple models, be addressed by voluntary interregional transfers without the need for a central government. Mansoorian and Myers (1993) show that this also applies with imperfect migration, which they model using the so-called attachment-to-home approach that is now widely used, and Wrede (1998) shows that it can apply if regional governments are not fully benevolent.

Two final bits of literature will be referred to in what follows. The first concerns the importance of the timing of decisions in a multi-government setting. Decentralized provision of regional public goods is shown to be efficient only if regional governments act first, followed by the central government and then private agents, the so-called 'decentralized leadership' case. Even with this order of decision-making, efficiency is prone to fail for other reasons. Regional governments will over-extend themselves if they anticipate getting bailed out by the central government, a phenomenon analyzed by Goodspeed (2002), Wildasin (2004), Boadway and Tremblay (2006), and Breuillé and Vigneault (2010), among others. This is not the only timing issue that matters. Mitsui and Sato (2001) show that if migration occurs before central and regional governments make their fiscal choices, dramatic consequences can occur. The presence of regional public goods, which rewards population size, combined with a redistributive federal government, which tends to equalize marginal utilities of consumption, induces households to agglomerate excessively in one or more regions.

The last relevant finding we draw on concerns the so-called neutrality theorem of voluntary contribution models of public goods. As Shibata (1971), Warr (1983) and Bergstrom et al. (1986) have all argued, when many agents are contributing voluntarily to a public good, a redistribution of income among them will have no effect on resource allocation or welfare, at least as long as they all remain contributors after the re-allocation. Boadway and Hayashi (1999) extend this analysis to a setting in which countries are contributing to an international public good. Contributing countries' welfare will be decreasing in their populations, but the neutrality result continues to apply.

This paper draws on all these literatures. Our approach is somewhat pedagogical. We catalog various ways in which decentralized pollution policies can lead to efficient outcomes both in federal settings and in multi-region settings in which migration is possible. We present a sequence of scenarios which share some features in common. These include a) the non-cooperative deployment of pollution control policies by regional governments when pollution causes damage to residents of all regions; b) the enactment of pollution policies before fiscal choices are made and, in some cases, before migration occurs; and c) the possibility of migration by households whose utility functions are identical but who may have different attachments to different regions. The models we use are highly simplified models of pollution control, whose features are only as complicated as necessary to make the point. Some of the models will be explicitly federal in the sense that there is a central government whose relevant function is to make interregional transfers. Other models will assume away federal transfers, either because they are redundant or because we want to consider economic union settings where regions are independent but where migration can occur.

The main elements of the basic model are described in the next section followed by a characterization of the social optimum. Section 4 then examines the outcome under decentralized pollution control policy when federal transfers are chosen after regional policies, and migration decisions follow policy decisions. This timing, referred to as decentralized leadership, is comparable to that initiated by Silva and Caplan (1997) and pursued by Caplan et al. (2000). Its application to decentralized pollution policies is studied in Naoto and Silva (2008) in a model similar to ours, and in Silva and Yamaguchi (2010). We then extend this base case in a number of directions. In Section 5, migration decisions are viewed as the longer-run decisions. Therefore, the timing of decisions is reversed, so that migration decisions are taken before policy decisions. Section 6 looks at the case where regional governments can provide voluntary transfers to each other, after enacting their pollution control policies, while in Section 7, we let regions contribute voluntarily to a national public good in addition to controlling pollution. In Sections 8 and 9, we characterize pollution policies when one or both regions can make commitments, either to matching the emission abatement of the other region, or to achieving some level of emission abatement contingent on some maximum level of emissions for the other region. Conclusions are provided in the last section.

2. The basic model

There are two regions denoted by $i = 1, 2$. Region i is populated with n_i mobile residents, where $n_1 + n_2 = N$. In the basic model, regional production $F_i(n_i)$ is used for a clean good x_i and a polluting good e_i, each with unit prices. (Later, we allow for public goods.) Each unit of production of good e generates one unit of pollution emissions whose damages are imposed on all N households according to $d(n_1e_1 + n_2e_2)$, with $d'(\cdot) > 0$ and $d''(\cdot) > 0$. The per capita benefit of emissions in region i, or equivalently the benefit of consuming each unit of the polluting good, is given by $b(e_i)$, where $b'(e_i) > 0$ and $b''(e_i) < 0$.

The mobility of individuals is limited by their degree of attachment to one of the regions. As in Mansoorian and Myers (1993), we assume that each individual is characterized by an attachment-to-region-2 parameter n, uniformly distributed over $[0,N]$. Apart from their regional attachment, all individuals are identical. The utility of an individual of attachment-type n is given by $u(x_1 + b(e_1) - d(n_1e_1 + n_2e_2)) + \alpha(N - n)$ if residing in region 1, and by $u(x_2 + b(e_2) - d(n_1e_1 + n_2e_2)) + \alpha n$ if residing in region 2, where $\alpha \in [0,\infty)$ is a parameter indicating the non-pecuniary cost of migration. These utility functions assume that underlying preferences over the clean good, the polluting good and total emissions are quasi-linear in x_i. Assuming that regional preferences are quasi-linear simplifies the analysis considerably by eliminating income effects on both the demand for the polluting good and the size of pollution damages. However, the assumption does sacrifice some generality, as we note further below. Silva and Yamaguchi (2010), who use a model very similar to ours, do not assume quasilinearity, nor do Caplan et al. (2000).

The migration equilibrium condition, assuming an interior equilibrium, is:

$$u(x_1 + b(e_1) - d(n_1e_1 + n_2e_2)) + \alpha(N - n_1) = u(x_2 + b(e_2) - d(n_1e_1 + n_2e_2)) + \alpha n_1 \quad (1)$$

where n_1 is the marginal person. Households with $n \leqslant n_1$ reside in region 1, so n_1 is the population in region 1 in equilibrium, and the population of region 2 is $n_2 = N - n_1$.