Regional Science and Urban Economics 48 (2014) 120–132

Contents lists available at ScienceDirect

Regional Science and Urban Economics

journal homepage: www.elsevier.com/locate/regec

Self-enforcing environmental agreements and capital mobility☆

Thomas Eichner [a,*], Rüdiger Pethig [b]

[a] Department of Economics, University of Hagen, Universitätsstr, 41, 58097 Hagen, Germany
[b] Department of Economics, University of Siegen, Hölderlinstr, 3, 57068 Siegen, Germany

ARTICLE INFO

Article history:
Received 11 December 2013
Received in revised form 17 April 2014
Accepted 17 June 2014
Available online 26 June 2014

JEL classification:
H23
H77
Q58

Keywords:
Capital mobility
Self-enforcing environmental agreements
Emission tax
Nash behavior

ABSTRACT

In a multi-country model with mobile capital and global pollution this paper analyzes self-enforcing environmental agreements (IEAs) when the coalition formed by the signatory countries plays Nash. In accordance with a previous environmental literature we show that there exists a unique self-enforcing IEA consisting of two or three signatory countries if emission tax rates are strategic substitutes. However, emission tax rates are strategic complements if the pollution is not too detrimental. In that case we find very small self-enforcing IEAs, as before, but now the socially optimal agreement among all countries may be self-enforcing as well. Special emphasis is placed on the investigation and interpretation of the conditions which render stable the grand coalition.

1. Introduction

Fighting climate change effectively requires the massive reduction of carbon emissions at the global scale that cannot be achieved without an encompassing international environmental agreement (IEA). The progress made over the last decades in international negotiations towards such an agreement is so small that prospects are bleak for stabilizing the world climate at safe levels. That calls for further efforts to investigate the conditions for the successful formation of an effective IEA. The challenge is to establish an IEA that overcomes the sovereign countries' reluctance to join an IEA unless it is in their self-interest. In other words, an IEA must be self-enforcing in the sense that no signatory has an incentive to leave the IEA and no non-signatory has an incentive to join it. Among the early contributions to an economic literature on IEAs based on that concept of self-enforcement are Carraro and Siniscalco (1991), Hoel (1992), and Barrett (1994). The working-horse model is a simple static model of identical countries without international trade. Some studies model climate coalitions[1] as Stackelberg leaders (e.g. Barrett, 1994; Diamantoudi and Sartzetakis, 2006; Rubio and Ulph, 2006) and others portray them as Nash players along with all non-signatories (e.g. Carraro and Siniscalco, 1991; Hoel, 1992; Finus, 2001; Rübbelke and Finus, 2013). In both variants of the basic model of the IEA literature the overall conclusion is that due to strong free-rider incentives large coalitions are unstable such that large potential gains from cooperation remain unexploited.

In order to find out whether the prospects of reaching an effective IEA enhance in more structured models, Eichner and Pethig (2012, 2013) extend the basic model of coalition formation by explicitly modeling production, consumption and international trade in fossil fuels and a composite consumption good. When the coalition is assumed to be the Stackelberg leader (Eichner and Pethig, 2013), stable coalitions turn out to comprise up to 60% of all countries. But unfortunately, such coalitions hardly reduce climate damage below its level in the non-cooperative scenario — regardless of how large they are. When the coalition plays Nash along with all fringe countries (Eichner and Pethig, 2012), stable conditions are both small and ineffective similar as in the basic model without trade.

The present paper also analyzes the formation of a climate coalition in a world economy with international trade, but in contrast to Eichner and Pethig (2012, 2013) our focus is now on capital mobility and capital-related global pollution. That means, we take as our point of departure the branch of the fiscal federalism literature dealing with decentralized policymaking in an economy with spillovers among jurisdictions. In their seminal paper Oates and Schwab (1988) argue

☆ Helpful comments from two anonymous referees are gratefully acknowledged. Remaining errors are the authors' sole responsibility.
* Corresponding author.
E-mail addresses: thomas.eichner@fernuni-hagen.de (T. Eichner), pethig@vwl.wiwi.uni-siegen.de (R. Pethig).
[1] In the present paper, the terms IEA and (climate coalition) are synonymous because our exclusive focus is on a single coalition. Also we take as equivalent the terms 'self-enforcing IEA' and 'stable (climate) coalition'.

http://dx.doi.org/10.1016/j.regsciurbeco.2014.06.002
0166-0462/

that the choice of capital taxes and environmental standards is efficient in an economy with identical jurisdictions, mobile capital and local pollution.[2] Ogawa and Wildasin (2009) extend the analysis to account for transboundary pollution (spillovers) and asymmetric countries, and still get efficient capital tax rates. Eichner and Runkel (2012) point out that it is the zero capital supply elasticity which drives Ogawa and Wildasin's result. They adopt a two-period framework employed e.g. by Bucovetsky and Wilson (1991) and Keen and Kotsogiannis (2002) and show that in case of strictly positive capital supply elasticities capital tax rates are inefficiently low in the decentralized equilibrium because the jurisdictions' choice of capital taxes is then distorted by their incentive for tax competition and their disregard of spillover effects.[3]

Ogawa and Wildasin (2009) and Eichner and Runkel (2012) investigate the (in)efficiency of capital tax competition in the presence of transboundary pollution when decision-making is decentralized, i.e. when all jurisdictions/countries act non-cooperatively. Here we will take up the analytical framework of Eichner and Runkel (2012) with some minor simplifications[4] to investigate the formation of stable coalitions when the fringe countries as well as the coalition play Nash. Although our approach shares with Eichner and Pethig (2012) both Nash behaviors on the part of the coalition and international trade, the pertaining models differ significantly. In Eichner and Pethig's one-period model there are world markets for a composite consumption good and fossil fuels; fuels are extracted and consumed by the countries' residents along with a consumption good that is produced without using fuel as an input. In contrast, following Eichner and Runkel (2012) we now model world markets for capital and a composite consumption good in the second period, and capital is an intermediate good in the production of the consumption good.

As reported above, Eichner and Pethig (2012) found no stable coalitions consisting of three or more countries. Similarly, in the present paper we will demonstrate that there exist small stable coalitions with two or three member countries. However, for a smaller but non-empty subset of parameter values the grand coalition turns out to be also stable. In other words, full cooperation of all countries may be self-enforcing. The crucial necessary condition for this unexpected result are economies (= parameter constellations) in which emission tax rates are strategic complements. For given preferences and technologies strategic complementarity of taxes *and* stable grand coalitions is the more likely, the smaller the total number of countries, the less severe the climate damage of emissions and the smaller the flow of emissions.

The paper is organized as follows. Section 2 introduces and describes the formal model and briefly characterizes the benchmark scenarios of global non-cooperation and social optimum. Section 3 analyzes the impact of climate coalitions of different but exogenously given sizes and investigates analytically and numerically economies in which emission tax rates are either strategic complements or strategic substitutes. Section 4 then turns to the existence and size of self-enforcing IEAs emphasizing the conditions under which the grand coalition is stable. Section 5 concludes.

2. The model

Consider a two-period economy with $n \geq 2$ identical countries. Each country is populated by a representative household who lives for two periods. At the beginning of the first period, country i's resident is endowed with $\bar{k}>0$ units of capital which she plans to use up for her living in both periods. Each country produces a consumption good in each period. In the first period capital can be transformed into a consumption good according to $x_i^1 = k_i^1$ for domestic first-period consumption. Correspondingly, $s_i = \bar{k} - k_i^1 = \bar{k} - x_i^1$ is the consumer's savings. It is the consumer's decision (to be specified below) how to allocate her capital endowment between first-period consumption and savings. In the second period there exists a representative firm in each country i that employs k_i units of capital to produce the (second-period) consumption good according to the production function

$$x_{is}^2 = X(k_i). \tag{1}$$

The function X satisfies $X' > 0$ and $X'' < 0$. The production process (1) generates emissions, e_i, in strict proportion to capital employed which we express by writing $e_i = \psi k_i$ with $\psi > 0$ and constant. Emissions are regulated in each country by means of an emission tax at rate t_i. Each unit of capital is purchased on the world capital market at the price $1 + r > 1$. Taking the consumption good of period 2 as numéraire, maximization of the after-tax profit $\pi_i = X(k_i) - (1 + r + t_i\psi)k_i$ yields

$$X'(k_i) = 1 + r + t_i\psi. \tag{2}$$

As described above, the consumer spends part of her capital endowment on first-period consumption and saves the rest, $s_i = \bar{k} - x_i^1$, for supply on the second-period world capital market. Accordingly, in the second period the consumer receives capital income $(1 + r)s_i$ and profit income π_i earned by the domestic second-period firm. Thus her second-period budget is $x_i^2 = (1 + r)s_i + \pi_i + t_i\psi k_i$ where x_i^2 denotes second-period consumption and $t_i\psi k_i$ is the lump sum transfer of tax revenues to the household. The utility of country i's resident is increasing in private consumption and is negatively affected by global pollution[5] $\sum_j e_j$. The utility function is given by

$$U\left(x_i^1\right) + x_i^2 - D\left(\sum_j e_j\right). \tag{3}$$

The subutility function U is increasing and concave and the damage function D is increasing and convex. Maximizing Eq. (3) with respect to s_i subject to the budget constraints gives $U'\left(\bar{k} - s_i\right) = 1 + r$. This equation determines the savings (= the second-period supply of capital) as a function of the interest rate. The non-zero interest elasticity of capital supply is crucial in the present context since otherwise it would not be possible at all to reduce global emissions by means of cooperative or non-cooperative climate policies.

Capital and the second-period consumption good are traded on perfectly competitive world markets. The condition

$$\sum_j s_j = \sum_j k_j \tag{4}$$

clears the capital market. According to Walras' Law the world market for the second-period consumption good is also in equilibrium if and only if Eq. (4) is satisfied.[6,7]

The model outlined above adopts from Ogawa and Wildasin (2009) the fixed capital endowments and the capital/emission tax competition with emissions being proportional to capital inputs. However, Ogawa and Wildasin employ a one-period model in which capital/emission tax policies leave global capital and hence global emissions unaffected.

[2] Decentralized policy making with labor mobility and global pollution is recently analyzed by Boadway et al. (2013).

[3] In the literature on capital tax competition (e.g. Zodrow and Mieszkowski, 1986; Wilson, 1986) an additional source of inefficiency is the under-provision of public goods resulting from the requirement to finance public goods by capital tax revenues exclusively. If lump sum taxation is allowed along with capital taxation, as e.g. in Eichner and Runkel (2012), the provision of public goods is efficient.

[4] We do not model public goods whose allocation is efficient in Eichner and Runkel (2012) anyway because they allow for lump sum taxation. Second, we restrict the analysis to uniformly dispersed emissions ($\beta = 1$) which approximates the case of climate change.

[5] For convenience of notation, we write $\sum_j$ short for $\sum_{j=1}^{n}$.

[6] To see this, combine the (above) equations $x_{is}^2 = X(k_i)$, $\pi_i = X(k_i) - (1 + r + t_i\psi) k_i$ and $x_i^2 = (1 + r)s_i + \pi_i + t_i\psi k_i$ and take the sum of the resultant equation $x_i^2 = x_{is}^2 + (1 + r)(s_i - k_i)$ over all countries. Then $\sum_j x_{js}^2 = \sum_j x_j^2$ follows in view of (4).

[7] This observation is the rationale for the price of capital being equal to $1 + r$.