On Spatial Effects in Cooperative and Non-Cooperative Transboundary Pollution Dynamic Games

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Abstract

We analyze a transboundary pollution differential game where, in addition to the standard time dimension, a spatial dimension is introduced to capture the different geographical relationships among regions. Each region behaves strategically and aims to maximize its welfare net of environmental damage caused by the stock of pollution. The emission-output ratio in each region can be reduced by investment in clean technology which is region specific and evolves over time. The spatio-temporal dynamics of the stock of pollution is described by a parabolic partial differential equation. Using aggregate variables for the environmental variables of the model we study the feedback Nash equilibrium of a discrete-space model which could be seen as a space discretization of the continuous-space model. The discrete-space model still presents the three main feature of the original formulation: first, the model is truly dynamic; second, the decision agents behave strategically; third, the model incorporates spatial aspects. For special functional forms previously used in the literature of transboundary pollution dynamic games we characterize analytically the feedback Nash equilibrium and evaluate the impact of the introduction of the spatial dimension in the economic-environmental model. We show that our spatial model is a generalization of the model that disregards the spatial aspects in the sense that the behavior of the environmental variables at the equilibrium in the non-spatial setting can be reproduced as a limit case of the spatial setting. In particular, this link is obtained when the parameter describing how pollution diffuses among regions tends to infinity and the stocks of pollution in the regions are mixed instantaneously, which is the main hypothesis made in the non-spatial differential game.

Keywords: Transboundary Pollution; Spatial Dynamics; Spatially Distributed Controls; Differ-

ential Games; Parabolic Differential Equations.

JEL Codes: Q5; R12; C73; C61.