Pollution diffusion in spatial growth model

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Abstract

In this research, we study an agricultural production model using spatial growth model framework. Each location needs fertile soil to produce but the production activity locally pollutes and transforms fertile soil into polluted soil that is non-usable for production. The economy can either use its production for consumption or for depolluting soil that has been affected by the production process. Moreover, we allow the pollution to diffuse across locations and we model the diffusion process using Fick's law of motion. This means that the activity at one location depends and has an impact on its surrounding locations as the pollution of one location's surroundings can reach this location and reciprocally.

We solve the problem using Sturm-Liouville theory allowing to transpose a optimal spatial control problem into an eigenvalue problem. We solve the problem in the most general way, allowing for heterogeneity in productivity, population and soil characteristics. We give the optimal path for consumption as well as soil fertility distribution along the optimal consumption path that maximizes welfare. We prove that under specific assumptions on the model's parameter, the detrended fertile soil distribution converges and that its mean value is conserved throughout the optimal consumption path.

In the case of an homogenous economy, in which productivity, population and soil characteristics are homogenous in space, we are able to give the analytical expression of growth rate. We also study the transfert in consumption and in soil fertility due to diffusion and show that soil pollution diffusion tends to transfert consumption from the region that was initially more allocated in fertile soil to the region that was initially less allocated in fertile soil. We then consider than population are divided into producers that participates to production but are responsible for pollution, and cleaners that depollutes soil and give the optimal population repartition between cleaners and producers that maximizes growth rate. Finally, we numerically study the case of the heterogenous economy. We show how soil characteristics has an impact on the overall consumption level as well as on fertile soil distribution, and we study the impact of inequality aversion with respect to consumption and fertile soil spatial inequalities.