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Environmental policy, first nature advantage and the emergence of economic clusters

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ABSTRACT

We explain the spatial concentration of economic activity when the cost of environmental policy – which is increasing in the concentration of pollution – acts as a centrifugal force, while positive knowledge spillovers and a site with natural cost advantage act as centripetal forces. We study the agglomeration effects caused by trade-offs between centripetal and centrifugal forces which eventually determine the distribution of economic activity across space. The equilibrium solution with spatially myopic environmental policy results either in a monocentric or in a polycentric city with the major cluster at the natural advantage site. The regulator's optimum results in a bicentric city, which suggests that when environmental policy is spatially optimal, the natural advantage sites do not act as attractors of economic activity. In general, our results suggest that sites with inherent advantages can lose their comparative advantage when social costs at these spatial points are taken into account.

1. Introduction

The location decisions of firms and the size and number of economic clusters they form have been studied extensively in urban models. Production externalities, increasing returns, inherent advantages, and resource abundance are some of the factors that have been identified by the literature and analyzed in theoretical and empirical contexts. When discussing the factors which encourage or impede the concentration of economic activity, the role of pollution – and more precisely the role of environmental policy on the location decisions of economic agents and the observed spatial patterns – should be accounted for. There has been a lengthy discussion about the ambiguous results of strict or lax environmental regulations on location decisions. Strict environmental regulations may promote a clean environment, but the other side of the coin is that strict policy may restrict economic activity by increasing costs and may lead firms to stop operating or move to another country. The opposite arguments hold in case of lax policies. Current discussions about future climate change policies again raise the issue of how environmental regulations affect the level and the location of economic activity.

The questions of where firms choose to operate or where people choose to live are "spatial" by nature. In this paper, we try to study the role of pollution externalities and environmental policy on the location decisions of economic agents in the interior of a finite spatial domain. In our model, environmental policy takes the form of emission taxes which are different among locations and tend to be higher in sites where the concentration of pollutants is relatively higher. Furthermore, the concentration of pollutants in a given site is determined not only by emissions generated in that site, but also by emissions generated in nearby locations, since in our model emissions diffuse in space. To put it differently our model contains emission spillovers.

Environmental issues have not been studied extensively in "spatial" models. Some exceptions are the recent works of van Marrewijk (2005) and of Lange and Quaas (2007) who study the effects of pollution on agglomeration assuming local pollution. Arnott et al. (2008) assume non-local pollution while investigating the role of space in the control of pollution externalities. These authors explain the emergence of residential and industrial zones in space, when the different levels of workers' commuting cost interact with environmental externalities. They also show that in a spatial context, in order to achieve the global optimum, a spatially differentiated added-damages tax is needed. Zeng and Zhao (2009) study the "pollution-haven" effect using a spatial-economy model of two

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countries and two sectors. They find that when two countries are asymmetric in size, the agglomeration forces in the larger country, stemming from imperfect competition and increasing returns to scale, can dominate the pollution effect, which means that a pollution haven does not arise. Conrad (2005) shows that strict environmental regulations do not affect firms' relocation decisions when countries are not too similar in terms of productivity and factor price differences. In particular, when cost of production differentials across locations is significant, lax environmental standards do not cause firms to relocate in the countries with these laxer standards.

The present paper attempts to gain insights into the spatial clustering of economic activity by combining industrial pollution and environmental policy with two of the most important determinants of agglomeration forces: knowledge spillovers and the existence of a location with natural cost advantage. The two agglomeration forces that promote clustering can be traced back to Marshall. In addition to external economies associated with knowledge spillovers, Marshall (1920, p. 269) argued that the location decisions of industries are highly influenced by physical conditions, such as climate, soil, mines or quarries in nearby areas, or easy access by land or water.

Krugman (1999) identifies not only the importance of first nature advantage and Marshallian externalities in explaining agglomeration, but also the interaction between them. Thus, natural geography determines the city site in most cases. For example a lot of cities are created around a port so as to have easy access to the goods transported, or a lot of industries using mineral resources in the production process are located near the mines so as to avoid high transportation costs. There are many examples of this kind and the result is easily predicted: sites with "natural advantages" are more likely to attract a large number of agents and economic activity. But once the site has been chosen and the city is established, there are other forces that persist and lead to an even higher concentration of economic activity around the first nature advantage point. These are the interactions among knowledge and information spillovers, economies of intra-industry specialization, or labor market economies. As Krugman (1999) points out, these agglomeration forces have been proved to become stronger after natural geography has determined the agglomeration point. Thus when certain industries decide to locate around that site, then the need for other industries to locate nearby so as to benefit from information and knowledge spillovers is even stronger. As a consequence, a higher concentration of economic activity around first nature advantage sites is expected.

The first nature advantage and the interactions between economic agents have also been studied empirically. Ellison and Glaeser (1999) show that one-fifth of this clustering can be attributed to observable natural advantages such as resource and labor-market natural advantages. LaFountain (2005) finds strong evidence supporting the location of specific firms around natural advantage sites. Roos (2005) shows that more than one-third of agglomeration in Germany can be attributed to natural features and agglomeration economies, while Rosenthal and Strange (2001, 2004) find empirical evidence regarding the significance of natural advantages and knowledge spillovers as determinants of agglomeration.

The theoretical and empirical literature mentioned above implies that first nature advantage sites will attract a high number of industries. However, high industrial concentration is sometimes associated with certain negative externalities, such as pollution or congestion. In this case, as Krugman (1999, p. 159) argues, government intervention and enforcement of the suitable policy are required, and this may lead to a situation different from the one corresponding to unregulated equilibrium.

Thus, in our context, knowledge spillovers and natural cost advantage act as centripetal forces which promote agglomeration and clustering of industrial activity, while environmental policy acts as an endogenous centrifugal force, since agglomeration tends to increase the concentration of pollutants and consequently emission taxes, which represent a higher cost to the industry.[2] Our purpose is to examine how the enforcement of environmental policy will affect the concentration of economic activity that results from knowledge spillovers and natural advantage. The question we try to answer is whether environmental policy can reverse the premise (e.g. Krugman, 1999) that agglomeration of economic activity will emerge around a first nature advantage site as a result of the interaction between knowledge spillovers and natural cost advantage forces.

In our model the spatial distribution of industrial activity, in a given finite spatial domain, is determined under two different assumptions regarding the implementation of environmental policy: a "spatially myopic" policy and a "spatially optimal" policy. When policy is myopic, the emission tax in a given location does not take into account the impact that emissions in this same location have on aggregate pollution and associated environmental damages in nearby locations due to spatial diffusion of emissions. Myopic policy is associated with the concept of the equilibrium solution where profit maximizing firms in each location treat knowledge spillovers and the concentration of pollution as fixed parameters. A spatially optimal or simply optimal policy is determined in the context of the regulator's optimum. In this case, emission taxes in a given location account for the impact of local emissions on pollution concentration and environmental damages in neighboring locations. We model emission and knowledge spillovers by symmetric exponentially declining integral kernels, while natural cost advantage is modeled by iceberg type input costs which increase with the distance from the natural advantage location.

In order to explicitly take into account the effects of emission and knowledge spillovers in determining the equilibrium amount of inputs, output and pollution, we use a novel approach for solving systems of integral equations with symmetric kernels. This approach is based on a Taylor-series expansion method (Maleknejad et al., 2006) which allows for the endogenization of the kernels describing the two externalities. In other words, by applying this method, we avoid assigning arbitrary values to the functions of aggregate pollution and knowledge spillovers, which we believe is a contribution to the solution of models with this type of spillovers.[3] More precisely, we think that the joint analysis of environmental policy with emission and knowledge spillovers, and inherent advantage, along with the endogenization of the spillover kernels in the solution of the problem, represents contributions which can provide new insights into the clustering of economic activity under some of the most common agglomeration and anti-agglomeration forces.[4]

Our results, based on numerical simulations, indicate that when the centripetal forces of knowledge spillovers and natural cost advantage for a location are combined with the centrifugal force of spatially differentiated environmental policy, then in equilibrium the main cluster of economic activity is always observed around the natural advantage location as suggested by the literature.[5] However, when

[2] The argument that environmental regulations impede the agglomeration of economic activity has been established by the empirical literature. Henderson (1996) shows that air quality regulation leads pollution industries to spread out, moving from polluted to cleaner areas. Greenstone (2002) finds that environmental regulation restricts industrial activity.

[3] The use of this approach differentiates our work from previous studies exploring the effects of pollution diffusion on spatial structures, such as Arnott et al. (2008), and allows us to obtain numerical results which provide insights into the comparison of equilibrium and optimal spatial patterns.

[4] In this paper, we follow Lucas (2001) and Lucas and Rossi-Hansberg (LRH, 2002) in the modeling of knowledge spillovers, but we differentiate in the approach for numerically solving the model. More specifically, LRH (2002), in the numerical experiments they present, assign arbitrary values – different at each spatial point – to the productivity function that describes knowledge spillovers. We consider that our approach, which explicitly solves the integral equations resulting from endogenizing of the spatial kernels, constitutes an advance as we obtain numerical solutions without using simplifying assumptions regarding the externalities.

[5] Although we prove existence and uniqueness of the equilibrium and the regulator's optimum, specific results are obtained by simulations due to the well-known intractability of urban models that prevents closed form solutions.