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Are environmental policies counterproductive?

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Abstract

Environmental problems are often amplified by agglomeration of activities. We show that environmental policies may be counterproductive: by reducing polluting emissions, they reduce also the agents' disutility of pollution and increase their incentive to agglomerate. The result may be more pollution.

Keywords: environmental policies; concentration of activities
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1. Introduction

A large literature has studied the interactions between trade and environment. In this framework, a lot of papers have analyzed the effects of freer trade on environment with local (Barrett, 1994; Antweiler, Copeland and Taylor, 2001) or transboundary (Copeland and Taylor, 1995) pollution.

In contrast, in our paper, we focus on the interaction between environmental policy and agglomeration of environmentally sensitive industries. Many papers have discussed the spatial dimension of environmental policies. Most of them consider an oligopoly market producing a homogeneous good and analyze the problem of plant relocation decisions in response to environmental restrictions (Markusen, Morey and Olewiler, 1995; Hoel, 1997; Petrakis and Xepapadeas, 2003). Other papers study the trade off between the negative effects of deterioration in the environmental quality and positive agglomeration externalities in a spatial equilibrium of cities (Papageorgiou and Pines, 2000; Tabuchi, 1998). However, there are still two related issues where there is a lack of theoretical research in the spatial dimension of environmental problems. One is the differentiated-goods models and the other is the effect of environmental policies on the agglomeration of activities. Most of the time, the pollution problems are aggravated by agglomeration. Traffic-jams, hurtful emissions by clustered polluting industries, or pollution of soil and rivers by concentrated agricultural activities are some examples. However empirical evidence shows that such agglomerations exist. This paper discusses the impact of environmental policies on the agglomeration of people and activities. We argue that environmental policies may be subject to a kind of moral hazard problem: because each firm (or agent) is less polluting when a regulator enforces an emission tax or quota, the global disutility of pollution decreases with environmental policies and this strengthens the incentive for people and activities to agglomerate. The final result may be more pollution because of the scale effect, even if each firm is cleaner. Copeland and Taylor, 1999, have also shown, in a model where pollution policy is ruled out, that, under some conditions, feedback effects can occur between trade and environment. What is new in our results is that the environmental degradation is brought on by the domestic environmental policy itself.

We adapt the analytical framework from the economic geography model that has highlighted the conditions under which geographic concentration of activities occurs (Krugman, 1991a, 1991b). In that basic model without congestion costs, the market size effect always leads to agglomeration of industries in the larger region unless the transport cost is prohibitive.

In this paper we assume that firms are polluting and we introduce a disutility of pollution in the agents' welfare. We show that this disutility undermines the incentive to agglomerate in the large region. Finally, we introduce an environmental regulation which decreases at first the global pollution. It follows that the agents' welfare, net of the disutility of pollution, is now higher and that the larger region becomes, once again, more attractive.

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2. The model

At first, we follow Krugman's model closely. In two regions, i=1,2, we consider two categories of consumers, mobile workers and immobile farmers. The regions differ only in one respect: the number L_i of workers. The overall number of mobile workers is μ, and $L_1=f\mu$ and $L_2=(1-f)\mu$, with $0\leq f\leq 1$. In each region there are $(1-\mu)/2$ farmers.

Farmers and workers have identical preferences. Their utility (equivalent in this particular model to their real wage) is described by:

$$U = C_m^{\mu} C_a^{1-\mu} \qquad (1)$$

where C_a is consumption of the homogeneous agricultural good (used as numeraire) and C_m is the Dixit-Stiglitz, 1977, subutility function:

$$C_m = [\sum_{k=1}^{n} C_k^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}} \qquad (2)$$

with $\sigma>1$, the elasticity of substitution among the n manufactured goods (and the perceived price elasticity of demand).

The amount of labor l_k required to produce a quantity x_k of good k ($k=1\ldots n$) is

$$l_k = \alpha + \beta x_k \qquad (3)$$

where α is fixed cost and β constant marginal cost. Increasing returns to scale imply that each firm in each region produces a single product. The firms are Chamberlinian monopolistic competitors and, in equilibrium, set a price P_i that is uniform within each region:

$$P_i = \frac{\sigma}{\sigma-1}\beta W_i \qquad \text{(i=1,2)} \qquad (4)$$

with W_i the wage rate of workers in region i.

Free entry and exit conditions imply $x^* = \frac{\alpha}{\beta}(\sigma-1)$ (5)

where x^*, common to every active firm, is the equilibrium quantity produced by each firm, whatever the region.

The full employment condition determines the number of firms in each region:

$$n_i = \frac{L_i}{\alpha\sigma} \qquad \forall i=1,2. \qquad (6)$$

Krugman assumes that the agricultural good can be freely transported from one region to the other. Transportation costs for manufactured goods take Samuelson's iceberg form: $0\leq r\leq 1$, an inverse index of transportation cost, is the fraction of one unit of manufactured good that, shipped from one region, reaches the other.

Demand for each industrial good is obtained by maximizing consumers' utility (given by (1) and (2)), subject to their budget constraint.

Equating supply (5) and demand for each good in both regions, together with the full employment condition (6) determines the equilibrium prices and wages for a given allocation of workers, L_i

$$\frac{\alpha}{\beta}(\sigma-1) = \frac{\mu}{P_1}\left| \frac{W_1 L_1 + \frac{1-\mu}{2}}{n_1 + n_2\left(\frac{W_1 r}{W_2}\right)^{\sigma-1}} + \frac{W_2 L_2 + \frac{1-\mu}{2}}{n_1 + n_2\left(\frac{W_1}{W_2 r}\right)^{\sigma-1}} \right| \qquad (7)$$

$$\frac{\alpha}{\beta}(\sigma-1) = \frac{\mu}{P_2}\left| \frac{W_1 L_1 + \frac{1-\mu}{2}}{n_2 + n_1\left(\frac{W_2}{W_1 r}\right)^{\sigma-1}} + \frac{W_2 L_2 + \frac{1-\mu}{2}}{n_2 + n_1\left(\frac{W_2 r}{W_1}\right)^{\sigma-1}} \right|. \qquad (8)$$

Using the results of maximizing agents' utility and relation (1), the workers' real wages in each region are

$$U_1 = ((1-\mu)W_1)^{(1-\mu)} \left[n_1 \left| \frac{1}{P_1} \frac{\mu W_1}{n_1 + n_2 \left(\frac{W_2}{W_1 r}\right)^{1-\sigma}} \right|^{\left(\frac{\sigma-1}{\sigma}\right)} + n_2 \left| \frac{1}{P_2} \frac{\mu W_1 r}{n_2 + n_1 \left(\frac{W_1}{W_2} r\right)^{1-\sigma}} \right|^{\left(\frac{\sigma-1}{\sigma}\right)} \right]^{\left(\frac{\mu\sigma}{\sigma-1}\right)} \qquad (9)$$

$$U_2 = ((1-\mu)W_2)^{(1-\mu)} \left[n_1 \left| \frac{1}{P_1} \frac{\mu W_2 r}{n_1 + n_2 \left(\frac{W_2}{W_1} r\right)^{1-\sigma}} \right|^{\left(\frac{\sigma-1}{\sigma}\right)} + n_2 \left| \frac{1}{P_2} \frac{\mu W_2}{n_2 + n_1 \left(\frac{W_1}{W_2 r}\right)^{1-\sigma}} \right|^{\left(\frac{\sigma-1}{\sigma}\right)} \right]^{\left(\frac{\mu\sigma}{\sigma-1}\right)} \qquad .(10)$$

Assuming that workers move, from the low to the high *real wage* region, Krugman shows that when transportation cost falls below some critical level (r^*), the larger region has the higher real wage because of the larger size of the local market: the result is a tendency to concentration of all manufacturing in this region.

We assume now that firms are polluting. Pollution, purely local, is a by-product of the manufactured good production process. As assumed most of the time in the environmental literature, we consider that the relation between emission (e) and production (x) by each firm is linear and given by $e= \theta x$, where $\theta>0$ represents the firms' environmental performance (a lower θ means less polluting emissions). Assume that workers are harmed by the global pollution ($n_i\, e$) and take into account this disutility when they decide to migrate or not. They move now from the low to the high *welfare* region: in region "*i*" the workers' welfare net of the global disutility of pollution is:

$$S_i= U_i - D(n_i\, \theta x) \qquad (11)$$

where U_i is the real wage in region i (given by (1)) and $D(n_i\, \theta x)$ measures the global negative impact of pollution on health or utility. Following most of the models in the related literature, we assume damages are separable. As a result, in our model (as in Chichilnisky, 1994 and Copeland and Taylor, 1995) there are no substitution effects between environment and marketed goods. Smith and Espinoza, 1996 have considered in a computable general equilibrium model, the jointness of marketed and environmental goods. They show that the non-separability assumption has an impact on the evaluation on trade policy and demonstrate that feedback effects may produce counterintuitive results. Because we focus on the linkage between agglomeration and environmental policy, we assume here that pollution affects only the level of utility: this simple framework allows to isolate the centripetal and centrifugal effects which are central arguments in this kind of model. Global disutility is increasing in the global emission, and thus in the number of firms and the output per firm. In the remainder of the article, it will be useful to work with a linear function $D(n_i\, \theta x) \equiv \delta n_i\, \theta x$ with $0<\delta<1$.

Clearly, the workers' welfare has now two components working in opposite ways: if region 1 is the larger region ($f > 0.5$), on the one hand, as in the basic model, it is more attractive to workers than the other region because the real wage is higher, $U1> U2$ (the market size effect) but, on the other hand, it is less attractive because the disutility of pollution increases in the region where agglomeration occurs and plays the role of a centrifugal force. The result of the tension between centripetal and centrifugal forces depends on the relative values of the parameters. For given values of α, β, μ and σ, the critical level of the transportation cost (leading to a concentrated sustainable equilibrium because $S1 > S2$) decreases when the marginal damage δ increases ($r^{*\prime}(\delta)>0$). It follows that a concentration of all activities in a single region is now less likely to occur.

Obviously, for given values of μ, σ, and r, there exists a limit value of δ such that workers are so deterred by pollution that agglomeration of firms never occurs.

3. The effect of environmental policy on agglomeration equilibrium

It is well known that polluting agents need to be induced to internalize the social cost of pollution damage, otherwise they would engage in excessive levels of polluting emission. We assume that a national environmental regulator enforces in **both** regions a quota of emission. It follows that firms must undertake a costly abatement effort in order to reduce their emission level, by reducing θ. This effort results in an increase in marginal cost $\beta(\theta)$ with $\beta'(\theta)<0$. This is the only way to introduce a pollution control in this kind of *partial* equilibrium and particular economic geography framework (in *CGE* analyses, like in Smith and Espinoza, 1996, a more complex pollution control can be incorporated in order to show how emission control will both affect and be affected by final good consumption).

Let us underline that we focus entirely on the costs imposed by the regulator: we are neither concerned, here, by the choice among policy instruments, nor by the optimal quota level (for a survey, see Cropper and Oates, 1992). We simply assume that the firms' behavior is Pareto-efficient: given the announced quota, the polluting agent undertakes an effort increasing its costs such that the marginal benefit from reduced pollution equals the marginal abatement cost.

What is the impact of such an environmental policy on the agents' welfare, then on their location decision? We have to consider the two components of S_i.

First, let us consider the centripetal force. It depends on the difference between the real wages (U_1-U_2). Several results are apparent from equations (4), (5) and (6).

Faced with a higher marginal cost, firms lower their production level (5) and raise their price (4). The number of firms in each region is unchanged (6).

It follows that pollution, as a by-product of production, falls since θ is lower and because global output ($n_i x^*$) decreases in both regions. This is the positive impact of the environmental policy.

Workers' wages are unchanged when β increases: using (4), it is easy to see in (7) and (8) that nominal wages are not modified because supply and global demand fall in the same proportion. Real wages are lowered, through higher prices. In equations (9) and (10) we can check that workers' utilities (U_1, U_2) decrease in the same proportion in both regions when β increases. It follows that the difference (U_1-U_2) falls also in the same proportion, and obviously reaches zero ($U_1=U_2$) for the same critical level of r (r^*) whatever the value of β. The interesting result is that the break point, r^*, where the real wage becomes higher in the large region ($U_1>U_2$), is the same whatever the marginal cost level. The result is that the centripetal force is unchanged when β increases.

Let us consider now the centrifugal force. It depends on the difference between the regions' global disutility of pollution. We have underlined that pollution decreases in both region with a higher marginal cost. The important result here is that, because n_i is proportional to L_i (6), the decrease in the global disutility of pollution ($\delta n_i\, \theta x$) is higher in the larger region. As a consequence, the centrifugal force is softened by the environmental policy. Because the centripetal force is unchanged, the striking result of such an environmental policy is to worsen the tendency for firms to agglomerate: compared to the case without environmental policies, concentration occurs now for a higher transportation cost ($r^{*\prime}(\theta)>0$).

4. Conclusions

The empirical evidence indicates that agglomeration of activities occurs, even if it generates excessive pollution. Focusing on the consequences of an environmental policy in a model of economic geography, we show the basis of a moral hazard problem: by reducing the effect of centrifugal force and enlarging the range of transportation costs for which the market size effect dominates, environmental policies increasing the firms' marginal cost may stimulate agglomeration, then global pollution.

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