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Economic Geography and the Environment

Introduction

Economic geography was a largely neglected area of economic theorising until Paul Krugman re-established the field by publishing his short monograph "Geography and Trade" in 1991. He showed how mathematical tools known from modern models of international trade theory can be used to explain the distribution of economic activity in geographical space. The advantage of his approach compared with the earlier literature was the use of comprehensive economic models in which the concept of geographical space was linked to that of general economic equilibrium. The result is a theory that does not rely on *ad hoc* arguments and heuristics to explain spatial patterns of economic activity, but instead builds on a self-contained modelling framework.

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One of the major objectives of my stay at CAS was to use this framework to explain spatial patterns of pollution and population. I conjecture that there are three such patterns that are ideal or 'pure':

- concentration, i.e., a geographical pattern where the most populated regions are the most polluted ones, e.g. big cities such as Shanghai, Mexico City, or Los Angeles;
- the separation of pollution and population, the example being nuclear power stations, which are usually located in peripheral regions with low population densities;
- dispersion, i.e., a pattern where people and pollution are evenly distributed in space.

Of course, these ideal patterns will not be observed in reality in their pure forms (e.g. perfect separation or complete concentration), but nevertheless these concepts are useful as benchmarks to which real-world situations can be compared.

Elements of modern economic geography: Two workhorses, centrifugal and centripetal forces

The main task of a model of economic geography is to generate micro-economic foundations for two forces: centripetal forces, which lead to concentration of economic activities (production and consumption) in geographical space, i.e., agglomeration, and centrifugal forces, which induce economic activities to move away from the agglomerations. This is achieved by using mathematically tractable models of demand, supply and trade. In economic geography, this is achieved by two modelling

'workhorses': so-called Dixit-Stiglitz preferences and melting-iceberg transportation costs. See Fujita et al. (1999) and Baldwin et al. (2003) for overviews.

Simple models of economic geography look at a world consisting of two regions, called 'the East' and 'the West' in the remainder of this paper. People are mobile between East and West and their mobility costs are neglected. There are two commodities, an agricultural good, which for the sake of brevity will not be considered explicitly in the following presentation, and a manufactured good. The manufactured good is potentially available in infinitely many varieties which are close substitutes for each other from the point of view of consumers (e.g., different types of cars). The preferences are modelled such that the ideal world from the representative consumer's point of view is one in which she can choose from a continuum of infinitely many varieties. A formal model to represent this was introduced by Dixit and Stiglitz (1977). This model is one of the two workhorses of modern economic geography. According to Dixit and Stiglitz, the invention and introduction of a new variety into the market involves a high fixed cost, which the consumer must ultimately bear. Thus, there is a trade-off between diversity and low prices. Consumers are willing to give up some diversity if they get fewer products at lower prices. In the end, only a limited number of varieties will be supplied. This generates the possibility of gains from trade. If n varieties are available in the East and n^* varieties in the West, trade between the two regions makes it possible for each consumer to choose among $n+n^*$ varieties. The second workhorse in the economic-geography literature is melting-iceberg transportation cost. Albeit introduced into modern economic theory by Paul Samuelson (1954), the original contribution dates back to the German economist Johann Heinrich von Thünen (1842), who argued that horses pulling carriages of grain from the rural areas to the city are fed with grain from the carriages. Thus, the transportation cost is simply a share of the value of the transported commodity and a transportation sector does not have to be modelled. Transportation cost in connection with the Dixit-Stiglitz approach of love of diversity and fixed cost of production generates centripetal and centrifugal forces that affect the spatial patterns of production (location of firms) and consumption (location of mobile citizens).

- Centripetal forces in this simple modelling context are related to what Fujita et al. (1999, p. 346) call "thick markets". Since transportation is costly, people want to live in the region in which many commodities are produced. Moreover, producers benefit from locating close to where the majority of the consumers live. Thus producers attract consumers and consumers attract producers.
- The centrifugal forces are related to congestion. If the number of consumers in a region is large, this raises the prices of domestically produced goods, which are not affected by transportation costs. This makes the region less attractive to potential immigrants. The other centrifugal force is environmental pollution. People do not like to live in areas where polluting industries are concentrated. On the supply side, the concentration of production in a region will increase the demand for inputs in this region and thus factor prices and production costs.

There are additional centripetal and centrifugal forces in more complex models of economic geography, which allow, e.g., for linkages across firms (See Fujita et al., 1999, p. 346).

The impact of the environment and of environmental regulation

The standard models of economic geography can be extended by taking into account the environmental impact of production activity. Thus, environmental regulation has two effects. On the one hand, tight environmental regulation raises production costs and reduces the economic competitiveness of the region implementing such regulation. On the other hand, people benefit from less pollution and, *ceteris paribus*, prefer to live in less polluted regions. Thus consumers like to be geographically separated from producers who generate environmental harm. Let us consider three cases:

1. All factors of production are immobile. Production capacities are installed in a region and can be relocated only at some cost in the long term. In the short term, these capacities are fixed.
2. Capital is mobile. This is the longer-term view in which capacities can be relocated from one region to the other. Note that capital owners do not have to live in the region where their factors are employed.
3. Workers are mobile. In a mobile-workers' model, the owner of a factor of production (the worker) must live close to the place where her factor (labour) is employed. This restricts flexibility and generates results that are different from those obtained for a world in which factors and their owners can be separated geographically.

Some results

In a first step, consider a scenario in which factors of production are immobile, but their owners are mobile. People like to live close to the producers if environmental problems are minor and if transportation costs for manufactured goods are high. Stricter environmental regulation can lead to inward or outward migration. Outward migration is the result if the dominant effect of environmental regulation is to raise the cost of production. If the increase in cost is dominated by the environmental effect, however, the region using stricter environmental policies becomes more attractive and there will be inward migration. An interesting result turns up if we look at optimal environmental regulation. In most economic models of environmental regulation, the government of a jurisdiction has no incentives at all to take transfrontier spillovers of its domestic pollution into account and, as a consequence, environmental policy will be too lax. This is different in the economic-geography model with mobile residents. If people can freely choose where they want to live, there will be a migration equilibrium determined by the fact that potential migrants are equally well off in both regions. Thus, well-being in the neighbouring jurisdiction determines the well-being of domestic citizens. This forces the domestic government to take foreign well-being into account and, therefore, to care about cross-border pollution spillovers. Finally, as a last result, I was able to show that all three patterns – concentration, hot spots and dispersion – are possible. (See Rauscher, 2005).

The second case is that of mobile capital. Capitalists do not have to live at the location where their source of income is employed. They choose

their location of residence on the basis of environmental quality and consumption possibilities. If the environmental impact of production is severe, they prefer to live in a non-industrial region. If the environmental impact of production is minor, they prefer to live close to where production takes place. Producers, in contrast, always like to be close to consumers. They benefit from large local markets since there are transportation costs. As a consequence, we obtain two patterns that I call 'agglomeration' and the 'chase' (See Figures 1 and 2). In each figure, there is a kinked line indicating that producers are unwilling to relocate if the sizes of the two markets are equal or if 100 per cent of production capacity is in the region where population density is higher. Otherwise, they relocate to the more densely populated region. Factor owners are characterised by the other indifference line, which may slope upward or downward. If environmental harm or environmental concern is small, then this line will slope upward. People want to live close to the places where the goods they want are produced. *Ceteris paribus*, however, they avoid congestion. People move to the East if many people live in the West. This is the horizontal component of the dynamics depicted by the arrows in Figures 1 and 2. In Figure 1, the complete dynamics composed of the horizontal and the vertical components point to agglomeration: the industry wants to be close to consumer and the consumers want to be close to the industry. In Figure 2, however, environmental concern is large and the mobile residents' indifference line is negatively sloped. The result is the 'chase', i.e. a situation in which, again, the industry wants to be close to the consumers, but the consumers flee the industry.

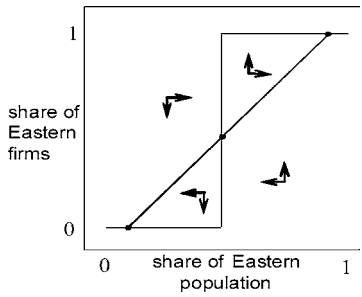

Figure 1: Low environmental concern: agglomeration

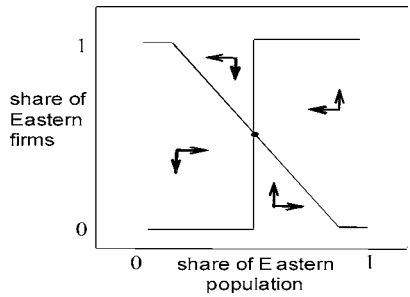

Figure 2: Large environmental concern: the chase

The third scenario is the mobile workers' model, i.e. factor owners have to live where their factors are employed. In this case, we have the Krugman-type economic-geography model with agglomeration. As long as environmental problems are not too severe, economic activity tends to be concentrated in one region. Workers benefit from high wages and low commodity prices if they move to agglomerations. Matters are different if environmental harm is substantial. Then workers do not like to live in agglomerations. However, production is impossible without workers living in the vicinity of the plants. The result then is dispersion: in a world of two symmetric regions, 50 per cent of the population and 50 per cent of industry are located in each region. Thus, it appears that consideration for the environmental impact of production mitigates agglomeration forces. As a final result, one can show that changes in environmental regulation may have a dramatic impact on the regional patterns of production in

situations with agglomeration. Small changes in environmental regulation may make agglomeration equilibria vanish. For example, a stable agglomeration equilibrium with 80 per cent of the population living in one region and 20 per cent living in the other disappears and, as a result, the patterns of agglomeration are reversed so that workers and producers move to the other region.

Extensions

My recent work with Edward Barbier has concentrated on combining models of economic geography with bioeconomic approaches to biodiversity (See Rauscher/Barbier, 2006). We look at endemism versus redundancy of species and develop conditions for the establishment of protected areas, where production activities are completely prohibited. It is shown there that the bioeconomic categories of endemism and redundancy interact with the economic-geography parameters, resulting in agglomeration and dispersion. Further research in this area is underway.

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