Università degli Studi di Ferrara

DIPARTIMENTO DI ECONOMIA, ISTITUZIONI, TERRITORIO

Corso Ercole I D'Este n.44, 44100 Ferrara

Quaderni del Dipartimento

n.2/1998

February 1998

A Two-Region Model of Economic Geography with External Economies of Scale

Luisa Beltramello

February 1998

A Two-Region Model of Economic Geography with External Economies of Scale♣

Luisa Beltramello♦

Abstract

This paper develops a two-region, two-sector general equilibrium model of economic geography, where the manufacturing sector is characterised by constant returns to scale at a firm level and by increasing returns at an industry level. The simultaneous presence of low transportation costs, a large share of manufacturing in expenditure, a high value of external economies and a low regional size in one of the two regions gives raise to a pattern of location in which one region becomes the manufacturing core and the other the agricultural periphery. Thus, with external economies of scale, regional divergence depends in a crucial way by the presence of a large population in the region of defection

♣ I would like to thank Carlo Perroni (Warwick University) for his helpful comments

♦ Dottorato di Ricerca "Economia e Istituzioni", University of Bologna, postal address: c/o Bocconi University, Via U. Gobbi, 5, 20136 Milano, tel. 02/58365406, fax. 02/58365439, E-mail: luisa.beltramello@uni-bocconi.it

1. Introduction

Economists have long ignored the relationship between spatial theory and economics. In particular economists have assumed the international trade to be dimensionless, with zero or uniform transport costs.

An important contribution to the theory of economic geography has come from the work of Paul Krugman. In his 1991 paper, he has defined economic geography as "the location of production in space" and he sustains that economic geography has a central role in determining the national economic prosperity and trade. He has argued that, to better understand what happens in the world economy, it is necessary to start by examining what happens inside nations and to say something about location of economic activity in space it is necessary to conceptualise market structure. Furthermore, Krugman [16] says that "the most striking feature of the geography of economic activity is surely concentration" and that this geographical concentration is given by the pervasive presence of increasing returns. But increasing returns are more difficult to model than constant returns, and thus until recently the role of scale economies was neglected.

Two approaches are particularly relevant to the analysis of increasing returns and geographical concentration: the Marshallian and the Chamberlinian approaches. The Marshallian approach is based on the fact that economies of scale are external to firms, so the assumption of perfect competition is fully respected. Also Marshall distinguishes between internal and external economies. The presence of external economies is seen as an important element for agglomeration, because it focuses on increasing returns arising from interactions among firms. The Chamberlinian model is a formal model of monopolistic competition in which competition is among similar firms producing differentiated products that are close substitutes. This approach generally deals with intermediate products and services, where the possibility of differentiation is high and the market too small to exhaust the presence of scale economies.

Krugman‘s model of economic geography considers mainly internal economies of scale, in a Chamberlinian setting, and deals only briefly with diffusion of activities in the space. He sees externalities as difficult to measure and their general locational significance is seen as limited.

This paper tries to show how the introduction of such external economies of scale provides a plausible explanation for the rise of regional agglomeration. At this end, we develop a two-region model of economic geography à la Krugman where the manufacturing sector is characterised by increasing returns at an industry level and by perfect competition and constant returns to scale at a level of the n firms composing that industry. In this setting, we find that the pattern of localisation is determined by some value of the parameters representing transportation costs, scale economies and the share of income spent in manufacturing goods. The interesting result is that, in our model, regional divergence also depends in a crucial way on the presence of a large population in the region of defection.

The paper is organised as follows. The first section presents a brief survey of spatial theory and location theory. The second section sets out a model of economic geography with externalities, and the last one discusses our findings.

2. Theoretical approach

To better understand the relevance of the space in economics, it can be useful to examine part of the literature related to industrial location and economic geography.

The study of industrial location is one of the most important part of economic geography. The starting point of the modern industrial location theory is given by the contribution of A. Weber (Smith [28]). He sustains that there are two regional factors of transport and labour costs and one local factor of agglomerative or deglomerative forces influencing industrial location. Transport costs are viewed as the main determinant of plant location. Then, he derives a least-transport-cost location by using a so-called “locational triangle”. Other significant contributions are given by A. Lösch [21] who rejects the least transport cost location approach of Weber, producing the first location theory with demand as the major spatial variable; by M. Greenhut [8, 9] who deduces that the location factors are transportation and processing costs, the demand factor and what he describes as cost-reducing and revenue increasing factors. As in Weber, transportation costs are viewed as the main determinant of plant location; by W. Isard [12] who stresses the need for integration of location theory with other aspects of economic theory, using the so-called “principle of substitution”, and explaining that the way in which labour can be substituted for capital or land is equivalent to the problem of establishing the selection of a plant site among alternative locations.

The literature on economic geography is, instead, very recent. The main contribution has been given by Paul Krugman. Krugman [17] has looked at the dynamic implications of a model of economic geography examining three different theories: the theory concerned with “market potential” (Harris, [10]) that proposes that the desirability of a region as a location for production depends on its access to markets; the literature focused on cumulative processes in regional growth (Pred [26], Dixon and Thirwall [5]), suggesting that the initial advantages of some location is well explained by historical accident; and the central place theory (Christaller [3]) that addresses the trade-off between economies of scale and transportation costs. An additional perspective is given by the analysis of Krugman and Venables [18] who describe what determines the location of industries at the centre or at the periphery of the world. They find that there are strong forces that determine the concentration of manufacturing in the central economy at the expense of the periphery. In particular, when trade barriers are low, production move to the centre and the periphery becomes an importer of manufacturing good. From our point of view the most interesting contribution of Krugman is given by the two-region, two-sector general-equilibrium model of trade and production location decisions (Krugman [14]) where individuals maximise their utility function and producers their profit function. There are two sectors, manufactures and agriculture, using only one factor of production, labour. The population is rigidly divided between factory workers and farm workers (peasants). The former can freely move between regions while the latter are tied to land. Agricultural goods are produced in conditions of perfect competition with constant returns to scale and can be transported between regions without costs. Manufactured goods are differentiated in a greater number of variety, produced under increasing returns to scale, and they are subject to transportation costs of iceberg type, that is, for each unit of manufactures transported only a fraction $t < 1$ arrives. In this kind of economy, the presence of lower transport costs, strong scale economies and a high share of income spent in manufacturing goods will give raise to the concentration of all manufacturing industries in only one region.

3. A model of economic geography with external economies of scale

As we have briefly seen in the introduction, the concept of external economies is frequently used to explain scale economies due to agglomeration of economic activities, because these economies are viewed as external to individual firms. In this case increasing returns to scale become compatible with perfect competition. In fact, returns to scale are constant at the firm level while at the industry level, increasing returns to scale take the form of external economies.

Following Scitovsky [27], a broader definition of external economies that includes direct interdependence among producers and also interdependence through the market mechanism can be identified as a “pecuniary” external economy. In this case, externalities are created by investment of one producer that can lower prices of its products and raise the prices of its factors of production, benefiting users of these products and suppliers of these factors. When these benefits go to firms in the form of profits, they are defined as pecuniary external economies.

Within the equilibrium theory a definition is given by Meade [24]. For him, external economies exist when the output of a firm depends not only on the factor of production utilised by this firm but also on the output and on the factor of production of another firm or group of firms. Furthermore, he said that in this case there are constant returns to scale in each firm to the factors under its control, but there are no constant returns for the firms taken together, because activities of one firm may provide an “atmosphere” which is favourable to the activities of others. These external economies are characteristics of the production function, and they can be called, always following Scitovsky [27], “technological” external economies, and they indicate only a direct interdependence among producers.

In this case, the production function of a representative firm in an industry can be assumed to depend on the vector of inputs v utilised by the firm and on the vector of external effects x (Helpman and Krugman [11]) and it is given by

$$x_i = f_i(v_i, x).$$

The vector of external effects indicates all the elements that can influence the productivity of the representative firm, that is, it can indicate the size of the industry, the employment level or the aggregate output of the industry.

The usual formulation for this latter assumption is to assume that scale effects enter in a multiplicative form

$$X = g(X) f(v),$$

where *f(v)* shows constant returns to scale, while the industry production function is given by

$$X=F(v),$$

where *F(v)* shows increasing returns to scale, with an assumption of average cost pricing.

There are different theories to justify this formulation. For example, Ethier [6] suggests that a larger industry can sustain an expansion in the production of intermediate inputs at lower costs. Other justifications indicate that the freedom of entry in an industry can lead to an average cost pricing.

The microeconomic aspect of external economies is particularly useful to interpret processes of spatial diffusion of economic activities. It has been noted that in a perfectly competitive world, there is no need of transporting goods from a location to another and identical remunerations of factor of production results. Instead, the existence of scale economies internal to the firm can lead to a spatial concentration of economic activities.

But after Marshall and his Principles of Economics (Marshall [22]), other factors have been identified as responsible for agglomeration. Marshall himself recognises the existence of internal and external economies as important factors for geographical distribution of industries.

According to him: “We may divide the economies arising from an increase in the scale of production of any kind of goods in two classes: firstly, those dependent on the general development of the industry; and, secondly, those dependent on the resources of the individual houses of business engaged in it, on their organisation and the efficiency of their management. We may call the former *external economies*, and the latter *internal economies*. [..] but we now proceed to examine those very important external economies which can often be secured by the concentration of many small businesses of a similar character in particular localities: or, as it is commonly said, by the localisation of industry" (Marshall [22], Book IV, Chapter IX, p.221).

In this framework, it is possible then to identify two kinds of external economies: economies of localisation and urbanisation economies. The former show how external economies confer advantages to localised industries through hereditary skill, growth of subsidiary industries, use of highly specialised machinery, and local market for special skill (Marshall [22], Book IV, Chapter X). These factors determine, in a concentrated area, a labour market pooling for workers with specialised skills, that benefits workers and firms; a greater availability of inputs specific to the industry, at a lower cost; and the presence of technological knowledge spillovers, since information flows more easily in a concentrated location than over big distances. The result is an "industrial district" atmosphere where it is possible to see a trade-off between agglomeration forces and disadvantages of localisation resulting from concentration of several firms serving the same market and from increasing costs of inputs.

The second ones refer to the advantages that a firm in any industry can receive from locating in some large urban-industrial complex, like a big city or an industrialised region, and that are available to any firm independently on the industry to which it belongs (Smith [28]). The main advantages of being close to a large city or to an industrial region are the existence of public non-specific goods, like infrastructures or services. These advantages manifest themselves through the reduced cost of specific inputs, but while this kind of advantage may be clear and easily measured, it is important to notice that the main benefits from agglomeration may be given by several intangible and not easily measurable factors. Every firm that want to develop and innovate can have access to the urban environment, and manufacturers probably know that it will increase their efficiency or lower total costs.

In the following, we will introduce a formal model, with complete microfoundations, that tries to integrate external economies with industrial location and economic geography theories.

3.1 A model of external economies of scale

We begin with a model of perfect competition under increasing returns to scale, where economies of scale are external to individual firms.

Following Chipman [2], we consider an industry, composed by *n* firms, producing a single product with the aid of a single factor of production, labour. Every firm has access to the same technology and it is assumed to believe to operate under constant return to scale. The production function of each firm in the industry is given by

$$x_i = Al_i ; \qquad A \geq 0 , (i=1,2,...n), \tag{3.1}$$

where x_i is the amount of the commodity produced by the *i*-th firm, l_i is the amount of labour employed by each firm and *n* is the number of firms in the industry.

Then the labour used in producing the goods by each firm will be denoted by

$$l_i = \frac{x_i}{A} . \tag{3.2}$$

The industry production function is given by

$$X = AL , \tag{3.3}$$

where $X = \sum_{i=1}^{n} x_i$ and $L = \sum_{i=1}^{n} l_i$

External economies of scale are introduced in the following way. The term A is taken as a constant by each firm, but for the industry the scale effect A can be related to the aggregate quantity of employment as follows:

$$A = aL^{r-1}; \quad a > 0, r > 1, \tag{3.4}$$

where $r > 1$ indicates the presence of increasing returns to scale at the industry level.

Then, the production function of the industry becomes

$$X = aL^{r}. \tag{3.5}$$

The scale effect A can alternatively be expressed in terms of the aggregate output in the following way:

$$A = mX^{h}; \qquad -\infty < h < 0. \tag{3.6}$$

In this case the production function will be

$$X = m^{\frac{1}{1-h}} L^{\frac{1}{1-h}}, \tag{3.7}$$

which is the same as before if we assume $r = 1/1 - h$ and $a = m^{r}$.

Therefore, the labour used to produce the good at an industry level is

$$L = \left(\frac{X}{A}\right)^{1/r}. \tag{3.8}$$

It is possible to see the difference with Krugman’s original model where economies of scale were internal to firms, and expressed by a cost function with a fixed cost in terms of labour and a marginal cost. Now the marginal product of labour at a firm level is given by

$$\frac{\partial X}{\partial l} = A = al^{r-1}, \tag{3.9}$$

and there are no fixed costs.

The cost of production is given by

$$C = wl \, . \tag{3.10}$$

Hence, the cost function for each firm and for the industry will be obtained by substituting the production functions (3.2) and (3.8) respectively in this cost function. We will get

$$C_i = wl = w\frac{x_i}{A} \qquad \text{for each firm,} \tag{3.11}$$

$$C = wl = w\left(\frac{X}{a}\right)^{1/r} \qquad \text{for the industry.} \tag{3.12}$$

Each firm fixes its price in order to maximise its profits. Since the competing firm must take the market price as given, hence it engages in marginal cost pricing, where marginal cost is taken as those that are perceived by the firms. But in this case, because the scale effect is treated as a constant by the firm, the marginal cost coincides with the average cost and the profits will go to zero. The profit maximising price for each firm is therefore

$$p = \frac{\partial C_i}{\partial x} = \frac{C_i}{x} = \frac{w}{A} = wa^{-1/r}x^{(1-r)/r} \, . \tag{3.13}$$

For the industry marginal cost differs from average cost. We can write these two costs respectively as

$$\frac{\partial C}{\partial X} = \frac{1}{r}wa^{-1/r}X^{(1-r)/r} \qquad \text{(marginal cost)} \tag{3.14}$$

$$\frac{C}{X} = wa^{-1/r}X^{(1-r)/r} \qquad \text{(average cost)} \tag{3.15}$$

The ratio of average cost to marginal cost is one measure of economies of scale, and in this case it will be equal to r that is just the parameter representative of increasing returns to scale in the production function.

We have to consider now the issue of whether goods are priced according to marginal or average costs. From the point of view of the firm we have seen that profit maximising prices are equal to marginal as well to average costs. From the point of view of the industry, however, we will have an assumption of average cost pricing. In fact, in equilibrium profits will be driven to zero by the condition of free entry, implying that the output of the industry is given by

$$X = \left(\frac{p}{w}\right)^{r/(1-r)} k^{1/(1-r)} = \left(\frac{1}{K}\right)^{r/(1-r)} k^{1/(1-r)}, \tag{3.16}$$

By substituting this equation in (3.8) we get the quantity of labour used in each process:

$$L = \left(\frac{p}{w}\right)^{1/(1-r)} k^{1/(1-r)} = \left(\frac{k}{K}\right)^{1/(1-r)} \quad . \tag{3.17}$$

The difference with the Krugman model is evident. In this case the only things that matter are the scale effect and the parameter indicating the presence of increasing returns to scale, while in the monopolistic competition approach the unit of labour depends on the parameter representing the preference for variety s and on the fixed cost a.

3.2 The two-region model

We consider now a two-region model à la Krugman (Krugman [14]) with the manufacturing sector characterised by external economies of scale.

Assumptions of the model

There are two regions, North and South, producing two types of goods, agricultural and manufacturing good. The agricultural good is produced under constant returns to scale in conditions of perfect competition. The manufactured good is now produced by the *n* firms of an industry as that described before. The agricultural sector is tied to land and its output can be transported without costs. The manufacturing sector can be located in both regions and the distribution of its output from one region to the other is subject to transport costs of the iceberg type, that is, only a share $t < 1$ of each unit of manufactures reaches its destination.

All individuals have the same preferences, represented by a Cobb-Douglas utility function

$$U = C_A^{1-m} C_M^{m} \ ,$$

where C_A and C_M represent the agricultural good and the aggregate manufactured good and m the share of income spent in manufactured good.

The aggregate output for the manufactured good is given by the sum of all the output levels in each of the n firms in the industry

$$X_M = \sum_{i=1}^{n} x_i \ .$$

The size of the population is 1, with (1- m) peasants and m workers. Indicating with L^N and L^S the workers supply respectively in the North and in the South, we assume

$$L^N + L^S = m \ .$$

Peasants produce the agricultural good and workers the manufacturing good. Peasants cannot become workers and viceversa, and the distribution of peasants is assumed fixed, with $(1-m)/2$ peasants in each region, while workers are free to move between regions, depending on the wage rate offered.

The pattern of location

We ask if concentration of manufacturing will arise in one of the two regions, given the presence of transport costs and externalities for manufactured goods. To answer to this question, it is possible to assume that all manufacturing activities are concentrated in one region, the North, while the other region produces only agricultural goods.

We want to investigate under which conditions will be profitable for a firm localised in the North, enjoying of externalities and agglomeration advantages, move in the other region, the South. To change location, a firm needs to persuade workers to move to the South, paying them a wage that maintains their previous level of utility. Furthermore, it will only move if its profits are non-negative.

When a firm move to South, in the North there will be n-1 firms still producing the single homogeneous good, while in the South now there is a firm that produces the same good at a price such that $p^S = \frac{p^N}{t}$; that is, the only possible price of equilibrium for production in the South will be equivalent to the price of imports from the North.

Initially, we can assume that consumers continue to buy the manufacturing good from both regions; then, following Gorla and Folloni [7], we can proceed to analytically define the two conditions of defection.

To start to produce in the South, a typical firm of the North has to be able to attract manufacturing workers. We can first examine the general case in which we have a symmetric industrial structure in the two regions, with L^N workers in the North and L^S workers in the South. Then we will show how this solution works with the population concentrated in the North.

The utility given to workers must be the same in the two regions, because in order to move to the South workers have not to see their utility reduced. We have seen that all consumers share the same Cobb-Douglas utility function. Then the condition of equality of real wages for manufacturing workers can be expressed as

$$U^N = U^S \ ,$$

which becomes

$$C_{A(N)}^{1-m} C_{M(N)}^{m} = C_{A(S)}^{1-m} C_{M(S)}^{m} \quad \text{or}$$

$$\left(\frac{C_{M(S)}}{C_{M(N)}} \right)^m = \left(\frac{C_{A(N)}}{C_{A(S)}} \right)^{1-m} .$$

The demand of the agricultural good from workers is (in the North and in the South respectively)

$$C_{A(N)} = \frac{(1-m)w^N}{p^A} \ ; \qquad C_{A(S)} = \frac{(1-m)w^S}{p^A} \ ;$$

and the demand of the manufactured good is

$$C_{M(N)} = n^N x_N^N + n^S x_N^S \ ; \qquad C_{M(S)} = n^S x_S^S + n^N x_S^N \ ;$$

where $n^N = n-1$ and $n^S = 1$; p^A is the price of agricultural good, that, because of the assumption of zero transport costs, is the same in both regions; the variables x denote the individual consumption of manufactured good, where the superscript indicates the region of production of the good and the subscript the region of residence of consumers. Then, we can write

$$x_N^S = \frac{mw^N}{p^S/t} \quad \text{and} \quad x_S^N = \frac{mw^S}{p^N/t} \ .$$

After some manipulation, we obtain a general condition of equality of utilities

$$\left(\frac{w^S}{w^N} \right)^m \left(\frac{n^S p^N + n^N p^S t}{n^N p^S + n^S p^N t} \right)^m = \left(\frac{w^N}{w^S} \right)^{1-m} ;$$

which, when we consider the case of manufacturing concentrated only in the North (then $n^S \to 0$), becomes

$$\frac{w^S}{w^N} = \left(\frac{1}{t} \right)^m .$$

At this point we will have that the size of the manufacturing population in the North is L^N and that L^S workers will move to the South. In this framework, we will conduct the analysis at the firm level. Therefore, we can consider the second condition for defecting (i.e., to move to the South), that is, profits for the firm must be non-negative. Using S^N and S^S to denote the revenues of the firm in the North and in the South respectively, we can write this condition as

$$\frac{S^S}{S^N} \geq \frac{w^S l^S}{w^N l^N} \quad .$$

The revenues of the firm in the Southern region will be given by what this firm sells to workers and peasants in the South and to workers and peasants in the North. Therefore,

$$S^S = p^S x_S^S L^S + p^S x_{AS}^S \frac{L^A}{2} + \frac{p^S}{t} x_N^S L^N + \frac{p^S}{t} x_{AN}^S \frac{L^A}{2} \quad ,$$

where x_{AS}^S denotes the demand of manufactured good produced in the South from peasants living in that region and is given by

$$x_{AS}^S = \frac{mw^A}{p^S} = \frac{mw^A}{p^S} \frac{mw^S}{mw^S} = x_S^S \frac{w^A}{w^S} \quad ,$$

and x_{AN}^S is the demand of manufactured good produced in the South, from peasants living in the North, expressed as

$$x_{AN}^S = c_S^S \frac{w^N}{w^S} t \frac{w^A}{w^N} \quad .$$

Assuming that the agricultural output is equal to the agricultural population, and since the agricultural wage is equal to the price, we can write the zero profit condition for the agricultural sector as

$$w^A L^A (1-m) + w^S L^S (1-m) + w^N L^N (1-m) = p^A L^A = w^A L^A \quad .$$

Collecting terms and solving for w^A, we obtain

$$\frac{w^A}{w^S} = \frac{1-m}{m} \frac{L^N \frac{w^N}{w^S} + L^S}{L^A} \quad ;$$

$$\frac{w^A}{w^N} = \frac{1-m}{m} \frac{L^N + L^S \frac{w^S}{w^N}}{L^A} \quad .$$

After substitution, in S^S, and after some manipulation, we get

$$S^S = \frac{p^S x_S^S}{m} \left(L^S + L^N \frac{w^N}{w^S} \right) \quad .$$

In the same way, we will have, for the Northern region,

$$S^N = p^N x_N^N L^N + p^N x_{AN}^N \frac{L^A}{2} + \frac{p^N}{t} x_S^N L^S + \frac{p^N}{t} x_{AS}^N \frac{L^A}{2} \quad ,$$

where x_{AN}^N denotes the demand of domestic manufactured good from peasants in that region and it can be written as

$$x_{AN}^N = \frac{mw^A}{p^N} = x_N^N \frac{w^A}{w^N} \quad ;$$

and in a similar way, x_{AS}^N is given by

$$x_{AS}^N = x_N^N \frac{w^S}{w^N} t \frac{w^A}{w^S} \quad .$$

As before, after some manipulation, we get

$$S^N = \frac{p^N x_N^N}{m} \left(L^N + L^S \frac{w^S}{w^N} \right) \quad .$$

Hence, we can obtain the revenues of the defecting firm in the South relative to those of the firm in the North

$$\frac{S^S}{S^N} = \frac{p^S x_S^S}{p^N x_N^N} \frac{L^S w^S + L^N w^N}{L^N w^N + L^S w^S} \frac{w^N}{w^S} = \frac{p^S x_S^S}{p^N x_N^N} \frac{w^N}{w^S} \quad .$$

Now, we know, from the structure of the costs of our firm, that the labour used to produce the output in the South and in the North respectively are given by

$$l^S = \frac{x^S}{A^S} \ , \quad \text{and} \qquad l^N = \frac{x^N}{A^N} \ ,$$

where A^S can be considered as a constant by the defecting firm, because when it moves to the South, it will lose the scale effect present at the industry level in the North. At the same time, also A^N is taken as constant for the firm, but for the industry in the North it is now equal to

$$A^{N'} = aL^{N' r-1} \quad \text{with} \quad L^{N'} = \sum_{i=1}^{n-1} l_i \ .$$

Considering a firm level, we can write the ratio l^S / l^N as

$$\frac{l^S}{l^N} = \frac{x^S}{A^S}\frac{A^{N'}}{x^N} \ ,$$

and, after some manipulation

$$\frac{l^S}{l^N} = \frac{w^S}{w^N}\frac{A^{N'}}{A^S} t \ = t^{\,1-m} \frac{A^{N'}}{A^S} \ .$$

The sufficient condition for defecting becomes

$$\frac{S^S}{S^N} = \frac{p^S x_S^S}{p^N x_N^N}\frac{w^N}{w^S} \geq \frac{w^S}{w^N} t^{\,1-m} \frac{A^{N'}}{A^S} \ ;$$

and after some substitution we will get

$$\frac{S^S}{S^N} = \frac{1}{t^{\,1-2m}}\frac{A^S}{A^{N'}} \geq 1 \ .$$

We can see that when $\frac{S^S}{S^N}$ is greater than 1, it will be profitable for a firm to start to produce in the South, and thus the concentration of the manufacturing sector in one region is not sustainable. Instead, if $\frac{S^S}{S^N}$ is less than 1, a core-periphery equilibrium will be possible.

We can now investigate the implications of this formulation for the sustainability of a core-periphery pattern of industrial location. Relative sales depend on the parameter representative of transport costs t, on the share of income spent on the manufactured good m, and on the scale effect present only in the Northern region $A^{N'}$.

Before trying to assign some numerical value to the different parameters we can notice that scale economies, and also relative sales, depend on the size of population present in the North, but, residually, also on the size of population that left this region, because $L^{N'} = \sum_{i=1}^{n-1} l_i$.

However this parameter does not directly appear in our formula. To better examine this intuitive fact, we will assume that consumers in both regions consume only domestic goods. This seems a more reasonable framework when two regions produce the same good, as in our model.

The Autarky Framework

To start to produce in the South the defecting firm has to attract workers.

The consumption of the single manufactured good in the two regions will be now given by

$$C_{M(N)} = x_N^N = \frac{mw^N}{p^N} , \qquad C_{M(S)} = x_S^S = \frac{mw^S}{p^S} ,$$

The consumption of the agricultural good by manufacturing workers is not changed, then the condition of real wages equilibrium is

$$\frac{w^S}{w^N} = \left(\frac{1}{t}\right)^m ,$$

that is just the condition obtained before.

The second condition can be expressed in the same way as before, that is, non-negativity of profits implies

$$\frac{S^S}{S^N} \geq \frac{w^S l^S}{w^N l^N} \ .$$

But now the revenues of the defecting firm will come only by what it sells to workers and peasants in the South, that is

$$S^S = p^S x_S^S L^S + p^S x_{AS}^S \frac{L^A}{2} \ ,$$

where $x_S^S = \frac{mw^S}{p^S}$ and $x_{AS}^S = x_S^S \frac{w^A}{w^S}$.

Assuming that the agricultural output is equal to the agricultural population, the zero profit condition for the agricultural sector in the Southern region is given by

$$w^A L^A (1-m) + w^S L^S (1-m) = p^A L^A = w^A L^A \ ,$$

from where we get

$$\frac{w^A}{w^S} = \frac{1-m}{m} \frac{L^S}{L^A} \ .$$

After substitution in S^S we obtain

$$S^S = \frac{p^S x_S^S}{2m}(1+m)L^S \ .$$

In the same way, for the Northern region, we have

$$S^N = p^N x_N^N L^N + p^N x_{AN}^N \frac{L^A}{2} \ ,$$

where $x_N^N = \frac{mw^N}{p^N}$ and $x_{AN}^N = x_N^N \frac{w^A}{w^N}$.

The zero profit condition for agriculture in the North can be expressed as

$$w^A L^A (1-m) + w^N L^N (1-m) = p^A L^A = w^A L^A \ ,$$

then

$$\frac{w^A}{w^N} = \frac{1-m}{m}\frac{L^N}{L^A} \ .$$

After substitution in S^N, we get

$$S^N = \frac{p^N x_N^N}{2m}(1+m)L^N \ .$$

Now we can write relative sales in the South as

$$\frac{S^S}{S^N} = \frac{w^S}{w^N}\frac{L^S}{L^N} \ ,$$

and the condition of non-negativity of profits becomes

$$\frac{S^S}{S^N} = \frac{w^S}{w^N}\frac{L^S}{L^N} \geq \frac{w^S}{w^N}\frac{l^S}{l^N} \ .$$

As seen before, we know from the structure of the production function and costs that

$$l^S = \frac{x^S}{A^S} \quad \text{and} \quad l^N = \frac{x^N}{A^N} \ ,$$

and that A^S is considered as a constant, at least in the short run, because the defecting firm has lost the possibility of enjoying externalities present in the North when it moved in the other region.

A^N , at an industry level will be given, as before, by

$$A^{N'} = aL^{N'\,r-1} \ ,$$

where $L^{N'}$ is now given by $L^{N'} = \sum_{i=1}^{n-1} l_i$.

This means that the scale effect has been slightly reduced by the move of one firm to the South. Also the production function will be slightly modified as well as the demand because workers are also consumers.

Bearing in mind all these things, we can write

$$\frac{l^S}{l^N} = \frac{x_S^S}{A^S} \frac{A^{N'}}{x^{N'}} = t^{1-m} \frac{A^{N'}}{A^S} \ .$$

And the condition of non-negativity of profits will be

$$\frac{S^S}{S^N} = \frac{L^S}{L^N} \frac{1}{t^{1-m}} \frac{A^S}{A^{N'}} \geq 1 \ .$$

As before, if the value of relative sales is greater than one, it will be profitable to start production in the South, and only if relative sales are less than one there will be a core-periphery equilibrium.

Determinants of Equilibrium

Looking at the formula, we can observe that the value of relative sales will depend on the same parameters discussed before (that is, the value of transport costs, that of the share of manufactures in expenditure and the scale effect), but now there is another parameter of interest, namely the relative size given by the ratio of Southern population to Northern population.

At this point, we can try to assign some numerical value to the different parameters to better determine in which cases we will have a certain pattern of location.

Before starting, we have to remember that the parameter relative to transport costs can assume any value included between zero and one, and the same can be said for the share of expenditure. Then, when $t \rightarrow 0$ transport costs are very high, and when $m \rightarrow 0$ the share of income spent in manufacturing is very low. And viceversa.

Hence, we begin to simulate the model assigning some hypothetical value to every parameter, given the value of others.

We can say that when $t \rightarrow 1$ (i.e., low transport costs) and $m \rightarrow 1$ (i.e. high share of manufacturing in expenditure) the result will be indeterminate, depending on the values assumed by the other parameters. When we have the opposite (i.e., high transport costs and low share of expenditure), it would be convenient to defect, given the value of the other parameters.

Considering next the relative regional size, we assume that the total manufacturing population is L^M = 100.000. Therefore, we can observe that when the population in the South is much higher than the population in the North, always taking the value of the other parameters constant, it would be convenient to defect. If the size is equal in the two regions, the result will be indeterminate, depending on the other parameters.

Finally, if r (the parameter indicating the importance of external economies) is high (i.e., much greater than one), it would not be convenient to defect, always given the values of the other parameters. But, if $r \to 1$, the scale effect $A^{N'}$ would be more or less a constant (i.e., there are no more scale economies) and the result would depend on the value of the other parameters.

Now we can try to combine together these results. When we consider the presence of low costs, high share of expenditure in manufacturing, high value of scale economies, and low ratio of Southern population to Northern population, it can be concluded that the defection is not advisable for any value of the parameters. Instead, with very high costs, very low share of income spent in manufacturing, a high relative regional size in the South and some low value of external economies, it could not be possible to sustain a core-periphery pattern.

Therefore, a pattern in which one location becomes the manufacturing core and the other the agricultural periphery depends on some combinations of low transportation costs, a large share of manufacturing in expenditure, a large value of the parameter expressing the externality and a low regional size in the South relative to that in the North.

Some comments

The presence of external economies of scale gives, then, a result really similar to that obtained in Krugman (Krugman [14]), but it narrows the region of parameters for which regional divergence is an equilibrium. But the more significant difference is given by the presence of relative regional size influencing the pattern of location. In our model with external economies of scale, then, we have a sort of urbanisation economies where the localisation of an industry depends also on the size of the population living in one region. The interpretation and modellisation of urban dynamics are just begun within the economists, then, it is not too easy to do some comparison between this literature and our findings. We can only say that in these kind of models, like in our, scale economies are different from those considered in Krugman. They are agglomeration economies that push firms to produce in proximity of a big city (or region) to benefit of better infrastructures, of a specialised labour force, of a more efficient informative system and of lower costs at an aggregate level. Instead, in Krugman, these positive externalities are given by the concentration of production in few locations deriving from the presence of scale economies internal to each firm. This difference is expressed in the different market structure; while the assumption of increasing returns to scale needs a market structure alternative to that of perfect competition, with external economies of scale we have been able to maintain a perfectly competitive framework.

However, we have to consider that there are not only advantages deriving from a localisation of a firm in a large urban area. Those firms that locate in a city face problems as higher price to pay for certain inputs, such as land, taxes, etc., traffic congestion and lack of space. These disadvantages are become an important part of the modern world. These facts can be seen as in contrast with our findings, but the balance of advantages for a firm still appears to favour the localisation in a large-size region. Hence, the pattern of geography that emerges will depend sensitively on the fact that one region has more population than another.

4. Conclusions

This paper has presented a model of economic geography with two regions, two sectors and one factor of production, in a framework of external economies of scale and perfect competition. We have started our analysis by examining the literature relative to industrial location and economic geography. We have seen that the first contribution that gave rise to the traditional location theory came from Weber and his "location triangles" and that all the authors considered has also been useful to Krugman to explain how to understand his work. Paul Krugman's work has been very influential in sustaining a view that assigns a key importance to the role of internal geography of a nation. He develops a very simple model of regional divergence based on the interaction of economies of scale and transport costs. At the end of his models, he finds that a core-periphery pattern of industrial location can emerge, depending on some combination of values of few key parameters. We have then investigated some literature relative to external economies of scale to better understand how they can be influential in determining a pattern of location and to try to give rise to a framework alternative to that of monopolistic competition and internal economies of scale developed in Krugman's models of economic geography.

It is in fact possible to say, especially at the light of the Italian experience that in recent years we have assisted, in some regions, to a shift to flexible specialisation (Martin and Sunley [23]) that has been responsible for the rise of new industrial districts and for regional agglomeration. In those cases the assumption of monopolistic market structure can be considered in some way unrealistic; in some places, in fact, we are witnessing to the rise of a new type of competition involving downsizing and, consequently, a movement back toward a sort of perfect competition.

In this paper we have tried to formalise these ideas, and found that the pattern of industrial location depends on the following key parameters: the share of expenditures in the manufacturing good, transportation costs, the importance of the externality present in one region, and the size of the population in one region relative to that in the other region. Many of these are also found in Krugman's analysis and the conclusions are also similar. Thus, the pattern of localisation in a simple model with external economies of scale and perfect competition is similar to that resulting in a framework of internal economies of scale and monopolistic competition. With external economies of scale, however, regional divergence depends in a crucial way on the presence of a large population in the region of defection. This can be explained in terms of the argument of urbanisation economies outlined in the first chapter, where we noted that one of the determinants of agglomeration is given by the advantages received by a manufacturing firm localised in any large urban-industrial area in the form of infrastructure, etc.

Our findings should be qualified by noting that we have made a number of simplifying assumptions, and that in our formalisation of externalities, we have not precisely distinguished between localisation and urbanisation economies. Furthermore, it is not easy to infer policy prescriptions from such a simple model. A more realistic and global approach could be useful, even if it could imply a more difficult formalisation.

REFERENCES

1. H. Abdel-Rahman and M. Fujita, Product variety, Marshallian externalities and city sizes, *Journal of Regional Science*, **30**, 165-183 (1990).

2. J. Chipman, External economies of scale and competitive equilibrium, *The Quarterly Journal of Economics*, **3**, 347-385 (1970).

3. W. Christaller, *Central places in Southern Germany*, Jena, Fisher. English translation by C. W. Baskin, London, Prentice Hall (1933).

4. A. Dixit and J. Stiglitz, Monopolistic competition and optimal product diversity, *American Economic Review*, June, 297-308 (1977).

5. R. Dixon and A. P. Thirwall, A model of regional growth differences along Kaldorean lines, *Oxford Economic Papers*, **27**, 201-214 (1975).

6. W. Ethier, “National and international returns to scale in the modern theory of international trade”, *American Economic Review*, **72**, 389-405 (1982).

7. G. Gorla and G. Folloni, Increasing returns and externalities: introducing spatial diffusion into Krugman’s economic geography, *Discussion Paper No* 6, Universita’ degli Studi di Trento, Dipartimento di Economia (1995).

8. M. L. Greenhut, *Plant location in theory and in practice*, University of North Carolina Press (1956).

9. M. L. Greenhut, *Microeconomics and the space economy* (1963).

10. C. Harris, The market as a factor in the localisation of industry in the United States, *Annals of the Association of American Geographers*, **64**, 315-48 (1954).

11. E. Helpman and P. Krugman, *Market structure and foreign trade*, MIT Press, Cambridge, MA (1985).

12. W. Isard, *Location and Space-Economy*, MIT Press, Cambridge, MA (1956).

13. P. Krugman, Scale economies, product differentiation and the pattern of trade, *American Economic Review*, **70**, 950-959 (1980).

14. P. Krugman, Increasing returns and economic geography, *NBER, Working Paper No*. 3275 (1990a).

15. P. Krugman, *Rethinking the international trade*, MIT Press, Cambridge, MA (1990b).

16. P. Krugman, *Geography and trade*, MIT Press, Cambridge, MA (1991).

17. P. Krugman, *Development, geography and economic theory*, The MIT Press, Cambridge, MA (1995).

18. P. Krugman and A. J. Venables, Integration and the competitiveness of peripheral industry, *Centre for Economic Policy Research, Discussion Paper* 363, London (1990).

19. P. Krugman and A. J. Venables, Globalization and the inequality of nations, *The Quarterly Journal of Economics*, 857-879 (1995a).

20. P. Krugman and A. J. Venables, , The Seamless World: A Spatial model of International Specialisation, *Centre for Economic Policy Research, Discussion Paper* 1230, London (1995b).

21. A. Losch, *The economies of location*, Yale University Press (1954).

22. A. Marshall, *Principles of Economics*, MacMillan, London (1920).

23. R. Martin and P. Sunley, Paul Krugman's geographical economics and its implications for regional development theory: a critical assessment, *Economic Geography*, 259-292 (1996).

24. J. Meade, "External economies and diseconomies in a competitive situation", *Economic Journal*, **62**, 54-67 (1952).

25. T. Miyao and Y. Kanemoto, *Urban dynamics and urban externalities*, Harwood Academic Publishers (1987).

26. A. Pred, *The spatial dynamics of US urban-industrial growth,* Cambridge, MIT Press, MA (1966).

27. T. Scitovsky, Two concepts of external economies, *Economic Journal*, **62**, 52-67 (1954).

28. D. Smith, *Industrial location. An Economic Geographical Analysis*, J. Wiley & Sons (1971).

29. A. Weber, *Alfred Weber's theory of the location of industries*, University of Chicago Press, Chicago (1929).