Factor mobility and industrial clusters

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Abstract
This paper develops a general equilibrium model with two factors, labour and natural resources, and two traded goods. There are several regions and each region has a given endowment of natural resources which is immobile between the regions. The goods and the labour are completely mobile between the regions. The natural resources can be used together with labour to produce a numeraire good with constant returns to scale. The other good uses only labour and are produced with increasing return to scale (IRS) at the industry level. Because labour is mobile between the regions, a stable equilibrium implies clustering of the IRS-good in one region. But, contrary to most of the main literature on the new economic geography, the clustering region (the centre) will not be richer than the rest of the regions (the periphery) because labour is mobile between the regions. Factor prices will equalize between the regions. The size of each region will depend on the endowment of natural resources in the region, and whether the region becomes a centre which hosts the industrial cluster or not. The centre will be larger than it otherwise would have been, but which region becomes the centre is undetermined in the model.

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1. Introduction

In many countries or integrated economies such as the EU, there is a concern that industrial cluster will locate in some regions and create rich centres and poor peripheries. This concern is base on the fact that an industrial cluster is an industry with some agglomeration gains. These gains may be due to positive external effects such as knowledge spillovers or other real externalities, or they may be due to pecuniary externalities in industries with economies of scale and imperfect competition. The existence of agglomeration gains implies that there are increasing returns to scale at the industry level.

If some input factors are mobile between the regions, these factors will move to the region hosting an industrial cluster. Three questions are then appropriate. Firstly, how many regions will host an industrial cluster; will there be clusters in all regions or in just a few regions? Secondly, if some regions do not host a cluster, will these regions be poorer than the regions hosting a cluster? And thirdly, what are the implications for economic policy.

This paper analysis these questions within a simple general equilibrium model with two factors, labour and natural resources, and two traded goods. There are several regions and each region has a given endowment of natural resources which is immobile between the regions. The goods and the labour can move without trading costs between the regions. There is a numeraire good which is produced by labour and natural resources with constant returns to scale. The other good uses only labour and are produced with increasing returns to scale at the industry level.

The questions addressed in this paper have been analysed in the literature in several papers under the heading “new economic geography”. Common for all these papers are the focus on trade costs and demand side linkages. In this paper, however, there are no trading costs and the focus is on the supply side linkages.

We find that because labour is mobile between the regions, a stable equilibrium implies clustering of the IRS-good in one region. But, contrary to most of the main literature on the new economic geography, the clustering region (the centre) will not be richer than the rest of the regions (the periphery) because labour is mobile between the regions. Factor prices will equalize between the regions. The size of each region will depend on the endowment of natural resources in the region, and whether the region becomes a centre which hosts the
industrial cluster or not. The centre will be larger than it otherwise would have been, but which region becomes the centre is undetermined in the model.

Since there is increasing return to scale in one sector, this sector will not produce an optimal scale from a welfare economic perspective. We know that a market economy will allocate too little resources to an industry with increasing returns to scale. The optimal allocation implies that the value of the marginal product of an input factor is equal in every sector of the economy. But if one sector has increasing returns to scale, this sector can not hire input factors until the value of their marginal product is equal to the factor price. If they do, they will have a negative profit. Thus, a market economy will allocate too little resources to a sector with increasing returns to scale. A policy which stimulates the industry to produce more will therefore be a good policy from an efficiency point of view.

The paper is organized as follows. Section 2 presents the model, and section 3 deducts the stable general equilibrium. In section 4 the stable equilibrium is analysed, and finally, the conclusions are given in section 4.

2. The model

Assume that there are $M$ regions in the economy. Each region has a given amount of natural resources, $N_r$, where $r = 1, \ldots, M$. The natural resources are immobile between the regions. Furthermore, assume that there is a given amount of labour, $L$, in the economy, and that the labour is mobile between the regions.

There are two goods in the economy, $X$ and $Y$, and the $Y$-good is the numeraire good. Both goods can be traded freely between all regions.

Assume that all regions have access to the same technology. The amount of labour used in the production of good $i$ in region $r$ is notated by $L_{ir}$, $i = X, Y$. The production of $Y$-goods are given by the function

\begin{equation}
Y_r = N_r f \left( \frac{L_{yr}}{N_r} \right) = N_r f \left( l_r \right) \quad \forall \quad r = 1, \ldots, M,
\end{equation}
where \( \frac{L_{yr}}{N_r} = l_r \). There are constant returns to scale in the \( Y \)-sector, so \( f' < 0 \), and we assume that \( f'' > 0 \).

The wage in the \( Y \)-sector in region \( r \), \( w_{yr} \), is given by the value of the marginal product,

\[
(2) \quad w_{yr} = f'(l_r) \quad \forall \quad r = 1, \ldots M .
\]

Equation (2) gives the demand for labour in the \( Y \)-sector in each region. Figure 1 illustrates the demand for labour in the regions \( i, j, \) and \( k \). The more natural resources in a region, the more to the right is the demand function in the diagram. In figure 1 region \( i \) has the least endowment of natural resources and region \( k \) has the highest endowment of natural resources \( (N_i < N_j < N_k) \).

The \( X \)-goods are produced by using labour, only, and there are increasing returns to scale at the industry level. The production function is given by

\[
(3) \quad X_r = g(L_{xr}) \quad \forall \quad r = 1, \ldots M ,
\]
where \( g' > 0, \quad g'' > 0 \) and \( g(0) = 0 \). If \( L_{Xr} > 0 \), assume that the wage in the \( X \)-sector is given by the value of the average product,

\[
(4) \quad w = \frac{P g(L_{Xr})}{L_{Xr}} \quad \forall \ r = 1, \ldots, M,
\]

where \( P \) is the equilibrium price of the \( X \)-good.

Equation (4) gives the demand for labour in the \( X \)-sector. Since the technology is the same in all regions, the demand function for labour will also be the same in all regions. Figure (2) illustrates the demand for labour in the \( X \)-sector in region \( r \), \( r = 1, \ldots, M \).

\[\begin{align*}
\text{Figure 2: Illustration of equation (4) -- Demand for labour in the X-sector in region } r.
\end{align*}\]

**Equilibrium in the labour markets**

Assume that we label the regions so that region 1 to \( m \) host the production of \( X \)-goods, while the rest of the regions specialize in the production of the \( Y \)-good. Free mobility of labour between the sectors within a region implies that the value of the average product in the \( X \)-
sector is equal to the value of the marginal product in the $Y$-sector. Thus, equilibrium in the labour market in region $r$ is given by

$$ f'(l_r) = \frac{P_g(L_{Xr})}{L_{Xr}} = w^* \quad \forall \ r = 1, \ldots, m. $$

The equilibrium condition (5) is illustrated by the Ricardo-Viner diagram in figure 3. In the figure the supply of labour in a region is measured on the horizontal axis, and the return per worker are measured on the vertical axis. The demand for labour in the $X$-sector is measured from the left hand corner, and the demand for labour in the $Y$-sector is measured from the right hand corner. Point $E$ illustrates the equilibrium in the labour market in a region with production of both goods for a given supply of labour. In equilibrium $L_{Xr}$ workers are employed in the $X$-sector and $L_{Yr}$ workers are employed in the $Y$-sector in region $r$. The equilibrium wage is $w^*$. 

Free mobility of labour between the regions implies that the wages in the regions which are specialized in the production of the $Y$-goods are equal to the wages in the regions which are diversified in their production. Thus,
The equilibrium condition (6) is illustrated in figure 4 for a given supply of labour in a region which is specialized in the production of the $Y$-goods. Point $E_0$ illustrates the equilibrium where all workers in a region are employed in the $Y$-sector.

In order to find the equilibrium in the global labour market the total demand for labour must be equal to the total supply of labour,

\begin{equation}
\sum_{r=1}^{M} (L_{Xr} + L_{Yr}) = L.
\end{equation}

Equations (5) to (7) define the equilibrium in the labour markets.

**Equilibrium in the market for X-goods**
Assume that the global demand for $X$-goods depends on relative prices only, and do not depend on income (homothetic preferences). The inverse demand function is given by
\[ P = p(X) = p \left( \sum_{r=1}^{M} X_r \right) = p \left( \sum_{r=1}^{m} X_r \right) \]

where \( X \) is the total supply of \( X \)-goods, and \( p' < 0 \).

In equilibrium, wages and prices will be the same in all regions. This implies that all regions which produce the \( X \)-goods will produce the same amount of \( X \)-goods. The inverse demand function can therefore be written as

\[ (8) \quad P = p(mX_m). \]

3. General equilibrium

The equilibrium is defined by equation (5) -- (8) which give \( M+2 \) equations with \( M+2 \) unknown, \( w, p, L_1, L_2, \ldots, L_M \).

In this model there are several possible equilibria:

1) All regions produce the \( X \)-good.
2) Not all regions, but more than one, produce the \( X \)-good.
3) Only one region produces the \( X \)-good.

Case 3) is a stable equilibrium, but cases 1) and 2) are unstable equilibria.

In order to show which equilibria are stable and unstable, assume for a moment that there are three regions in the economy (\( M = 3 \)). Figure 5 illustrates an equilibrium where all regions are diversified in their production (case 1). The figure is put together by three separate figures each illustrating the equilibrium in one region. In the figure the total supply of labour in the economy, \( L \), is measured on the horizontal axis. The labour supply is allocated between the region as follows: \( L_1 \) is employment in region 1, \( L_2 \) is employment in region 2, and \( L_3 \) is employment in region 3. In region 1 the point \( E_1 \) illustrates the equilibrium, and in the regions 2 and 3 the points \( E_2 \) and \( E_3 \) illustrates the equilibria. In equilibrium the wages are the same in all regions. The sizes of the regions are determined by the amount of natural
resources: the more natural resources, the more labour in the region. In the figure, region 3
has the least amount of natural resources and region 2 has the most.

Figure 5: Case 1 – Unstable equilibrium with diversified production in all regions

The equilibrium described in figure 5 is an unstable equilibrium. To see this, assume that
some workers (by a mistake) move from one region to another, f.i. from region 2 to region 1.
Figure 6 illustrates this for fixed prices. In the figure $\Delta L$ workers are reallocated from region
2 to region 1. This implies that the demand for labour in the $Y$-sector in region 1 shifts to the
right and the wages in region 1 increase -- illustrated by a move from point $E_1$ to $E_1^*$. At the
same time in region 2, the reallocation of $\Delta L$ workers implies that the demand for labour in
the $X$-sector shifts to the right and the wages in region 2 decrease from $E_2$ to $E_2^*$. Thus, there
will be wage differences between the three regions, and the wages will be largest in region 1.
The reallocation of labour from region 2 to region 1 implies that the global production of $X$-goods increase because there are increasing returns to scale in this industry. The price, $P$, will therefore fall. But even though the price falls, the wage difference between the regions will still remain. More workers will therefore move to region 1 from the two other regions. The labour will continue to move until the wages are equal in all regions again. Then, all productions of $X$-goods are concentrated in region 1 (see figure 7).
Figure 7: Case 3 – Stable equilibrium with a cluster in one region

Figure 7 illustrates case 3 where all the productions of X-goods are concentrated in region 1. This is a stable equilibrium. If labour move from one region to another, i.e. from region 2 to region 1, then the wages will increase in both regions, but it will increase more in region 2 than in region 1. Thus, labour will move back to region 2 and we reach the stable equilibrium illustrated in figure 7.

In case 2 several, but not all, regions produce the X-goods. This case is also an unstable equilibrium because the same arguments yield for case 2 as for case 1. This is easy to see if we look at case 1 but assume that there are no productions of X-goods in region 3, and that region 1 and 2 have diversified production. Then there is still instability between region 1 and 2. If some workers move from region 2 to 1, then the wages in region 1 will be higher than in the other regions, and labour will continue to move to region 1 until we have reached the stable equilibrium with an industrial cluster in region 1. Case 2 is therefore an unstable equilibrium.

4. Analysis of the stable equilibrium

The following results can be shown:
Factor price equalization

Factor price equalization will occur because there are constant returns to scale in the Y-sector. Therefore, the factor prices in the Y-sector do not depend on the endowments of natural resources. The returns to the owners of the natural resources depend on wages, prices and technology. Since the technology is identical in all regions, and prices and wages are the same, the returns to the owners of the natural resources must also be the same.

Changes in prices

The Stolper-Samuelson theorem will hold. If the price, P, increases then wages will rise. The size of the cluster region will increase and the size of the other regions will decrease (labour will move to the cluster region from all the other regions).

Localization of the cluster and the size of the regions

The size of a region depends on the endowments of natural resources. In addition, the region which hosts the cluster will have an additional supply of labour. Which region to host the cluster is not determined by the model. Any region hosting the cluster will create a stable equilibrium with the same prices and factor prices.

Increase in factor supply

If the labour supply increases then wages can rise or fall. If the wages increase then the size of the cluster region increases and the other regions decreases (labour move to the cluster region from all of the other regions) and opposite if the wages decrease. Whether the wages decrease or increase depend on the price elasticity and on the scale elasticity.

The Rybczynski-theorem will hold as the theorem yields for given prices. If the prices are constant, then an increase in the labour supply will imply that the production of X-goods increases and the production of Y-goods decreases. If the endowment of natural resources increases in one region, then the production of Y-goods will increase, and the production of X-goods will decrease.

Global welfare

Since there are increasing returns to scale in the X-sector, the price will not equal the marginal costs. Instead, the price equals the average cost. But a global welfare maximum can be
reached if we can subsidize the cluster until price equals marginal cost, and if the subsidy is financed by a lump sum tax. Then, in a welfare maximizing equilibrium, one region will host a subsidized cluster and the rest of the regions will specialize in the production of Y-goods.

5. Conclusions

Three questions were addressed in this paper. In analysing these questions we find that only one region will host an industrial cluster. But the region hosting a cluster will not be richer than the other regions. On the contrary, factor prices will equalize between the regions.

The third question regards the policy implications. Sometimes, there is a pressure to stimulate industrial clusters to locate in several regions of the economy. A conclusion from this paper is that it is welfare improving to stimulate the industry to produce more, but it is not welfare improving to stimulate location outside the cluster region. Instead, the government should stimulate production to increase inside the cluster region.