Increasing returns and economic geography

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Understanding space

- The location of factor of production occupies a small part in the mainstream economics
- Trade theory treats nations as dimensionless entity and often ignore transportation costs.
- Some exceptions include models following von Thunen (1826) and Hotelling (1929)
- The omission is striking! For example, in North America only few segments are densely populated while the most part of it are sparsely populated.

Satellite night vision of the U.S.

Satellite night vision of India

Satellite night vision of South East Asia

Why do regions diverge?

- If the regions belong to the same nation, institutions cannot be a big driver of divergence.
- Geography must play a crucial role.
- Most of the localization literature follow Marshall's explanation consisting of three reasons.
  1. Pooled market.
  2. Production of non tradable of specialized input.
  3. Informational spillover.
- Krugman on the other hand tries to explain a core-periphery model where an agricultural periphery supplies to the manufacturing core.

- This paper takes the working assumption that the externality is pecuniary in nature rather than purely technological nature.
- There is not much role of pecuniary externality in presence of perfect competition and constant return to scale.
- However, with imperfect competition and increasing return to scale pecuniary externality works.

Understanding pecuniary externality

- Think of a two sector economy.
- Agriculture is characterized by constant returns to scale and intensive use of land.
- Manufacturing on the other hand shows increasing return to scale and has limited land use.
- Agricultural location is driven by distribution of suitable land.
- Question: where will the manufacturing firms locate themselves?

- An easy answer: wherever the demand is high.
- But what factors ensure that?
- It cannot be only the agricultural sector.
- One possible explanation comes from Hirschman type backward or forward linkage.
- Possibility of a circular process – manufacturing concentrates where demand is high but demand is high where manufacturing is concentrated.

- In such a circular mechanism what parameters will determine the pattern of concentration?
- This depends on transport cost.
- If manufacturing employs a small fraction of the population (and generates a small fraction of demand) the circularity does not work.
- The same happens if economies of scale is weak and transportaion cost is high.
- In that case market will be localized (pre railroad America)
- The situation will change with the emergence of mass production and improved transportation. Production will not be tied to the distribution of arable land.
- We have multiple equilibria type solution.

Model

- Two regions in the economy.
- Two sector economy. Agriculture is tied to land with CRS. Manufacturing with IRS.
- Each individual has utility function

$$U = C_M^{\mu} C_A^{1-\mu} \tag{1}$$

where C_A is consumption of the agricultural good and C_M is consumption of a manufacturing aggregate.

The manufacturing aggregate C_M is given by

$$C_M = \left[\sum_{i=1}^{N} c_i^{(\sigma-1)/\sigma} \right]^{\sigma/(\sigma-1)} \tag{2}$$

- where N is the number of potential products and σ is the elasticity of substitution.
- There are two regions in the economy and two factors of production.
- Each factor is specific to one sector.
- Peasants produce agricultural goods – the unit labor requirement is one.

Production structure

- Peasant population is equally distributed in two regions and completely immobile.
- So in each region peasant supply is $(1 - \mu)/2$
- Manufacturing worker supply is L_1 and L_2 in two regions whose values are endogenously determined such that

$$L_1 + L_2 = \mu \tag{3}$$

- The production of an individual manufactured good i involves a fixed cost and a constant marginal cost:

$$L_{Mi} = \alpha + \beta x_i \tag{4}$$

- This gives rise to economies of scale.

Transportation costs

- Transportation of agricultural output will be assumed to be costless.
- This assumption is made to make sure that the price of agricultural output and hence, the earnings of each peasant are the same in both regions.
- The transportation costs for manufactured goods will be assumed to take iceberg form – of each unit shipped from one region to the other region only a fraction $\tau < 1$ arrives.
- τ is inversely proportional to transport cost — high cost, low τ.

Behaviour of firms

- Given the agrregate of the manufacturing aggregate and the assumption of iceberg transport costs, the elasticity of demand facing any individual firm is σ. Hence,

$$p_1 = \frac{\sigma}{\sigma - 1}\beta w_1 \tag{5}$$

- Similar equation applies to region 2. So we have

$$\frac{p_1}{p_2} = \frac{w_1}{w_2} \tag{6}$$

Zero profit condition

- Zero profit condition implies that

$$(p_1 - \beta w_1)x_1 = \alpha w_1 \tag{7}$$

This implies

$$x_1 = x_2 = \frac{\alpha(\sigma - 1)}{\beta} \tag{8}$$

- So output per firm is the same in each region.
- This has the useful implication that the number of manufactured goods produced in each region is proportion to the number of workers (Prove!)

$$\frac{n_1}{n_2} = \frac{L_1}{L_2} \tag{9}$$

Short Run and Long Run Equilibrium

- Short run equilibrium is an equilibrium where the allocation between regions may be taken as given.
- We then suppose that workers move toward the region that offers them higher real wages.
- This could lead to convergence between regions as they move toward equality.
- Or to divergence as the workers congregate in one region.
- We start by looking at the demand within each region for products of the two regions.

- Let c_{11} be the consumption in region 1 of a representative region 1 product and c_{12} be the consumption in region 1 of a representative region 2 product.
- The price of the local product is simply the free on board price p_1.
- The price of a product from the other region is its transport cost-inclusive price p_2/τ. (Why?)
- So the relative demand of representative products is

$$\frac{c_{11}}{c_{12}} = \left(\frac{p_1\tau}{p_2}\right)^{-\sigma} = \left(\frac{w_1\tau}{w_2}\right)^{-\sigma} \tag{10}$$

- Define z_{11} as a ratio of region 1 expenditure on local manufacturers to that on manufacturers from the other region.

- $$z_{11} = \left(\frac{n_1}{n_2}\right)\left(\frac{p_1\tau}{p_2}\right)\left(\frac{c_{11}}{c_{12}}\right) = \left(\frac{L_1}{L_2}\right)\left(\frac{w_1\tau}{w_2}\right)^{-(\sigma-1)} \tag{11}$$
- Note that a 1 percent rise in the relative price of region 1 goods reduces the relative quantity by σ percent but reduces the relative value by $\sigma - 1$ percent.
- Similarly the ratio of region 2 spending on region 1 products to spending on local products is

$$z_{12} = \left(\frac{L_1}{L_2}\right)\left(\frac{w_1}{w_2\tau}\right)^{-(\sigma-1)} \tag{12}$$

- The total income of region 1 workers is equal to the total spending on these products in both regions.
- Let Y_1 and Y_2 be the regional incomes including the wages of the peasants.

- So the income of region 1 workers is

$$w_1 L_1 = \mu\left[\left(\frac{z_{11}}{1+z_{11}}\right)Y_1 + \left(\frac{z_{12}}{1+z_{12}}\right)Y_1\right] \tag{13}$$

- And the income of region 2 workers is

$$w_2 L_2 = \mu\left[\left(\frac{1}{1+z_{11}}\right)Y_1 + \left(\frac{1}{1+z_{12}}\right)Y_1\right] \tag{14}$$

- Recalling that the wage rate of peasants is the numeraire, we have

$$Y_1 = \frac{1-\mu}{2} + w_1 L_1 \tag{15}$$

and

$$Y_2 = \frac{1-\mu}{2} + w_2 L_2 \tag{16}$$

- The set of equations above determine w_1 and w_2 given L_1 and L_2
- If $L_1 = L_2, w_1 = w_2$
- If labor is then shifted to region 1, the relative wage rate $\frac{w_1}{w_2}$ can move either way.
- This is because there are two opposing effects.
- Home Market Effect: wage is higher in the larger market.
- Competition effect: Workers in the region with the smaller manufacturing labor force will face less competition for the local peasant market than those in the more populous region.

Long Run

- In the long run equilibrium however, a third consideration enters the picture.
- Workers are interested not in nominal wages but in real wages.
- Workers are interested not in nominal wages but in real wages. Workers in the region with the larger population will face a lower price for manufactured goods.
- Let $f = \frac{L_1}{\mu}$ – the share of the manufacturing labor force in region 1.

Price Index

- The true price index of manufactured goods for consumers residing in region 1

$$P_1 = \left[f w_1^{-(\sigma-1)} + (1-f)\left(\frac{w_2}{\tau}\right)^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \tag{17}$$

- That for consumers residing in region 2 is

$$P_2 = \left[f\left(\frac{w_1}{\tau}\right)^{-(\sigma-1)} + (1-f) w_2^{-(\sigma-1)} \right]^{-1/(\sigma-1)} \tag{18}$$

Real Wage

- The real wages of workers in each regions are

$$\omega_1 = w_1 P_1^{-\mu} \tag{19}$$

$$\omega_2 = w_2 P_2^{-\mu} \tag{20}$$

- If the wage rates in the two regions are equal, a shift of workers from region 2 to region 1 will lower the price index in region 1 and raise it in region 2.
- So real wage in region 1 compared to region 2 will rise.
- This provides another reason for divergence.

- How does $\frac{\omega_1}{\omega_2}$ vary with f?
- When $f = \frac{1}{2}$, wages are equal in two regions.
- But is this a stable equilibrium?
- It is a stable equilibrium if $\frac{\omega_1}{\omega_2}$ goes down with f – whenever a region has larger work force, relative real wage falls.
- if $\frac{\omega_1}{\omega_2}$ goes up with f we see concentration.
- The opposite possibilities appear because of home market effect and price index effect – which effect will dominate depends on τ – transport cost

Numerical solution concept

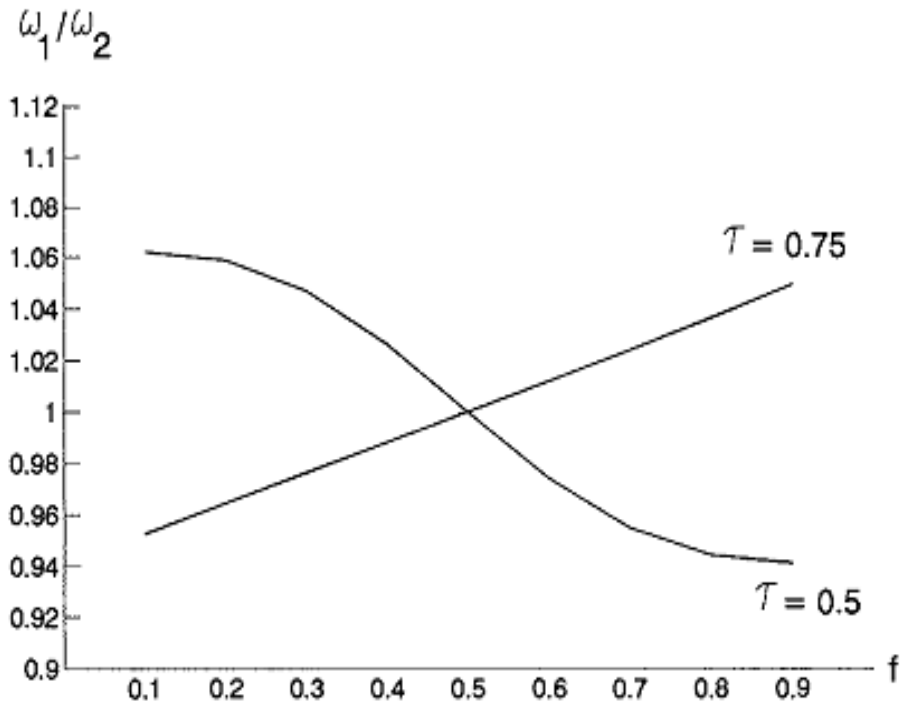

FIG. 1

- From the numerical solution we expect regional convergence for high transportation cost ($\tau = 0.5$) – falling relation between f and $\frac{\omega_1}{\omega_2}$.
- If transportation cost is low, we may expect concentration in one area.

Necessary condition for Manufacturing concentration

- In the last section we asked whether an equilibrium in which workers are distributed equally between the regions is stable.
- In this section we see if concentration equilibrium can be stable. a situation in which all workers are concentrated in region 1.
- Region 1 will the constitute a larger market than region 2.
- A share μ of total income is spent on manufactures and all this income goes to region 1.

- The difference between region 1 and region 2 income is the sales from manufcaturing
- So, $Y_1 - Y_2 = \mu(Y_1 + Y_2)$
- This yields

$$\frac{Y_2}{Y_1} = \frac{1-\mu}{1+\mu} \tag{21}$$

Let n be the total number of manufacturing firms. Each firm will have a value of sales equal to

$$V_1 = \frac{\mu}{n}(Y_1 + Y_2) \tag{22}$$

Question: Is it possible for an individual firm to commence production profitably in region 2?

Such firm will be referred to as the defecting firm

- In order to produce in region 2, a firm must be able to attract workers.
- To do so it must compensate them for the fact that all manufactures must be imported.
- Hence, the price faced by the workers is $P\tau^{-1}$. Hence we must have

$$\frac{w_2}{w_1} = \left(\frac{1}{\tau}\right)^{\mu} \tag{23}$$

- Given this higher wage, the firm will charge a profit maximizing price that is higher than that of other firms in the same proportion.
- In region 1, the defecting firm's value of sales will be the value of sales of a representative firm times $\left(\frac{w_2}{w_1\tau}\right)^{-(\sigma-1)}$.
- In region 2, its value will be that of a representative firm times $\left(\frac{w_2\tau}{w_1}\right)^{-(\sigma-1)}$.

- The value of the defecting firm's sales will be

$$V_2 = \left(\frac{\mu}{n}\right)\left[\left(\frac{w_2}{w_1\tau}\right)^{-(\sigma-1)} Y_1 + \left(\frac{w_2\tau}{w_1}\right)^{-(\sigma-1)} Y_2\right] \tag{24}$$

- Similarly we can calculate defecting firm's sale to the sales of firms from region 1 in region 1 and call it V_1.
- The fraction $\frac{V_1}{V_2}$ is a constant made of the parameters.
- However, the defecting firm pays a higher wage in the region 2.
- If the sale ratio is big enough to justify the higher wage firm can start production 2.
- the condition for that is given by $\frac{V_2}{V_1} > \frac{w_2}{w_1}$

- Define a new variable

$$\nu = \frac{1}{2}\tau^{\mu\sigma}[(1+\mu)\tau^{\sigma-1} + (1-\mu)\tau^{-(\sigma-1)}] \tag{25}$$

- Whenever $\nu < 1$ it is unprofitable for a firm to begin production in 2 if all firms are concentrated in 1.
- The condition (25) defines a boundary of critical parameter values that mark the division between concentration and concentration.

Effect of large manufacturing sector

- Next, e find how different parameters affect this boundary condition.
- We find

$$\frac{\partial \nu}{\partial \mu} < 0 \tag{26}$$

- This means that the larger the share of income spent on manufactured goods, the lower the relative sales of the defecting firm.
- This takes place for two reasons.
- First, Workers demand a larger wage premium in order to move to the second region – forward linkage. The larger the share of expenditure on manufactures, the relative size of the region 1 market and hence the stronger home market effect – backward linkage.

Effect of transportation cost

- When transportation is 0, location is irrelevant.

$$\frac{\partial \nu}{\partial \tau} = \frac{\mu\sigma\nu}{\tau} + \frac{\tau^{\mu\sigma}(\sigma-1)[(1+\mu)\tau^{\sigma-1} - (1-\mu)\tau^{-(\sigma-1)}}{2\tau} \tag{27}$$

- For τ close to 1, the second term approaches $\mu(\sigma-1) > 0$, hence, the entire expression becomes positive.
- So at a low level of τ it is profitable to defect.