New economic geography, part I:
Understanding agglomeration

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1 Motivation

- Until the early 1990s, economic geography received relative little attention in mainstream economic theory.

- Despite the fact that:
  - Production, trade and income are distributed extremely unevenly across physical space.
  - Agglomeration of overall economic activity most evident in cities:
    * By 1990, 37.6% of the world’s population lived in cities.
    * By 1995, 15 cities with a population > 10 million.
  - Geographical concentration of particular activities:
    * US manufacturing belt in NE and Eastern Midwest.
    * Dalton as a carpet manufacturing centre in Georgia.
    * Silicon Valley and Route 128 in Massachusetts.

- What do we mean by economic geography? Location of economic activity in space:
  - First-nature geography: Physical geography of coasts, mountains and endowments of natural resources.
  - Second-nature geography: The spatial relationship between economic agents.

- Our analysis will largely focus on second-nature geography: How does the spatial relationship between agents determine how they interact, what they do, and how well off they are?

2 Agglomerations

The occurrence of agglomerations raises several questions:

- How come that economic activity is agglomerated instead of evenly spread out across space?

- What implications do agglomerations have for welfare and economic policy?
- How do increased globalization and integration affect the number, size, and localization of industrial agglomerations?

The purpose of the new economic geography:

- to explain and model economic agglomeration (applying micro economic tools);
- analyze the consequences of such agglomerations for industrial structures, trade patterns, employment, welfare, and
- to provide insight to distinguish self-reinforcing agglomerations from simple agglomerations based on natural resources or other immobile factors of production.
- to study the policy implications of self-reinforcing agglomerations.

3 Self-reinforcing agglomerations

An agglomeration is self-reinforcing when the profitability of a firm is determined by the localization of other firms. In other words, self-reinforcing agglomerations rely on the existence of localized external economies of scale.

Implications of self-reinforcing agglomerations and the new economic geography for location of activity:

- the existence of multiple equilibria
- irreversibility
- cumulative causality
- critical mass
- coordination
- history
- (self-fulfilling) expectations
What makes self-reinforcing agglomerations special?

- Self-reinforcing agglomeration are important, because other things equal, they lead to higher real income in a country – which may take the form of higher employment, wages, or returns to capital.
- Self-reinforcing agglomerations rely on external economies of scale and entail challenges for economic policy.

The nature of Self-reinforcing agglomerations

- Industrial agglomerations
- "Specialized" agglomerations
- General agglomerations

depending on whether the gains from agglomeration are due to interaction between firms within the same industry, between divisions of firms (ex. R&D or marketing) across industries, or due to interaction between economic agents in general regardless of industry or activities.

4 The seminal Krugman (1991) model

When will an industrialized core and a agricultural periphery emerge endogenously in equilibrium?

Marshall (1920) identified three forces for agglomeration

- Market for workers with specialized skills
- Provision of non-traded inputs in greater variety & lower cost
- Technological knowledge spillovers

Krugman (1991) focuses on the second of these forces and hence upon pecuniary rather than technological externalities

- Transport costs, increasing returns to scale and love of variety provide forces of agglomeration (forward & backward linkages)
Mobility of manufacturing workers is central and, therefore, the mobile may be more applicable within than between countries

Immobile agricultural laborers provide a force for deagglomeration

4.1 The model

- An economy with two locations: North and South of Europe
- There are two goods:
  - Agricultural goods: Homogeneous, perfect competition and CRS
  - Manufacturing goods: Differentiated, monopolistic competition and IRS
- There are two factors (a specific factors model)
  - Workers used only in the manufacturing sector and geographically mobile, \( L_M = \mu \)
  - Farmers used only in the agricultural sector and geographically immobile
    * Each region endowed with \( L_A^i = (1 - \mu)/2 \) farmers

4.1.1 Consumption and Production:

Consumer preferences

\[
U = C_M^{\mu} C_A^{1-\mu}
\]

\[
C_M = \left[ \sum_j c_j^{\frac{1}{1-\sigma}} \right]^{\frac{1}{1-\sigma}} , \quad P_M = \left[ \sum_j p_j^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \quad \sigma > 1
\]

Production

- Agriculture

\[
Z = L_A
\]

- Manufacturing

\[
L_{Mj} = \alpha + \beta x_j
\]

No transportation costs in agriculture, but iceberg transportation costs in manufacturing whereby, in order for one unit of a manufacturing good to arrive, \( T > 1 \) units must be shipped
4.1.2 Producer Equilibrium (as in Krugman 1980)

Profit Maximization

$$\max p_{Mj}x_j(p_j) - w_M (\alpha + \beta x_j(p_j))$$

First-order conditions for profit maximization

$$p_{Mj} = \left( \frac{\epsilon_j}{\epsilon_j - 1} \right) \beta w_M \quad \forall j$$

Based on Consumers’ utility maximization problem + Assuming a large number of varieties are produced in equilibrium and manipulating the above equation, we obtain:

$$\epsilon_j = -\frac{p_j}{x_j} \frac{\partial x_j}{\partial p_j} = \sigma, \quad p_{Mj} = p_M = \left( \frac{\sigma}{\sigma - 1} \right) \beta w_M, \quad \forall j$$

Free entry implies zero equilibrium profits

$$(p_M - \beta w_M) x_j = \alpha w_M$$

Implies constant equilibrium output of each variety

$$x = \alpha \left( \frac{\sigma - 1}{\beta} \right)$$

Combining CES demand, profit maximization and the expression for equilibrium output yields a wage equation for region r

⇒ Pins down the maximum wage that a firm in any location can afford to pay consistent with zero equilibrium profits

$$\left( P_M^N \right)^{\sigma} = \frac{\mu}{\bar{x}} \left[ Y_M^{N} (P_M^{N})^{\sigma-1} + Y_M^{S} (P_M^{S})^{\sigma-1} T^{1-\sigma} \right]$$

$$w_M^{N} = \frac{\sigma - 1}{\sigma \beta} \left( \frac{\mu}{\bar{x}} \right)^{\frac{1}{2}} \left[ Y_M^{N} (P_M^{N})^{\sigma-1} + Y_M^{S} (P_M^{S})^{\sigma-1} T^{1-\sigma} \right]^{\frac{1}{2}}$$

4.1.3 Number of Varieties, Real Wages and Regional Income

Equilibrium number of manufacturing varieties

$$n = \frac{L_M}{\alpha + \beta \bar{x}}$$
Equilibrium price of agriculture

\[ p_A = w_A = 1 \]

because of: perfect competition, zero transport costs and agricultural good chosen as numeraire.

Equilibrium real wage of manufacturing workers

\[ \omega_N^M = \frac{w_N}{(p_N^M)^{\alpha}} \left( p_A^N \right)^{1-\alpha} \]

Equilibrium regional income

\[ Y_N^M = w_M L_N^M + \left( \frac{1-\mu}{2} \right) \]

Convenient Normalizations

Choice of units to measure output of manufacturing varieties

\[ \beta = \frac{\sigma - 1}{\sigma} \Rightarrow p_M = w_M \]

Choice of units with which to count manufacturing varieties

\[ \alpha = \frac{\mu}{\sigma} \Rightarrow \left\{ \begin{array}{l} n_M = \frac{L_M}{\mu} \\ \bar{\tau} = \mu \end{array} \right. \]

Denote North’s share of manufacturing workers by \( \lambda \) and hence South’s share by \( (1 - \lambda) \)

### 4.1.4 Determination of Equilibrium

Eight simultaneous non-linear equations in eight unknowns

Income

\[ Y_N = \mu \lambda w_N^M + \left( \frac{1-\mu}{2} \right) \quad Y_S = (1 - \lambda) w_S^M + \left( \frac{1-\mu}{2} \right) \]

Price Indices

\[ p_M^N = \left[ \lambda \left( w_M^N \right)^{1-\sigma} + (1-\lambda) \left( w_M^S T \right)^{1-\sigma} \right]^{1/(1-\sigma)} \]
\[ p_M^S = \left[ \lambda \left( w_M^N T \right)^{1-\sigma} + (1-\lambda) \left( w_M^S \right)^{1-\sigma} \right]^{1/(1-\sigma)} \]

Nominal Wages

\[ w_M^N = \left[ Y_N^M \left( p_M^N \right)^{\sigma-1} + Y_S^M \left( p_M^S \right)^{\sigma-1} T^{1-\sigma} \right]^{\frac{1}{\sigma}} \]
\[ w_M^S = \left[ Y_N^M \left( p_M^S \right)^{\sigma-1} T^{1-\sigma} + Y_S^M \left( p_M^N \right)^{\sigma-1} \right]^{\frac{1}{\sigma}} \]
Real Wages

\[ \omega_{NM}^N = \frac{w_N^N}{(P_M^N)^\mu} \]
\[ \omega_{SM}^S = \frac{w_S^S}{(P_M^S)^\mu} \]

4.2 The Price Index and Home Market Effects

Price index effect

- The location with a larger manufacturing sector also has a lower price index for manufacturing goods
  - Because a smaller proportion of the region’s manufacturing consumption bears transport costs

⇒ Forward linkage: workers wish to be close to abundant supplies of manufacturing goods

Home market effect

- Increasing returns to scale implies that producers wish to concentrate production in a single location
- Transport costs imply that they wish to concentrate production close to a large market

⇒ Backward linkage: firms wish to locate production close to large markets for manufacturing goods

4.3 Home Market Effect, Nominal and Real Wages

Home market effect

- Implies a 1 percent change in manufacturing demand leads to a more than proportionate increase in manufacturing production
  - Magnification effect – an implication of IRS and transport cost
  - Contrast with predictions under CRS and transport costs constant returns to scale

⇒ See Davis & Weinstein (1999) for empirical evidence
• Implies that locations with higher demand for manufactures will tend to pay higher nominal wages

⇒ See Hanson (1998) and Redding & Venables (2004) for empirical evidence

Price index and home market effects imply that locations with more manufacturing sectors will, other things equal, pay higher real wages

⇒ Forward and Backward linkages together provide forces of Cumulative Causation

4.4 Sustainability of a Core-Periphery Pattern

Suppose that all manufacturing is concentrated in the North. When is this an equilibrium?

– Set \( \lambda = 1 \) and guess \( w^N_M = 1 \)

– Then confirm \( w^N_M = 1 \) is indeed an equilibrium from the Northern wage equation

\[
Y^N = \left( \frac{1 + \mu}{2} \right) \quad Y^S_M = \left( \frac{1 - \mu}{2} \right)
\]

Price Indices

\( p^N_M = 1 \)

\( p^S_M = T \)

Real Wages

\( \omega^N_M = 1 \)

\[
\omega^S_M = T^{-\mu} \left[ \left( \frac{1 + \mu}{2} \right) T^{1-\sigma} + \left( \frac{1 - \mu}{2} \right) T^{\sigma-1} \right]^{\frac{1}{\sigma}}
\]

The concentration of manufacturing in the North will be an equilibrium if and only if \( \omega^S_M < 1 \), i.e. workers in the North do not have any incentive to move to the South.

⇒ Solve for the level of transport costs (Sustain point \( T(S) \)) at which \( \omega^S_M < 1 \) and a core-periphery pattern is sustainable.

Determinants of the Sustain Point

Sustainability of a Core-Periphery Pattern

\[
\omega^S_M = T^{-\mu} \left[ \left( \frac{1 + \mu}{2} \right) T^{1-\sigma} + \left( \frac{1 - \mu}{2} \right) T^{\sigma-1} \right]^{\frac{1}{\sigma}}
\]

When will a worker wish to move to the South?

• First term, \( T^{-\mu} \), captures the forward linkage
– Price index is $T$ times higher in the South because manufacturing goods must be imported

• Second term in parentheses captures the backward linkage

– Transport costs imply that the demand for manufacturing goods produced in the South is lower
– A lower level of manufacturing demand reduces the nominal wage consistent with zero equilibrium profits

Transport costs and the Sustain Point

$$(\omega^S_M)^\sigma = \left[ \left( \frac{1+\mu}{2} \right) T^{1-\sigma-\mu\sigma} + \left( \frac{1-\mu}{2} \right) T^{\sigma-1-\mu\sigma} \right]$$

• When $T = 1$ (no transport costs), location is irrelevant: $\omega^S_M = 1$

• At small levels of transport costs, $T > 1$: Agglomeration is sustainable because $\omega^S_M < 1$.

• At high levels of transport costs, $T > 1$:

  – First term above becomes arbitrarily small
  – Second term has two possibilities:
    * If $(\sigma - 1) < \mu\sigma$, it becomes arbitrarily small and agglomeration forces are so strong that a core-periphery pattern is always an equilibrium
    * We typically assume $(\sigma - 1) < \mu\sigma$ (no black hole condition): Core-periphery pattern only an equilibrium for levels of transport costs below the sustain point $T(S)$

When is a Symmetric Equilibrium Broken?

Consider a symmetric equilibrium

$$\lambda = 1/2$$

$$Y^N = Y^S = 1/2, \quad w^N = w^S = 1$$

$$P^N_M = P^S_M = \left[ \frac{1 + T^{1-\sigma}}{2} \right]^{1/\sigma}$$
Check that all equilibrium conditions satisfied at these values for the endogenous variables

- Totally differentiate around the symmetric equilibrium and evaluate the impact of worker moving S to N on the real wage gap $\omega = \omega^N - \omega^S$

\[
\frac{d\omega}{d\lambda} = 0 \quad \text{if} \quad T = \frac{\sigma}{\rho}, \quad \rho = \frac{\sigma - 1}{\sigma}
\]

At $T < T(B)$, the symmetric equilibrium becomes unstable

Core-Periphery Bifurcation

5 Krugman (1991) and Helpman (1998)

- In Krugman (1991), the market for manufacturing goods provided by immobile agricultural laborers is a force against agglomeration

  - Whether a core-periphery pattern is observed depends on the strength of this force relative to the forward and backward linkages examined above
Helpman (1998) considers an alternative force against agglomeration—

- Immobile or non-traded amenities such as housing
- The concentration of manufacturing activity leads to an increase in the price of immobile housing

In both models, labor mobility is central to the process of agglomeration: Suggests that they may be more relevant to the analysis of economic geography within than across countries.

6 This lecture vs. next lecture

- This lecture has examined the determinants of the location of economic activity in space.
- Showed how the combination of transport costs, increasing returns to scale and the love of variety may explain agglomeration
  - The price index effect (forward linkage)
  - The home market effect (backward linkage)
  - Immobile agricultural laborers as a force against agglomeration
• Examined when a core-periphery pattern is sustainable and when a symmetric equilibrium is broken

• Next lecture will explore many of the same ideas within a framework where labor is geographically immobile, but input-input linkages provide a force for the concentration of manufacturing activity