Increasing Returns and Economic Geography: Dicussion of Krugman, JPE 1991

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Administration

Homework due next class, questions?

Paul Krugman

Nobel Prize winner 2008

Famous for contributions to trade and urban economics; most important founder of “New Economic Geography” (NEG)

Nice essay on Paul Krugman’s contribution to urban economics: Behrens and Robert-Nicoud, Papers in Regional Science, 2009

Glaeser (NYTimes): “[JPE 1991] is one of only two models that I insist that Harvard’s Ph.D. students in urban economics be able to regurgitate, equation by equation.”

Paul Krugman's most famous paper

Contributions of JPE 1991 according to Behrens and Robert-Nicoud:

1. understand how market size influences location choices and location choices influence market size (circular)
2. shows mechanism leading to persistence and path dependence
3. connects location theory to trade theory
4. provided a framework (NEG) applicable to many contexts (ex: taxes) and flexible to incorporate many extensions

Main Questions of Paper

What is the main question of this paper?

Why is manufacturing concentrated and specifically, can we explain this with the interaction of transportation costs and economies of scale?

Sub-questions:

- How sensitive are concentration results to transportation costs?
- What is overall effect of divergence forces (access to bigger market, lower transportation) and convergence forces (competition among firms for fixed expenditure)?
- When will all manufacturing be concentrated in one region? Does the starting point matter?

Basic Setup

- There are two regions and two sectors, farming and manufacturing, which employ farmers and manufacturing workers
- Farmers are immobile but manufacturing workers can migrate costlessly across regions
- Trade: the farm good (numeraire) can be shipped to other region costlessly but manufacturing goods have iceberg transport costs: if you send 1 unit of a good from region 1 to region 2 it melts to only τ units when it arrives in region 2, $\tau < 1$
- Goal: characterize equilibrium in terms of manufacturing workers in each region; this will provide insight into determinants of concentration

Consumption

All residents (farmers and workers) have two-level utility function:

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

$$C_M = \left[\sum_{i=1}^{N} c_i^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}} \tag{1}$$

N is number of potential products, $\sigma > 1$; notice consumers have taste for variety

Why two-level? Parameter μ determines expenditure on manufacturing, key to concentration

Production

Farmers: one unit of farm labor produces one unit of agricultural good

Supply of farmers is fixed and equal in both regions: $(1-\mu)/2$

Workers are mobile but define L_1 and L_2 as workers in each region

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

Production function of manufacturing good i: $x_i = \frac{L_{Mi}-\alpha}{\beta}$, or

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

Notice: fixed cost generates IRS and that will vary with wage rate

Optimal price

Symmetry will yield that price is the same for all varieties

Let p_1 be price of representative variety in region 1, w_1 manufacturing wage. Optimization gives:

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

Region 2 has similar equation, thus:

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

Free entry gives zero profit: $\pi = 0$:

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

Number of varieties

Zero profit condition and price ratio across regions $p_1/p_2 = w_1/w_2$ gives:

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

Notice that output of any good does *not* depend on any region specific variables

With output of each firm we can figure out labor requirement of each firm, which is $\alpha\sigma$

Then number of firms in a region is total labor divided by per-firm labor, $n_1 = L_1/\alpha\sigma$, and:

$$\frac{L_1}{L_2} = \frac{n_1}{n_2} \tag{2}$$

Elasticity of substitution measures economies of scale

Turns out that σ shows MPL/APL

MPL=$\frac{1}{\beta}$, APL=$\frac{\sigma-1}{\beta\sigma}$

MPL/APL=$\frac{\sigma}{\sigma-1}$

Smaller σ gives greater economies of scale (MPL/APL larger)

Why? As σ decreases consumer wants to consume more and more varieties ($\sigma = 1$ is Cobb-Douglas)

Low σ leads to more firms, lower output per firm, less labor per firm, lower APL

Note: this is a bit confusing since firms are more productive (lower AC) with *higher* σ; however, lower σ leads to greater agglomeration economies (same as models with CES production and intermediate input sharing)

Short-run Equilibrium

In short-run workers in each region can't migrate, want to look at wages

Define c_{11} as *total* consumption in region 1 of a representative region 1 good and c_{12} is region 1 consumption of representative region 2 good

Region 2 must ship $1/\tau$ units so that 1 unit arrives in region 1, thus region 1 consumers pay $p_2 * (1/\tau)$ for one unit

In region 1, ratio of demand for good 1 to good 2 is:

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

This equation comes from demand function and equation 6

Expenditure Ratios

Define z_{11} as ratio of total region 1 expenditure on region 1 goods to region 1 expenditure on region 2 goods

$$z_{11} = \left(\frac{n_1}{n_2}\right)\left(\frac{p_1\tau}{p_2}\right)\left(\frac{c_{11}}{c_{12}}\right) = \left(\frac{L_1}{L_2}\right)\left(\frac{w_1\tau}{2_2}\right)^{-(\sigma-1)} \tag{11}$$

1. A one percent increase in relative prices reduces quantities sold by σ (eq 10) but reduces value by only $\sigma - 1$; basically p is higher in $p * q$
2. As a region's *number* of goods increases overall expenditure share z_{11} also increases

Closing Model

To close model write equations for both regions where total income has to be equal to total expenditure

Define Y_1 and Y_2 as total income in a region

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

Then we have:

$$w_1 * L_1 = \mu \left[\left(\frac{z_{11}}{1+z_{11}} \right) Y_1 + \left(\frac{z_{12}}{1+z_{12}} \right) Y_2 \right] \tag{13}$$

Short-run equilibrium results

From set of equations one can solve for wages

Because many results echo 1980 AER paper he doesn't discuss in detail

Main focus in short-run is ratio of wages in regions w_1/w_2:

1. Increase in manufacturing employment raises utility (lowers variety-adjusted price index) because allows for greater number of firms
2. Increase in employment also can raise wages by more than proportionally increasing output: home market effect
3. However, also a competitive effect working in opposite direction–workers have to share limited amount of peasant expenditure

Long-run Equilibrium: Choice of Units

In long-run we allow workers to migrate

Krugman carefully chooses units to simplify this problem (but without mentioning this, ridiculously confusing!)

$\beta = \frac{\sigma - 1}{\sigma}$ and $\alpha = \frac{\mu}{\sigma}$

Since $p_1 = \frac{\sigma}{\sigma - 1}\beta * w_1$ and $n_1 = \frac{L_1}{\alpha * \sigma}$

This implies that $p_1 = w_1$ and $n_1 = L_1/\mu$

Long-run Equilibrium: Price Indices

With CES a price index is cost of purchasing one unit of *composite* good at optimal consumption of each variety

$$P = \left[\sum_{i=1}^{N} p_i^{1-\sigma} \right]^{\frac{1}{1-\sigma}} \tag{N1}$$

Price of consumption in region 1 includes local goods and imports

Let f be fraction of total workers in region 1, $f = L_1/\mu$, then using choice of units:

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

Real Wages

Workers migrate based on real wages: what they can consume given region's nominal wage

To calculate real wages we need a cost-of-living index: cost of a given level of utility in a region

CES has a convenient form because expenditure measures utility: $P^{\mu} * P_A^{1-\mu}$

Then real wages are:

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

Equilibrium Comparative Statics

Main goal is to explain concentration across regions: when will most workers concentrate in one region ("core") with small region ("periphery") versus more equal sized regions?

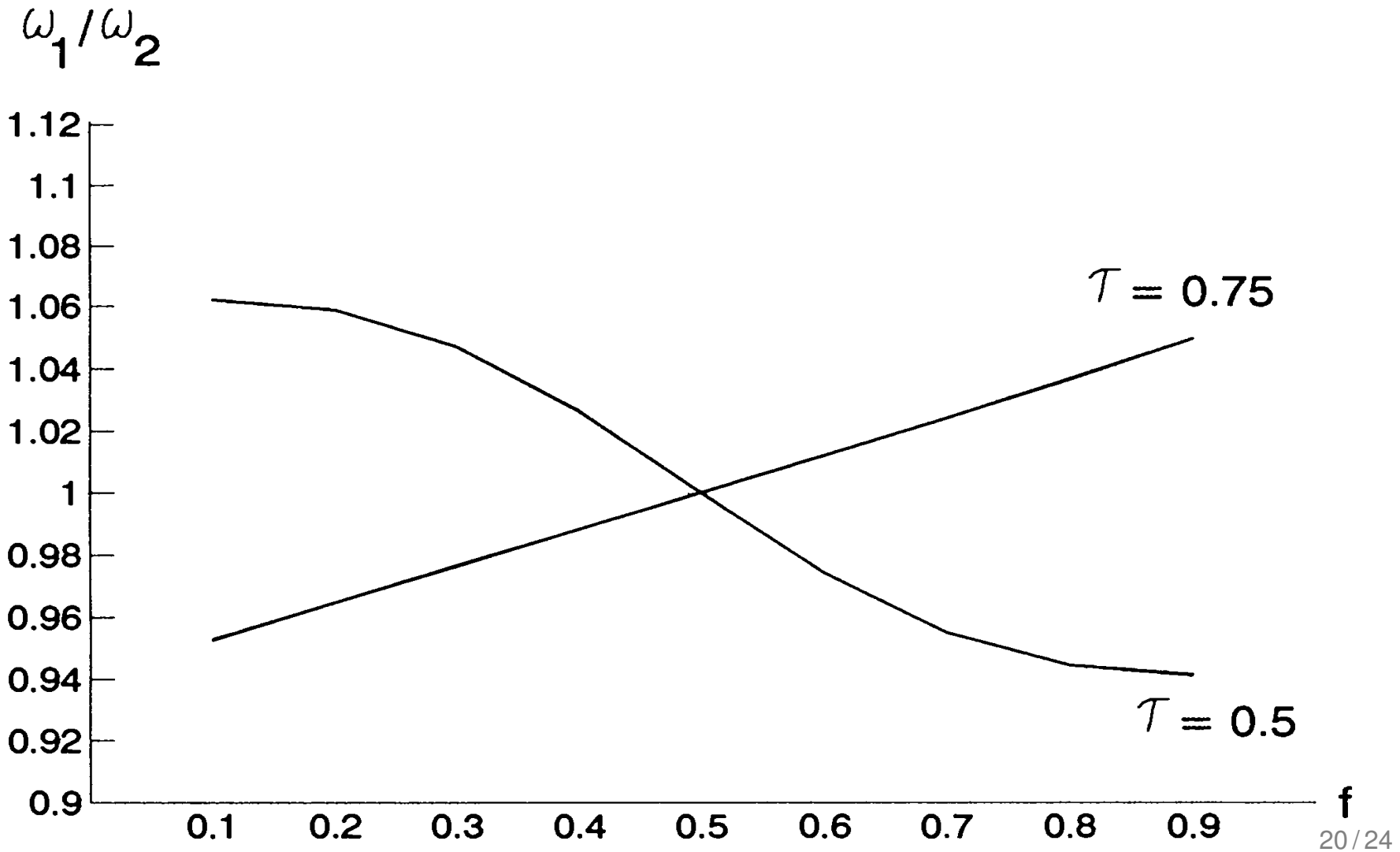
Key is to know how real wage ratio ω_1/ω_2 varies with share of labor force f; if real wage increases with migration then feedback effects will lead to core-periphery equilibrium

Set of non-linear equations makes analytical solution difficult; instead uses numerical exercises to illustrate main idea

Three parameters:

1. Share of consumer budget spent on composite good μ
2. Transportation cost τ–transportation cost increases when τ *decreases*
3. Elasticity of substitution σ, which can measure economies of scale: smaller σ greater economies of scale

Effect of concentration on wage ratio varies by transport cost



Interpretation

When will industry concentrate?

Depends on interaction of key parameters

Dispersion: high transportation cost, low manufacturing consumption share, weak economies of scale

Concentration: low transportation cost, high manufacturing consumption share, large economies of scale

Next figure draws boundaries for convergence (concentration)

Boundaries for concentration equilibrium

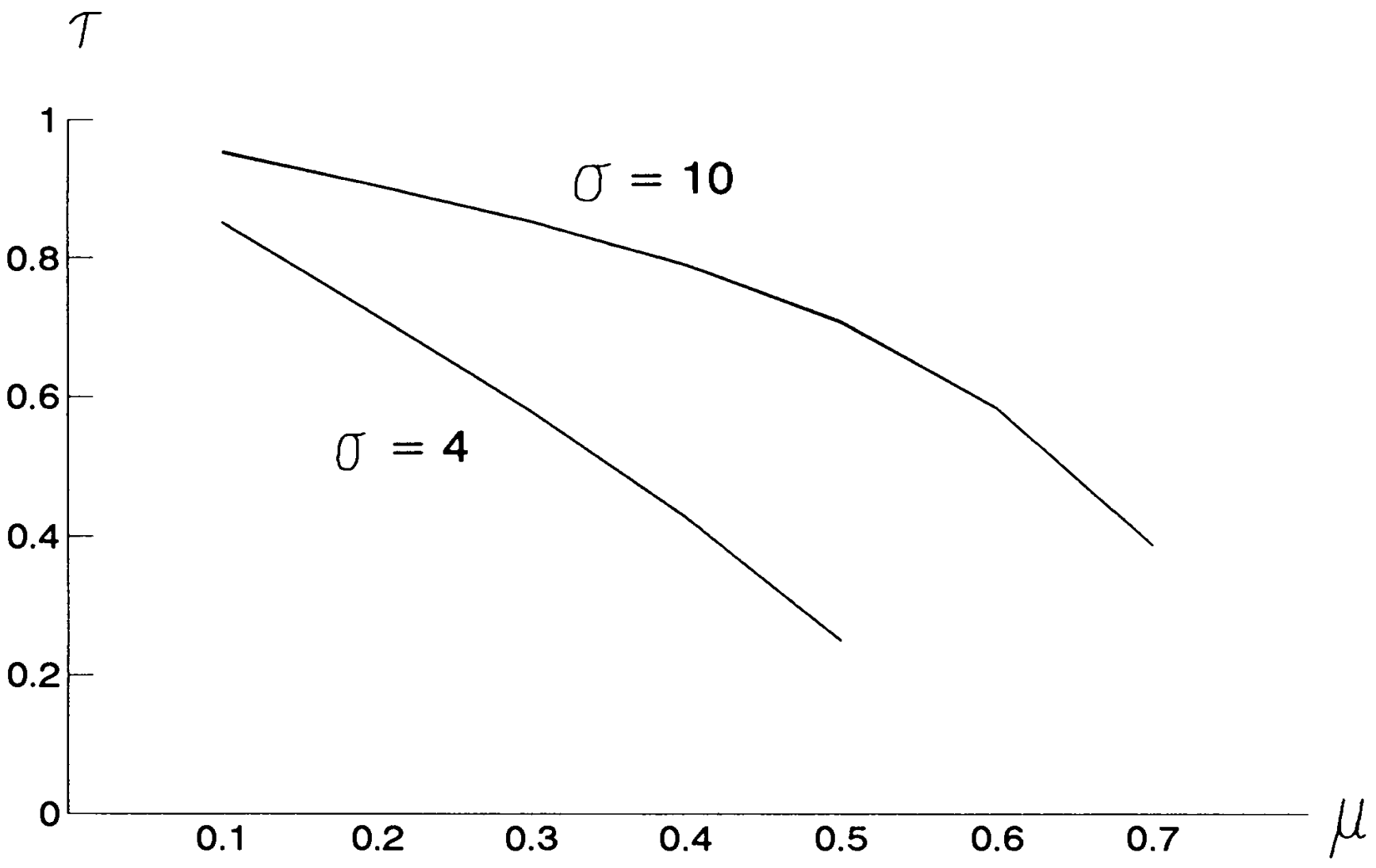


FIG. 3

When $\nu < 1$ manufacturing will concentrate

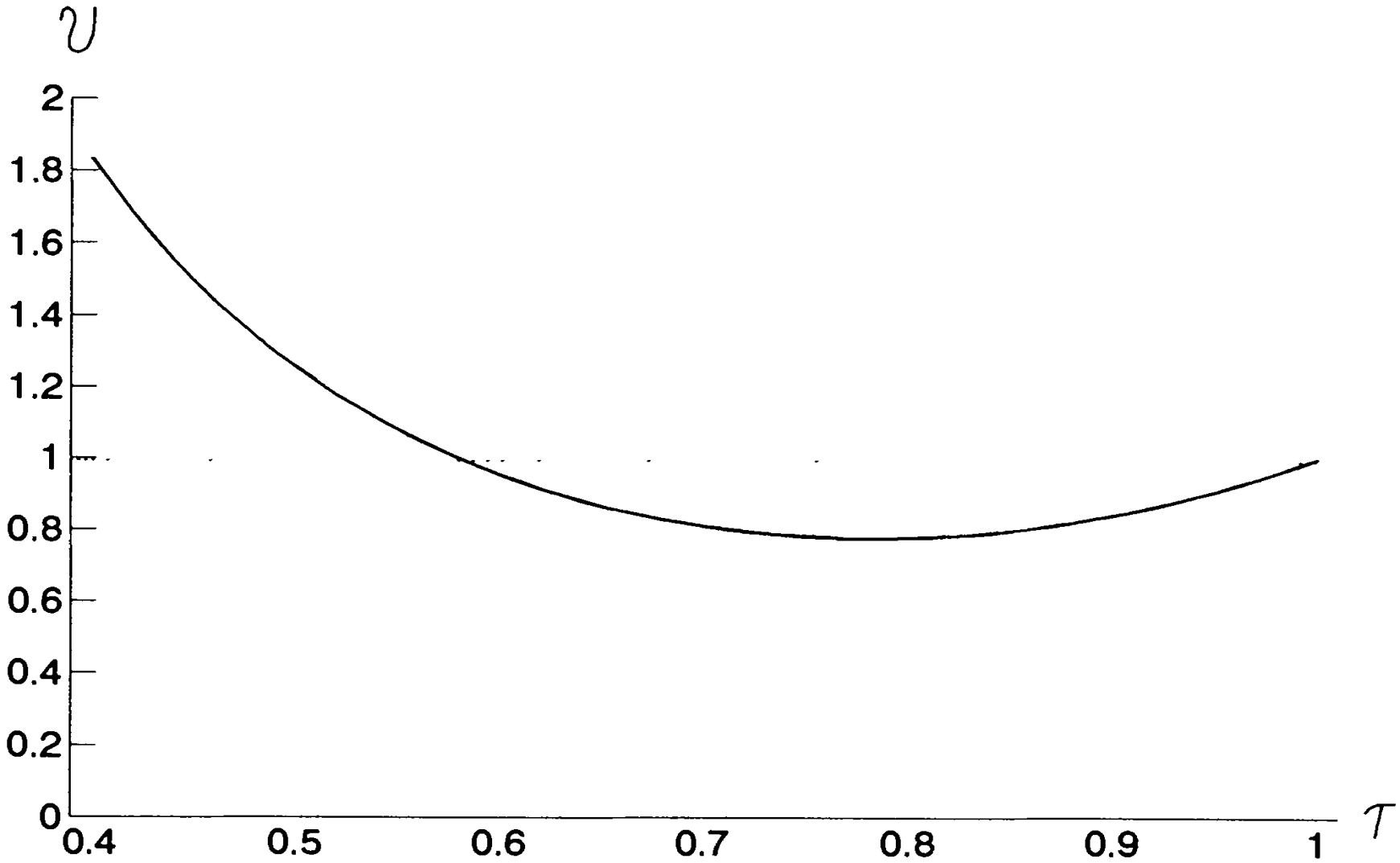


FIG. 2

Main Forces

Pecuniary Externalities: no direct spillovers in terms of productivity but larger markets have important effects (ex: raise demand, allow more varieties, increase utility)

IRS and taste for variety: leads to one firm per type

Home Market Effect: firms want to locate in larger markets

Can sell to domestic consumers without transportation costs (demand higher, price index lower)

This effect exists even without allowing for mobile workers; in Faber paper connecting two asymmetric regions leads to greater concentration in bigger region (firms ship goods to smaller region)

Reinforcement: given parameters, mobile workers can reinforce home market effect by moving to bigger region, increasing market size with own consumption