# *Paper 11*
# *Urban Economics*

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# Theory : main results

**Increasing returns to city size**

$$Q = \phi N^{\gamma}$$

↓

$$\ln Q = \ln \phi + \gamma \ln N$$

↓

$$\ln(Q / N) = \frac{\ln(\varphi)}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right] \ln(Q)$$

**Nonlinear**

↓

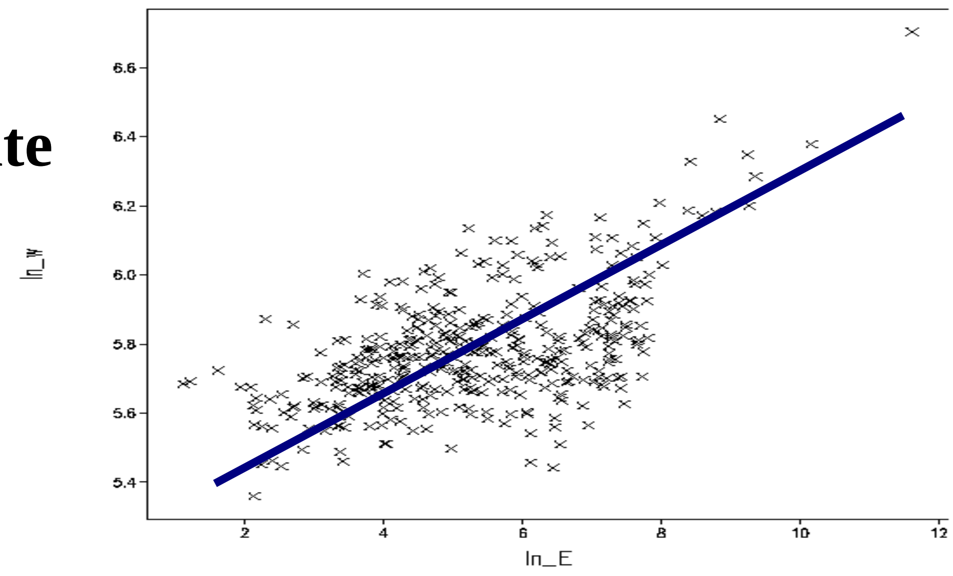
**Take natural logarithms loglinear**

**Wages a function of city size (*Q*)**

# Theory : main results

**Evidence: UK local authorities**

**Log wage rate**




**Log Employment density ≈ city size**

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# Theory : main results

$$Q = M^{\beta} I^{1-\beta}$$ industry

$$I = [\sum_{t=1}^{x} i(t)^{1/\mu}]^{\mu}$$ composite services

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# Theory : main results

$$i(t) = kp^{-\frac{\mu}{\mu-1}}$$

demand for services

$$M = \beta N$$

labour in industry

$$(1-\beta)N$$

labour in the service sector

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# Theory : main results

$$L = s + ai(t)$$

labour requirement
In service firm *t*

$$p_t = wa\mu$$

Equilibrium price of
Service variety *t*

$$i(t) = \frac{s}{a(\mu - 1)}$$

Equilibrium output of
Service firm *t*

$$x = \frac{(1-\beta)N}{ai(t)+s}$$

number of service
firms in equilibrium

# Theory : main results

$$I = [\sum_{t=1}^{x} i(t)^{1/\mu}]^{\mu} = [xi(t)^{1/\mu}]^{\mu} = x^{\mu} i(t)$$

$$I = x^{\mu} i(t)$$

composite services level in equilibrium

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# Theory : main results

$$Q = M^{\beta} I^{1-\beta}$$

$$I = x^{\mu} i(t)$$

$$Q = M^{\beta} (x^{\mu} i(t))^{1-\beta}$$

$$Q = M^{\beta} x^{\mu-\mu\beta} i(t)^{1-\beta}$$

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# Theory : main results

$$Q = N^{\beta+\mu-\mu\beta} \overbrace{\beta^{\beta}(ai(t)+s)^{\mu(\beta-1)} i(t)^{1-\beta}(1-\beta)^{-\mu(\beta-1)}}^{\phi}$$

$$Q = N^{\beta+\mu-\mu\beta}\phi$$

$$Q = \phi N^{1+(1-\beta)(\mu-1)}$$

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# Theory : main results

$$Q = \phi N^{\gamma}$$

$$\gamma = 1 + (1 - \beta)(\mu - 1)$$

$$\beta < 1$$

$$\mu > 1$$

***The Conditions for Increasing Returns to the City Size***

otherwise $\gamma = 1$

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# The Conditions for Increasing Returns to the City Size

$$Q = M^{\beta} I^{1-\beta} \qquad \gamma = 1 + (1-\beta)(\mu - 1) = 1$$

- $\beta = 1$ : composite services have zero weight in the final goods production function
  - there may be a large variety of specialized services in the city
  - But they don't count when it comes to final goods output
  - The only input that matters is $M$

# The Conditions for Increasing Returns to the City Size

$$e_s = \frac{\mu}{\mu - 1} \qquad \gamma = 1 + (1-\beta)(\mu - 1) \quad = 1$$

- As $\mu$ approaches 1, service firms monopoly power diminishes and the elasticity of substitution of varieties tends to infinity
- $\mu = 1$ the services are completely interchangeable, there is no variety
- therefore no increasing returns

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# Testing the Theory

$$Q = \phi N^{\gamma}$$

$$\gamma = 1 + (1 - \beta)(\mu - 1)$$

- How do we know the values of $\phi$ and $\gamma$ to use in any real situation, so that we can get a realistic plot of the relation between city size $N$ and level of output $Q$?

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# Testing the Theory

- If we knew $\beta$ and $\mu$ we could obtain $\gamma$
- However, we don't know $\beta$ and $\mu$
- but we do know the sizes (*N*) of a collection of cities and the amount of industry production (*Q*) in each city
- The relation between *Q* and *N* tells us if we have increasing returns to scale, or is it just a theory with no empirical support

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# Testing the Theory

- Given real data on $N$ values and $Q$ values, it is a simple matter to obtain and estimate of $\gamma$.
- First, it is better to express the relationship between $N$ and $Q$ as a straight line, then look at the slope of the line to check if we have increasing returns.

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# Testing the Theory

If we take natural logs then the relation between ln($Q$) and ln($N$) is the equation of a straight line

$$\ln(Q) = \ln(\phi) + \gamma \ln(N)$$

The slope of the line $\longrightarrow$ $\gamma = \dfrac{\partial \ln(Q)}{\partial \ln(N)}$

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# Testing the Theory

- It is possible to use regression analysis to estimate the coefficient $\gamma$
- And test the null hypothesis that $\gamma = 1$
- If we do not reject the null, there is no evidence for increasing returns
- If we reject the null in favour of the alternative hypothesis that $\gamma > 1$, then we have empirical evidence for increasing returns to scale

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# Testing the Theory

A similar approach can be adopted

When we write our theory in terms of wages

Output as a function of $N$ $\longrightarrow$ $\ln(Q) = \ln(\phi) + \gamma \ln(N)$

$$\gamma \ln(N) = \ln(Q) - \ln(\phi)$$

$$\ln(N) = \frac{\ln(Q) - \ln(\phi)}{\gamma}$$

$$\ln(Q) - \ln(N) = \ln(Q) - \frac{\ln(Q)}{\gamma} + \frac{\ln(\phi)}{\gamma}$$

Wages as a function of $Q$ $\longrightarrow$ $\ln(Q/N) = \frac{\ln(\phi)}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right]\ln(Q)$

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# Testing the Theory

Wage Analysis

$$\ln\left(Q/N\right) = \frac{\ln(\phi)}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right]\ln(Q)$$

$$\ln(w) = k + \tilde{\beta}\ln(Q) + \varepsilon$$

Test of null hypothesis $\tilde{\beta} = 0$

**Or**

Given that $\ln(Q) = \ln(\phi) + \gamma\ln(N)$ ,$Q$ is determined by $N$

hence $\ln(w) = \ln(\phi) + \kappa\ln(N) + \varepsilon$

Test of null hypothesis $\kappa = 0$

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# BUT……..

- A problem with this kind of analysis is that it does not completely explain the data
- We need to consider other factors that will also have an effect (ε)
- This leads us to consider the role played by externalities
- And look at how we might incorporate these effects into our modelling structure

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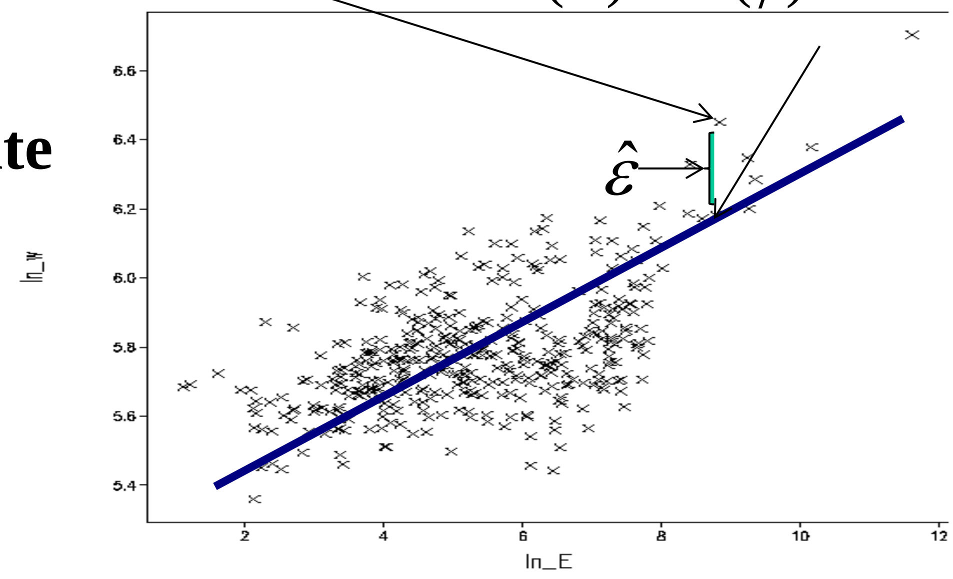
# Evidence: UK local authorities

$$\ln(w) = \ln(\hat{\phi}) + \hat{\kappa}\ln(N) + \hat{\varepsilon}$$

$$\ln(\hat{w}) = \ln(\hat{\phi}) + \hat{\kappa}\ln(N)$$

**Log wage rate**




**Log Employment density ≈ city size**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# Externalities

- Externalities, also known as spillovers, involve interdependence of utility, production or profit functions.
- Externalities arise because of
- market interdependence
- the non-existence of markets
  - There are many factors, which are not manifest in the market and unpriced, which affect urban productivity

# Externalities

- Two types
- Pecuniary externalities
  - We have already been considering these!
  - Involve the market : market interdependence
- Technological externalities
  - These make up the bulk of what we will consider from now on
  - Typically occur when we have market failure

# Pecuniary Externalities

- Affects firm's demand and profit functions mainly through changes in prices
- referred to as market interdependence (backward and forward linkages)

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# Pecuniary Externalities

‘Investment in an industry leads to an expansion of its capacity and may thus lower the prices of its products and raise the prices of the factors used by it. The lowering of product prices benefits the users of these products; the raising of factors prices benefits the suppliers of these factors. When these benefits accrue to firms, in the form of profits, they are external pecuniary economies’

Scitovsky (JPE, 1954)

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# Pecuniary Externalities

- A large industry market supports a large services market, which supports a large industry market, and so on
  - A concentration of industry in a city provides a large local market for a variety of specialized services
  - This enhances industry productivity, and thus helps to maintain the markets for industry and services
- Hence we have market interdependence

# Technological Externalities

- Occur when the well-being of a consumer or output of a firm are directly affected by the action of another agent in the economy
- The word 'directly' means that we exclude effects mediated by markets

# Technological Externalities

Classic Example

- Assume we have a river with two activities, a fishery (downstream) and an oil refinery (upstream)
- the fishery's productivity is reduced as a direct result of water pollution from the oil refinery
- No involvement of the market

# Technological Externalities

- Technological externalities are becoming an increasingly important dimension of our understanding of economic development
- Glaeser et al. (1992) observe that recent theories of economic growth have stressed the role of technological spillovers, particularly in cities where close communication between people greatly facilitates knowledge spillovers
- Being within a city provides external economies that are beneficial for economic activity

# Technological Externalities

Glaeser et al (1992)

- 'Urban economics needs to specialize in non-market interactions, because these interactions are (I believe) central to understanding the causes and effects of cities’
- ‘Krugman (1991) shows that a brilliant theorist can explain cities without non-market interactions. But it is less obvious to me why one would want to do so’

# Papers that criticize urban economics as an explanation

- Glaeser et al (1992) “Growth of cities”, Journal of Political Economy, 1992, vol.100, no. 6, 1126-1152
  - Urban economics ignores non-market interactions
- Neary J P (2001) 'Of Hype and Hyperbolas: Introducing the New Economic Geography' Journal of Economic Literature XXXIX 536-561
  - The theory itself is faulty, why monopolistic competition?
    - No strategic interaction between firms< unrealistic
    - No barriers to entry of firms < unrealistic
  - Oversimplified, no technological externalities

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# Technological Externalities

- Positive
  - Knowledge spillovers within cities
- Negative
  - Urban congestion
  - pollution

# Externalities : Knowledge spillovers

- Knowledge is often created in an urban environment
- but its benefits are often not captured completely by the innovator
- others free-ride on someone else's effort without paying for it

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# Externalities : Congestion effects

- On the production side firms 'get in each others' way' or 'step on each others' toes' and this affects their costs
- Congestion arises when firms use common, but unpriced inputs in short supply
  - inadequate physical space
  - infrastructural inadequacies relating to power supplies, water (for cleaning, cooling etc), road and other communications etc

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# Externalities : Congestion effects

- However, there is a wider sense in which congestion occurs, it is when firms innovate and the innovations tend to be substitutes rather than complements
- For instance, if R&D within different firms is substantially the same, there will be congestion externalities and over-investment in R&D

# Externalities : Congestion effects

- So I have argued that congestion is not simply road congestion but is a wider concept
- Congestion comes from various sources which make production more costly in a restricted space

# Modelling technological Externalities

In what follows we develop the model to include two specific types of technological externalities:

- congestion
- knowledge spillovers

# Congestion in Industry

So far we have ignored land ($L$) as a factor of production, this is equivalent to assuming $\alpha$ = 1 since then

$$L^{1-\alpha} = L^0 = 1$$

$$Q = \left[ M^{\beta} I^{1-\beta} \right]^{\alpha} L^{1-\alpha} = M^{\beta} I^{1-\beta}$$

More generally the value assigned to the coefficient is not extreme (at 0 or 1) but in the range $0<\alpha<1$

$\alpha$ determines the relative importance of land ($L$) versus other inputs ($M$,$I$)

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# Congestion in Industry

Assume now that $L$ = 1, in other words we are calculating output for a unit of land. The resulting equation, allowing for congestion effects so that 0<$\alpha$<1, then becomes

$$L^{1-\alpha} = 1^{1-\alpha} = 1, \text{ hence } Q = (M^{\beta} I^{1-\beta})^{\alpha} L^{1-\alpha} = (M^{\beta} I^{1-\beta})^{\alpha}$$

writing $M^{\beta} I^{1-\beta} = \phi' N^{\gamma'}$

$$Q = (\phi' N^{\gamma'})^{\alpha}$$

We use primes here to distinguish our old parameters now with primes from some new ones without

If we set $\alpha$ close to its lower limit 0 then congestion effects greatly inhibit output. As $\alpha$ approaches the upper limit of 1, congestion effects have less and less impact on $Q$

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# Congestion in Industry

$$Q = (\phi' N^{\gamma'})^{\alpha}$$

Original $\gamma$ ⟶ $\gamma' = 1 + (1-\beta)(\mu - 1)$

$$Q = \phi'^{\alpha} N^{\alpha\gamma'}$$

New $\gamma$ ⟶ $\gamma = \alpha\gamma' = \alpha(1 + (1-\beta)(\mu - 1))$

*New* $\phi$ ⟶ $\phi = \phi'^{\alpha}$

$$Q = \phi N^{\gamma}$$

# Congestion in Industry

What does including congestion imply for the new definitions of the parameters $\phi$ and $\gamma$?

old equation $\longrightarrow \gamma' = 1 + (1-\beta)(\mu - 1)$

However, when we also include congestion in the form of $\alpha$, then on expanding equation we find that

new equation $\longrightarrow \gamma = \alpha[1 + (1-\beta)(\mu - 1)]$

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# Congestion in Industry

With the earlier definition $\gamma' = 1 + (1-\beta)(\mu - 1)$, if services were irrelevant ($\beta = 1$) or if there were no internal increasing returns for service firms ($\mu = 1$) then there are no increasing returns for final producers with density ($\gamma' = 1$)

However with the new definition $\gamma' = \alpha[1 + (1-\beta)(\mu - 1)]$ there is a range of outcomes, depending on the respective values of $\mu$, $\beta$ and $\alpha$

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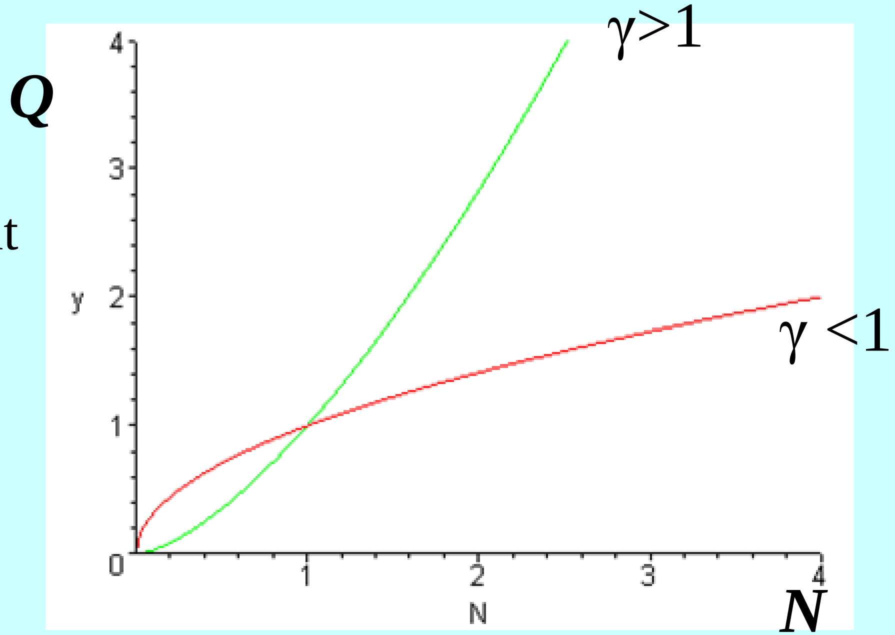
# Congestion in Industry

$$Q = \phi N^{\gamma} \qquad \gamma = \alpha[1 + (1 - \beta)(\mu - 1)]$$

↑ ↑

per unit area

With $\alpha$ small so that $\gamma<1$
the effect of congestion is so severe that it completely overturns any tendency to increasing returns. Increasing density is not accompanied by a commensurate increase in output, as shown by the diminishing slope of the line





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