Paper 11
Urban Economics

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Aim

- To describe a theoretical model is able to account for some of the most visible urban economic realities
- Workers and firms tend to agglomerate in cities, why is this?
- Large cities are associated with higher productivity and higher wage rates, but why?

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Evidence

- Urban population as a proportion of total population growing globally
  - according to UN, exceeded 50% in 2005
- Density of development correlated with wage rates in UK

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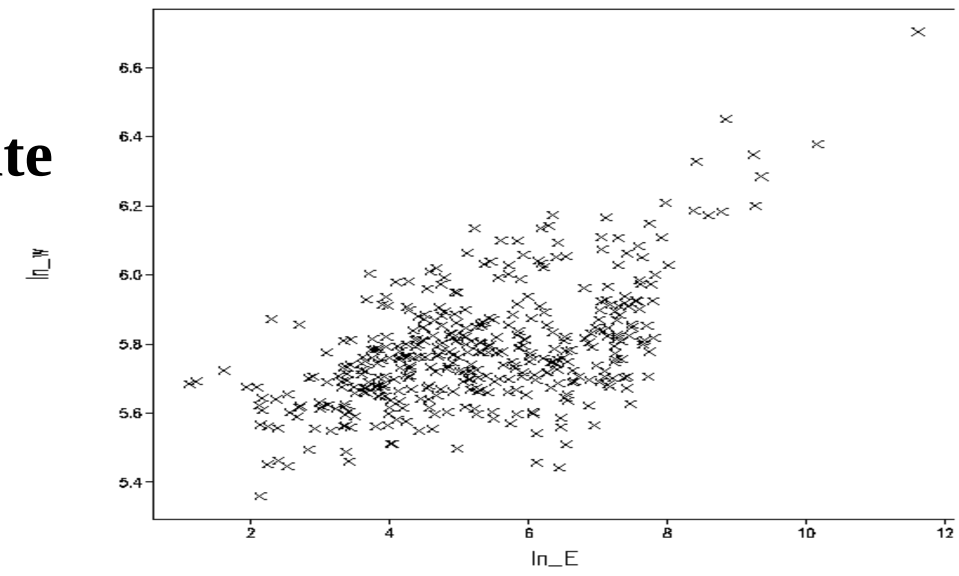
Evidence: UK local authorities

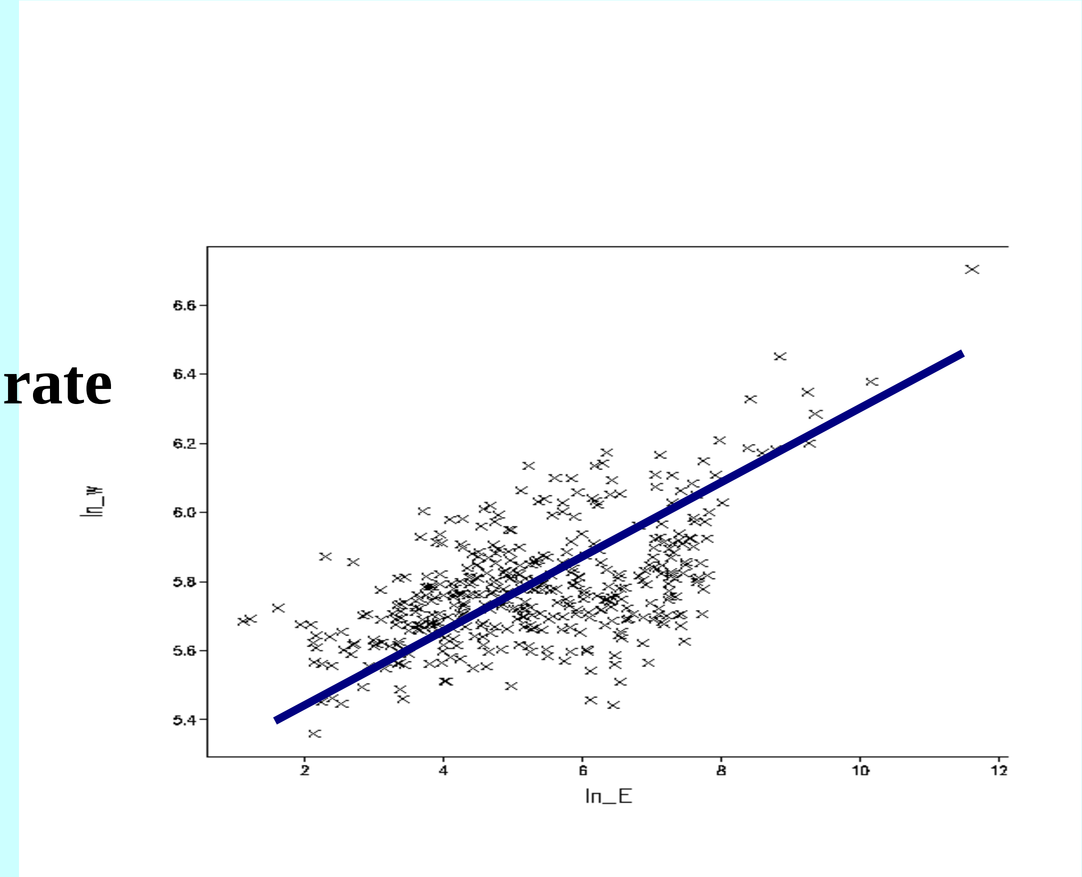
Log wage rate



Log Employment per sq km

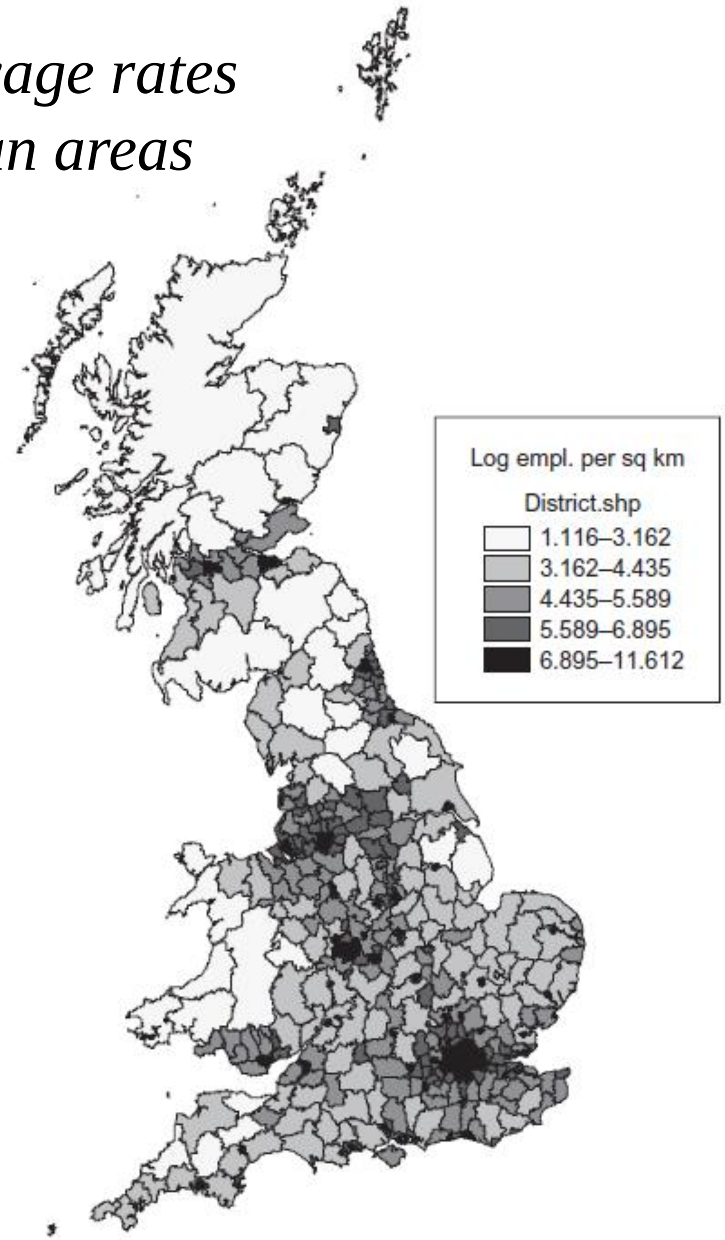
Evidence: UK local authorities

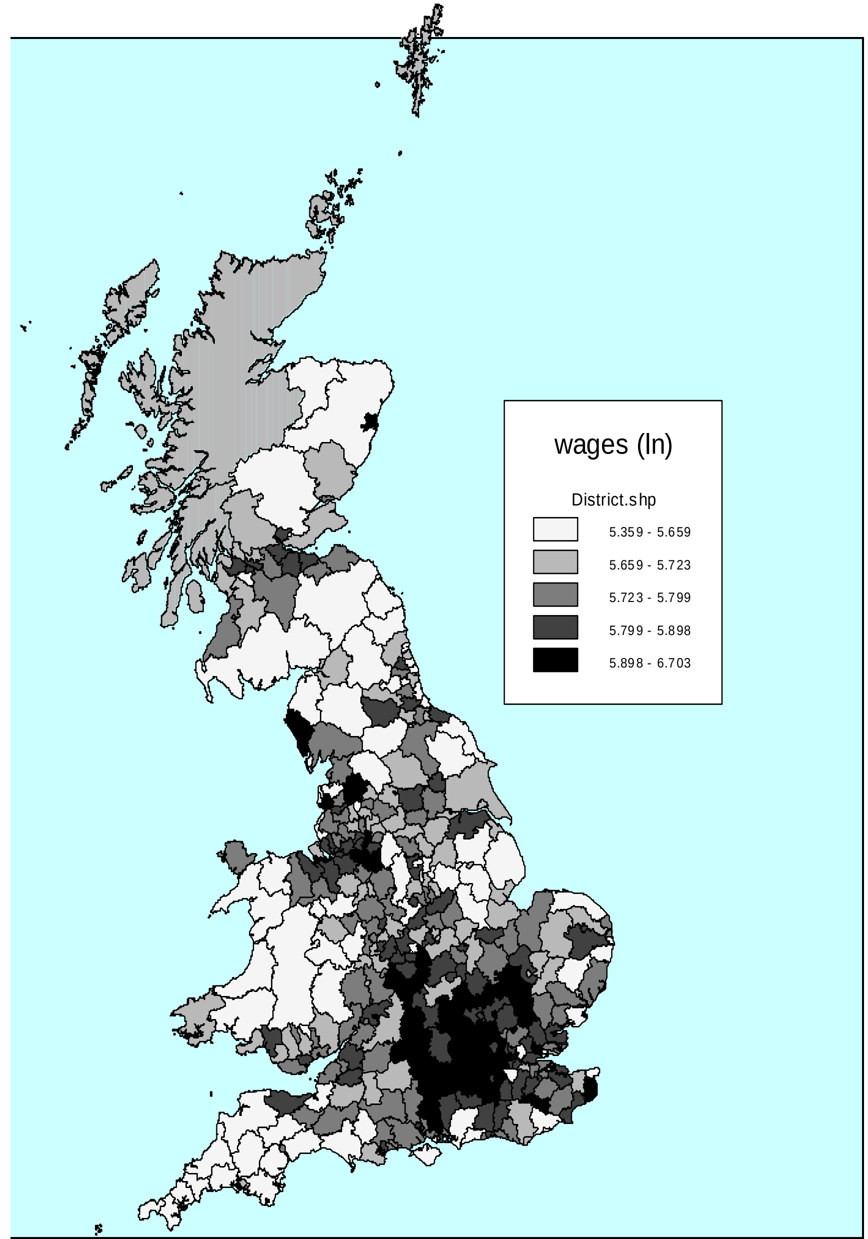
Log wage rate



Log Employment per sq km

High wage rates
In urban areas





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Top 10

Local authority area	ln (wages)	ln (employee density)
City_of_London	6.703	11.612
Tower_Hamlets	6.451	8.848
Westminster_City_of	6.379	10.168
Islington	6.348	9.251
Hackney	6.328	8.425
Camden	6.284	9.361
Slough	6.208	7.981
Kensington_and_Chelsea	6.200	9.264
Lambeth	6.186	8.389
Hammersmith_and_Fulham	6.183	8.790

Bottom 10

Local authority area	ln (wages)	ln (employee density)
Chester-le-Street	5.498	4.978
Torridge	5.494	2.844
Conwy	5.488	3.382
Richmondshire	5.462	2.404
Caradon	5.460	3.421
Weymouth_and_Portland	5.457	6.122
Berwick-upon-Tweed	5.452	2.248
West_Devon	5.445	2.534
Havering	5.442	6.456
Alnwick	5.359	2.140

Other Factors affecting city productivity/wages

- educational attainment
- skill differences
- access to productive in-commuters
- Etc
- However, the relationship between wage rates and the density of economic activity is an impressive one

Why are larger (denser) cities more productive and have higher wage rates?

Economic theory suggests:

- Increasing returns to scale
- Positive externalities

Internal Increasing returns

- From a firm's perspective, fixed costs become less important as firm size increases
- So total costs rise but average costs fall
- Downward sloping average cost curve

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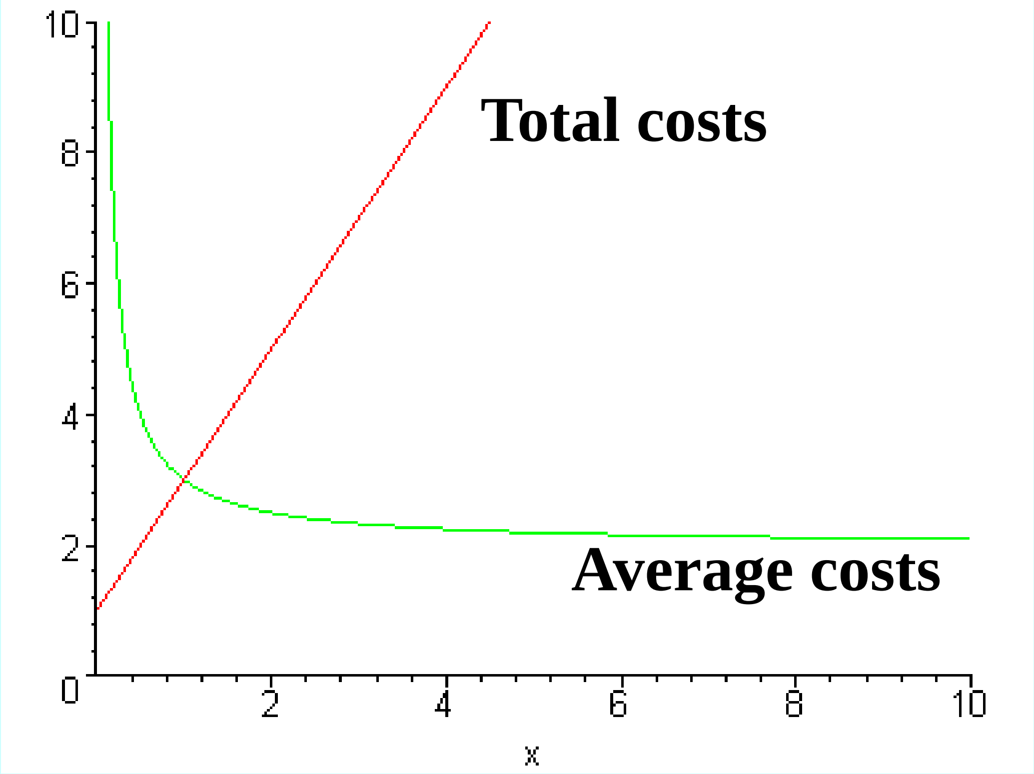
Internal Increasing Returns

As output (x) increases, while total costs rise average costs fall



Internal Economies of Scale

- Scitovsky (1954) distinguished between internal and external economies of scale
- Internal economies of scale
  - the decrease in average costs is due to an increase in the production level of the firm itself
  - This implies some advantage accruing from size, increasing size only possible under imperfect rather than perfect competition

Perfect Competition

- Large number of small consumers and producers who are price takers
- Homogenous good
- Perfect information
- No barriers to entry
- No increasing returns
- No externalities

Firms cannot increase in size due to restriction of perfect competition

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External Economies of Scale

- Scitovsky (1954) : external economies of scale
  - With external scale economies average costs depend on the level of output of the industry as a whole

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New Models

- It has long been intuitively obvious that increasing returns go hand in hand with city formation
- Mainstream economists found it difficult to develop formal theory, which embodied increasing returns

New Models

- Since the late 1980s, things have changed and urban economics has moved, along with economic geography, more to the centre stage of economics
- Elegant theory has been developed which incorporates increasing returns
- Key: the role of monopolistic competition

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Modelling Cities and Agglomerations

- Increasing returns to scale and externalities highlight the role of urban size and diversity as a reason why large cities are more productive
- In recent decades, formal models have emerged, which capture these types of effects in a formal way
- The key is the service sector under monopolistic competition

The Service Sector

- non-traded producer services sector
- traded services

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Non- Traded Services

- local services that provide inputs to industry and other services.
  - Not traded directly (imported or exported) in national or international markets.
  - Supply the city's industrial base and traded service sector
- examples: repair and maintenance services such as water and heating supplies, office equipment, industrial machinery servicing, communications, engineering, legal support, banking and insurance services etc etc

Non- Traded Services

- local services that provide inputs to industry and other services.
- For convenience we will refer to these kind of activities as ‘services’
- And refer to all other types of activity as ‘industry’ or sometimes ‘final goods and services’

The basic Model

Industry

- Production function for industry depends on: labour, and (non-traded) service inputs
- Industry production function has constant returns
- Industry is assumed to be in a competitive market

Industry Production Function

$$Q = M^{\beta} I^{\alpha}$$ (Cobb-Douglas)

Q – output
I - composite services
M – Industry Labour
β – coefficient on industry labour
α – coefficient on composite services

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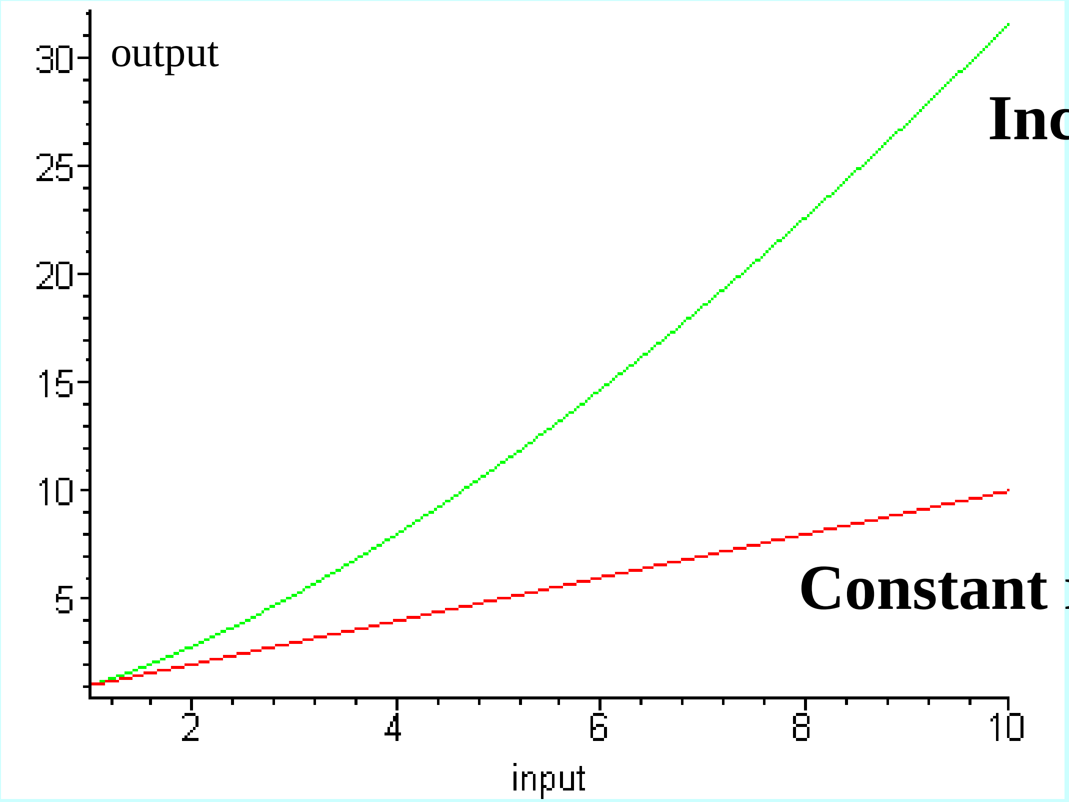
Returns to Scale in Cobb-Douglas

- when $\alpha + \beta = 1$ we have constant returns, so that doubling inputs doubles output
- *Then* $\alpha = 1 - \beta$
- when $\alpha + \beta > 1$ then we have increasing returns, doubling inputs more than doubles output

Returns to Scale in Cobb-Douglas



Increasing returns to scale

$\alpha + \beta = 1$

$\alpha + \beta > 1 = 1.5$

Constant returns to scale

Increasing Returns to the City Size

- In fact for industry we assume that production is competitive, there are no increasing returns because $\alpha = 1 - \beta$ so that $\alpha + \beta = 1$
- doubling inputs simply doubles outputs
- Nevertheless, it is possible to have increasing returns to city size
- How does this come about?

Service sector market structure

- Producer services are assumed to operate under monopolistic competition

Original contributions:

- E. H. Chamberlain (1933) *The Theory of Monopolistic Competition*
- J. Robinson (1933) *The Economics of Imperfect Competition*

Theoretical fundamentals

- The most influential recent paper is Dixit and Stiglitz (AER 1977) *Monopolistic Competition, and the Optimum Product Diversity*
- This revolutionized model-building in several fields of economics: trade theory, industrial organization, growth theory, geographical economics, and urban economics
- It provided an elegant and simple way to model production at the firm level benefiting from internal economies of scale operating in a monopolistically competitive market

Modelling approach

- Imperfect competition assumed for services not industry
- following the work of Abdel –Rahman and Fujita(1990) and Rivera-Batiz(1988) among others
- The so-called 'love of variety' effect obtained using the Constant Elasticity of Substitution (CES) production function and monopolistic competition as the market structure in the service sector.
- Greater service variety per se is relevant to the level of output of industry firms
- We are going to discuss this approach in greater detail later

Composite Services : I

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

- level of composite services I determined by increasing returns of CES (Constant Elasticity of Substitution) production function

Composite Services

$$I = \left[\int_{t=1}^{t=x} i(t)^{1/\mu} \, dt \right]^{\mu} \qquad \text{(CES)}$$

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

x – number of firms (varieties)
i(t) – firm output (constant), *t* = specific firm, *t* = 1…*x*
μ- parameter that regulates returns to scale and elasticities (to be explored later)

Composite Services

Assume for the moment that each firm *t* produces the same amount of output *i(t)*. In other words their costs are identical and the amount purchased is equal across all service firms. It is then the case that summing over *x* firms is the same thing as *x* multiplied by the constant *i(t)*. The rather complicated CES production function then becomes very much simpler

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

x – number of firms (varieties)
i(t) – firm output (constant across all firms)
μ- parameter that regulates returns to scale and elasticities

Composite Services

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

x – number of firms (varieties)

$i(t)$ – firm output (constant)

μ- parameter that regulates returns to scale and elasticities

If μ*=1, i(t)* = 9, x = 3

I = (3 * 9**1)**1= (3**1) * 9 = 27

3 firms each of size 9

I = 3 x 9 = 27

if μ = 2, *i(t)* = 9, x =3

I = [9**0.5 + 9**0.5 + 9**0.5]**2 = 81

I = (3 * 9**0.5)**2 = (3**2) * 9 = 81

But with increasing returns I = 81

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Composite Services

when $\mu = 1$, then the level of services I is simply
each firm's output $i(t)$ multiplied by the number of firms x

with μ=1 variety does not matter as a determinant of the level of services and 100 units of one variety gives the same input as one unit of 100 varieties. In this case products are perfect substitutes so that one unit less of one variety can be exactly compensated by one unit more of another variety

However, look what happens if $\mu > 1$, it is now the case that I is greater than $i(t)$ times x. There is an extra ingredient boosting the level of services

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The elasticity of substitution

$$e_s = \frac{\mu}{\mu - 1}$$

As μ becomes increasingly large,
the elasticity of substitution $e_s = \mu/(\mu\text{-}1)$ falls

A low elasticity of substitution means
the individual varieties of services are not very close substitutes for each other.
In other words, with a low elasticity of substitution, doubling the number of firms x results in a more than two-fold increase in I.
Variety matters.
This is the source of increasing returns for industry production

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Composite Services

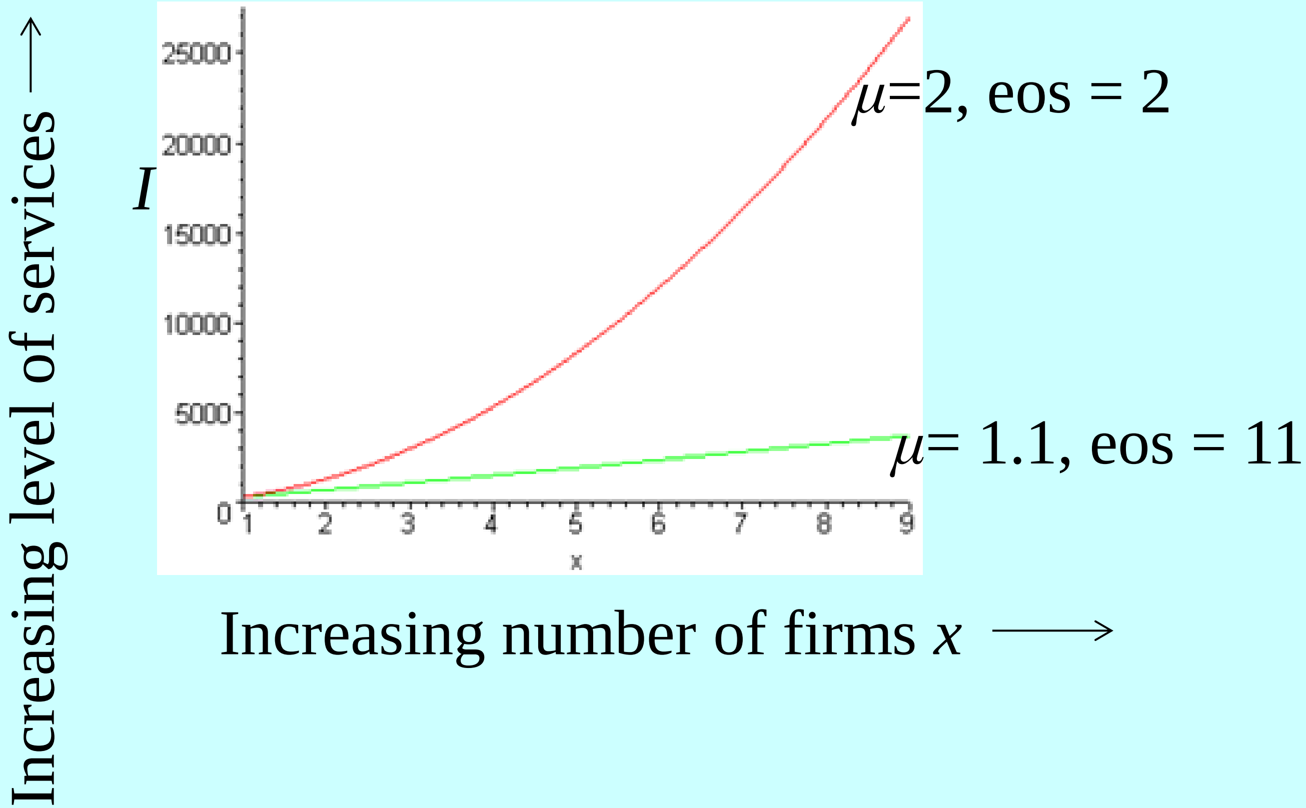
- The level of composite services I depends on three things
- The typical level of output of a service firm $i(t)$
- The number of service firms in the city x
- The elasticity of substitution parameter μ

Composite Services

- We have focussed on the effect on I of changing μ
- Now let us see what the effect of changing x is

Composite Services

The relationship between x and I for different μ



Increasing number of firms x ⟶

Composite Services

- The question is
- Is this a good model for production in the service sector?

Monopolistic Competition

- Motivation: In many economic activities market structure does not appear to correspond to either of the polar cases of perfect competition or monopoly
- Also, oligopoly only applies to a limited number of industries with small number of very large players

Monopolistic Competition

- The monopolistically competitive market structure has a large number of firms producing ‘similar’ but NOT identical products
- Product differentiation gives service firms some monopoly power

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Monopolistic Competition

- But the possibility of earning long-run super-normal profits is removed because of free entry into the market
- This matches the reality of a very large number of small diverse service firms with few entry barriers

Monopolistic Competition

- Markets structure for services
  - generally highly competitive
  - relatively minor entry and exit barriers
  - Product differentiation
- All features of monopolistic competition theory

Monopolistic Competition

- Industry has specialized demands
- each service firm is differentiated, supplying a specific product to industry
- The greater the variety, the greater industry efficiency

Monopolistic Competition

- Bottom line
- monopolistic competition allows internal increasing returns at the service firm level
- This is the basis for increasing returns with city size for industry

Love of Variety

Key Assumption

- A rise in the variety of different services will autonomously increases industrial output
- 100 different services more valuable than 100 providers of a single service

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Love of Variety

- The size of the city will determine the number of specialized services
  - a larger city will have a greater variety of services
- Since variety itself enhances industry output, larger cities are more productive

Industry output

- The question is, how can we show formally that increasing returns in the service sector under monopolistic competition leads to production gains for industry?
- This is the outcome when we combine our production functions for industry and services

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

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

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Industry output

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

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

M is industry labour

N is total labour = city size

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

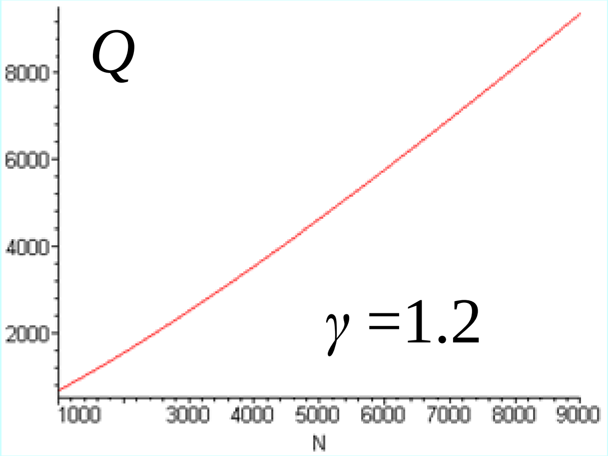
Output *Q* a nonlinear function

Of city size *N*

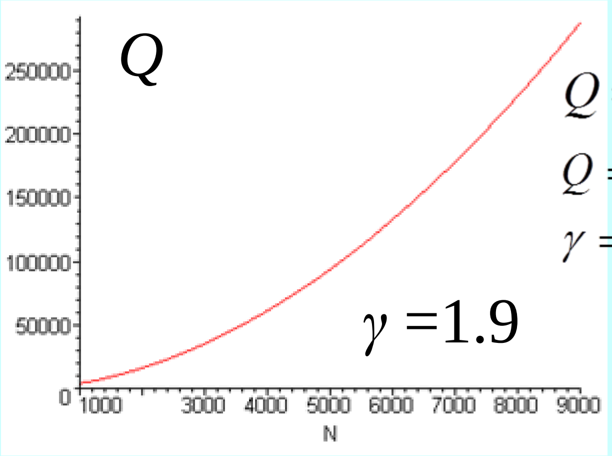
$$\gamma = 1 + (1-\beta)(\mu - 1)$$

Importance of industry labour

Industry output



The relationship between N and Q for μ =2, with β =0.8



The relationship between N and Q for μ =2, with β =0.1

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

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

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

As β decreases, composite services (I) becomes more important, Q becomes larger and the link between Q and city size (N) more nonlinear…..more increasing returns

This is due to nonlinear link in service sector between I and x

Becoming more prominent as a determinant of Q

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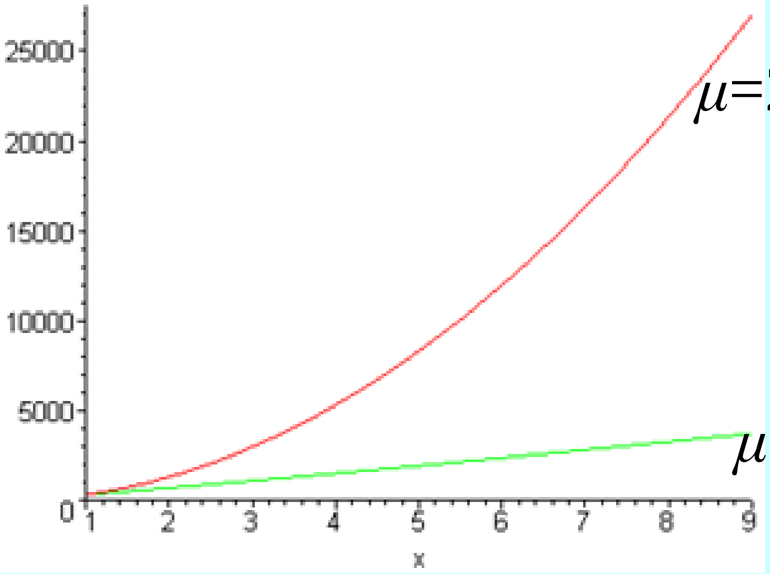
nonlinear link in services between *I* and *x*

The relationship between x and I for different μ

Increasing level of services →



I

μ=2, eos = 2

μ= 1.1, eos = 11

Increasing number of firms x ⟶

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Industry output

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

Likewise for given β, increasing μ causes link in service sector between I and x to be more curved

So the link between Q and city size (N) becomes more nonlinear…..more increasing returns

Increasing returns to city size

- We have seen that our model has two sectors, industry and services
- Industry is assume to have a competitive market structure with constant returns to scale
- Services are under monopolistic competition with internal increasing returns to scale

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Increasing returns to city size

- outcome is the nonlinear relationship between the level of industry output (*Q*) and city size (*N*)
- Bigger cities are more productive
- the same relationship is also an outcome of a different tradition in urban and regional economics, that which has been strongly influenced by people such as Keynes and Kaldor
- Fingleton B (2001) 'Equilibrium and economic growth : spatial econometric models and simulations' *Journal of Regional Science*, 41 117-148
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Increasing returns to city size

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

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

M is industry labour

N is total labour = city size

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

Output *Q* a nonlinear function

Of city size *N*

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

Importance of industry labour

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Increasing returns to city size

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

Nonlinear

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

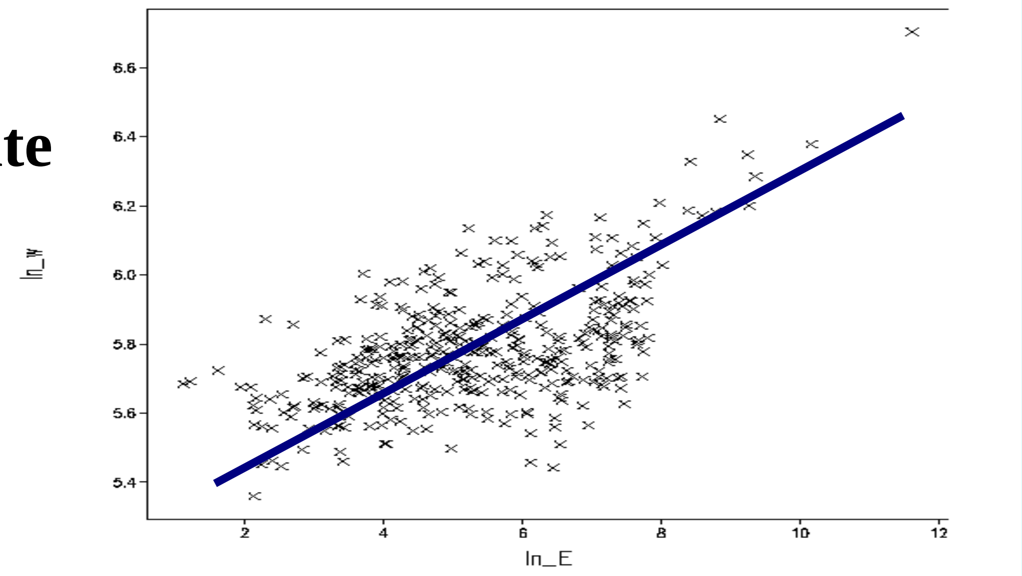
Take natural logarithms
loglinear

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

Productivity
(qua wages)
A function of city size (*Q*)

Evidence: UK local authorities

Log wage rate



Log Employment density ≈ city size

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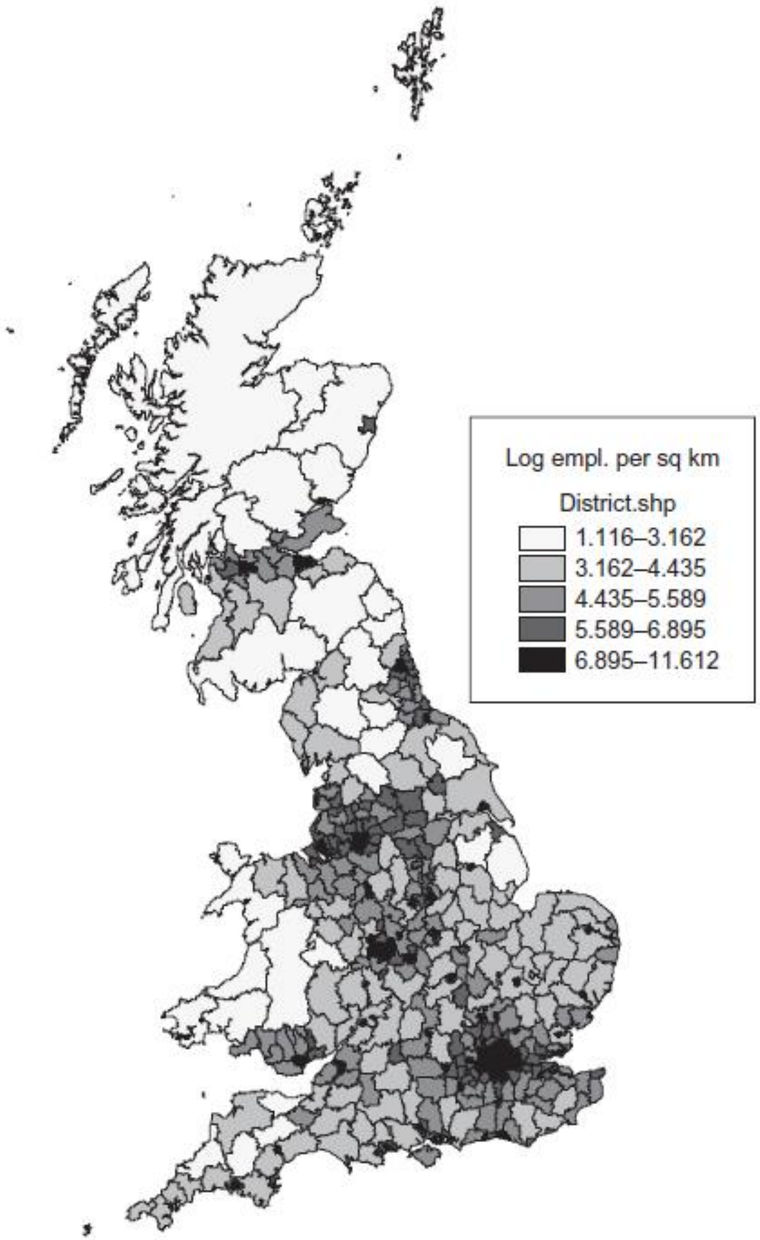

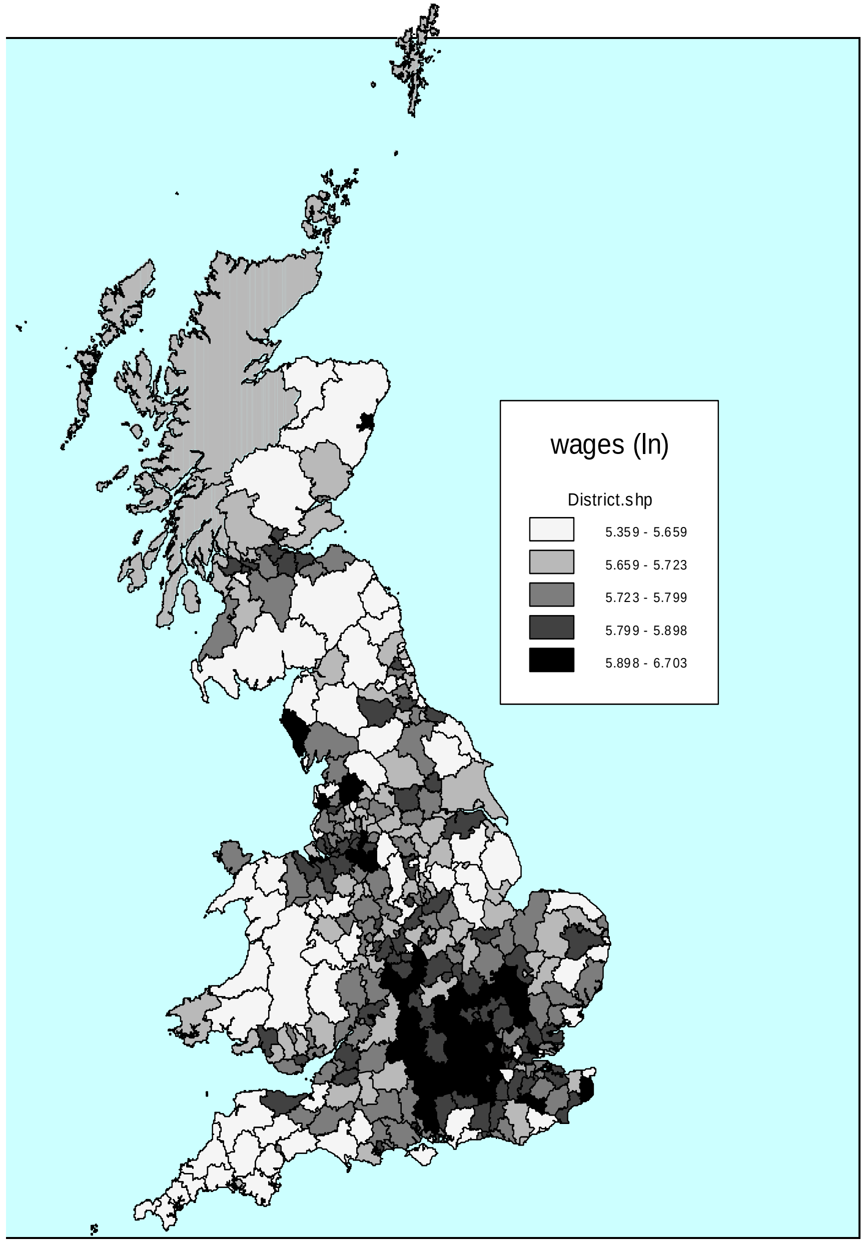

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Micro-foundations

- In order to understand how we combine the two production functions to arrive at the loglinear relationship between Q and N
- we need to examine the assumptions being made about firms' production more closely
- We need to examine the micro-foundations of our theory

- Essential requirement is the number of service firms x in the city
- This can be obtained by assuming that there is an equilibrium size for the typical firm, measured in terms of production $i(t)$ hence employment L
- And dividing total service sector employment by the number of workers in the typical firm (L) gives us the number of firms x

- How can we assume a typical equilibrium service sector firm size?

Micro-economic foundations : services

- Assume that the amount of labour L is a linear function of the amount of output (demand) $i(t)$
- Assume that we have fixed and variable costs, but with fixed labour costs s we have internal increasing returns for service firms
- So average costs fall as the firm get bigger

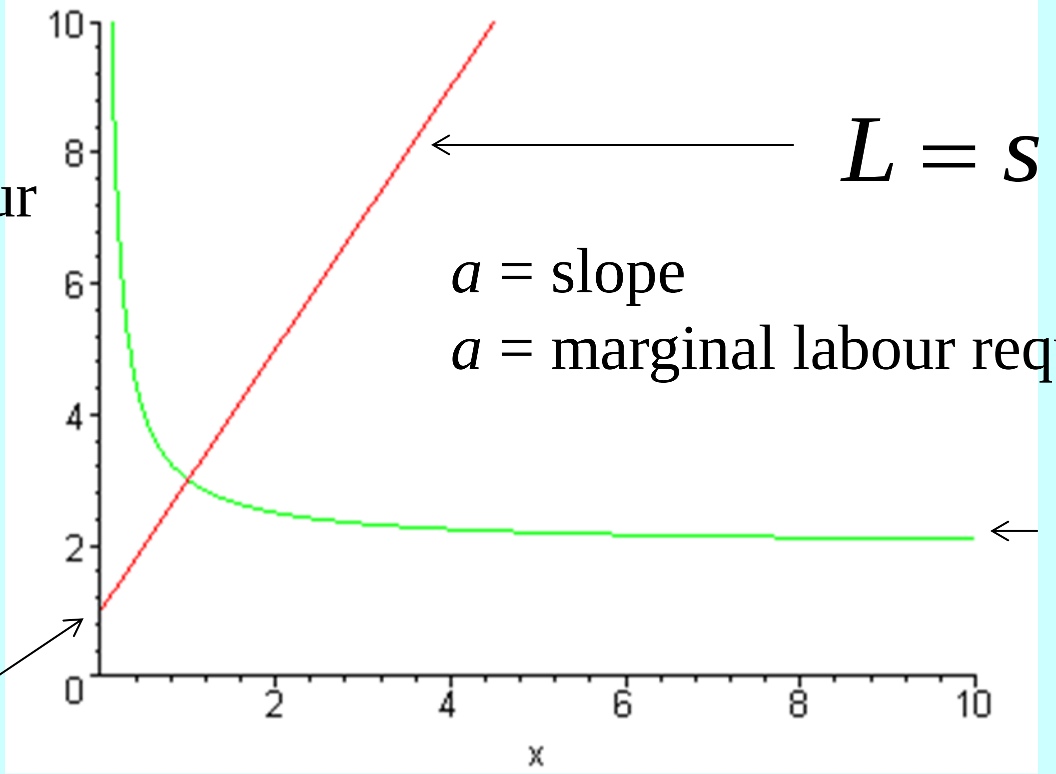
Micro-economic foundations : services

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

L = labour

a = slope

a = marginal labour requirement



Average cost curve

s = fixed labour requirement

Output $i(t)$

Micro-economic foundations : services

- Should firms with internal increasing returns keep increasing in size indefinitely, since bigger means better?
- Is there an equilibrium size to which they converge?
- Increasing output increases costs as well as revenues
  - Revenues increase because sales are higher, but costs increase because more workers are employed
- So, there is an equilibrium service firm size at which profits are at a maximum

Towards an equilibrium size for the typical service firm

- Assume a nonlinear relation between prices and demand for services
- Rising prices will cause falling demand (output)
- This will affect <u>BOTH</u> total revenue and total costs
- profits = revenue – costs will reach a maximum at a certain level of prices and demand

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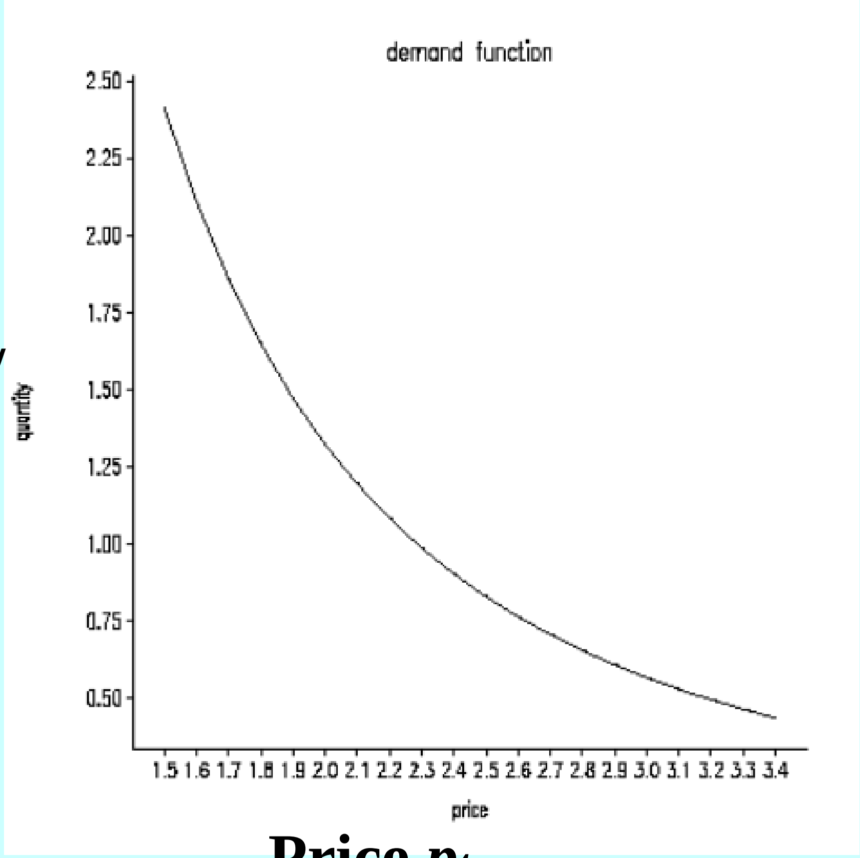
Quantity of services demanded by industry *i*(*t*) as a function Of the price per unit of services p_t

Quantity Demanded/ Produced $i(t)$



Price p_t

Services Profit Maximisation

Profit = revenue - costs

$$\pi = p_t i(t) - wL$$

$$\pi = \underbrace{p_t i(t)}_{\text{Price times quantity sold Equals revenue}} - \underbrace{w(ai(t) + s)}_{\text{Wages times labour Equals costs}}$$

Price times quantity sold
Equals revenue

Wages times labour
Equals costs

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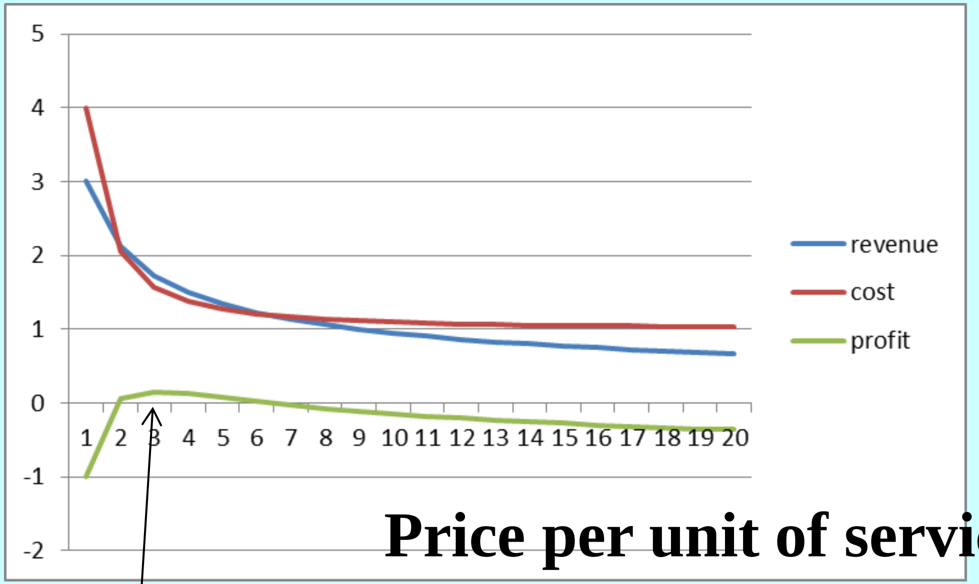
- As prices increase, demand falls, so total revenue falls
- As prices increase, (demand) output falls, labour input falls, so costs fall
- Profits rise to a peak as prices increase then fall
- So there is a level of prices and output which maximises profit
- This level of output is the equilibrium size of each firm

Some hypothetical numbers illustrating profit maximising price and level of demand/output

price	i(t)	revenue	cost	profit
1	3	3	4	-1
2	1.06066	2.12132	2.06066	0.06066
3	0.57735	1.732051	1.57735	0.154701
4	0.375	1.5	1.375	0.125
5	0.268328	1.341641	1.268328	0.073313
6	0.204124	1.224745	1.204124	0.020621
7	0.161985	1.133893	1.161985	-0.02809
8	0.132583	1.06066	1.132583	-0.07192
9	0.111111	1	1.111111	-0.11111
10	0.094868	0.948683	1.094868	-0.14619
11	0.08223	0.904534	1.08223	-0.1777
12	0.072169	0.866025	1.072169	-0.20614
13	0.064004	0.83205	1.064004	-0.23195
14	0.05727	0.801784	1.05727	-0.25549
15	0.05164	0.774597	1.05164	-0.27704
16	0.046875	0.75	1.046875	-0.29688
17	0.0428	0.727607	1.0428	-0.31519
18	0.039284	0.707107	1.039284	-0.33218
19	0.036224	0.688247	1.036224	-0.34798
20	0.033541	0.67082	1.033541	-0.36272

How revenue, costs and profit of services firms change As price per unit of services changes



Price per unit of services

Profit maximising price

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From equilibrium output to size of firm's labour force L

- Given an equilibrium profit maximising price p_t and hence an equilibrium level of demand/output $i(t)$ for the typical service firm, means that the typical firm has labour force L, since

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

From individual firm size to total number of service firms

In the Cobb-Douglas β is the share of total employment N that works in industry, that is $M = \beta N$

So 1- β is the share that works in services

Dividing total services employment (1- β)N by the size of each firm gives the number of service firms x

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

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Using x to merge two production functions to obtain $Q = \mathrm{f}(N)$

Industry p.f. $\longrightarrow$ $Q = M^{\beta} I^{1-\beta}$

Services p.f. $\longrightarrow$ $I = x^{\mu} i(t)$

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

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

number of service firms x $\longrightarrow$ $x = \dfrac{(1-\beta)N}{ai(t)+s}$ $\longleftarrow$ **Services employment** / $\longleftarrow$ **Employment per firm**

$M = \beta N$ $\longleftarrow$ **Industry employment**

Substitute for *x* and *M*

$$Q = N^{\beta+\mu-\mu\beta} \Big[\underbrace{\beta^{\beta} (ai(t)+s)^{\mu(\beta-1)} i(t)^{1-\beta} (1-\beta)^{-\mu(\beta-1)}}_{\text{constants}} \Big]$$

simplify

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

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

Increasing returns to city size

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

Nonlinear

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

Take natural logarithms
loglinear

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

Productivity
(qua wages)
A function of city size (*Q*)

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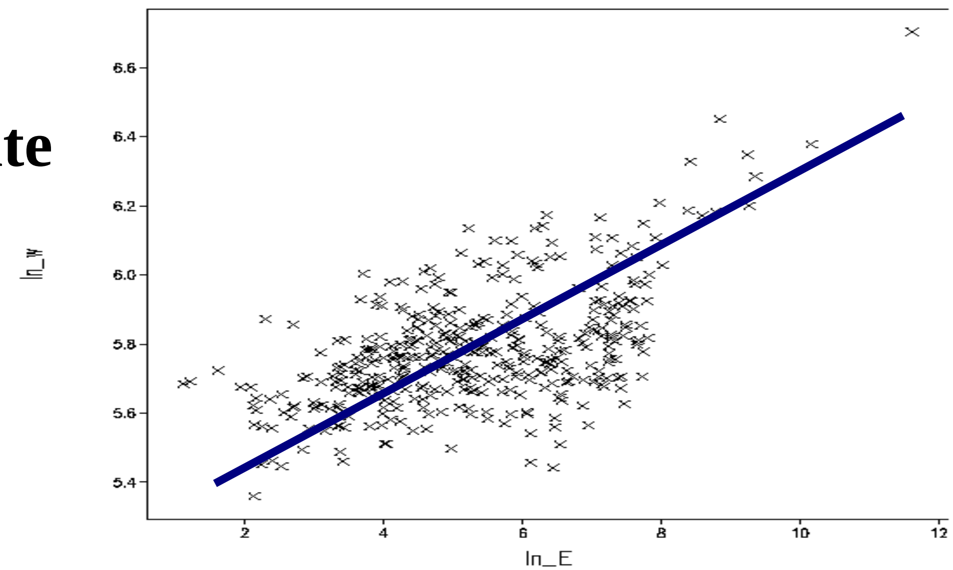
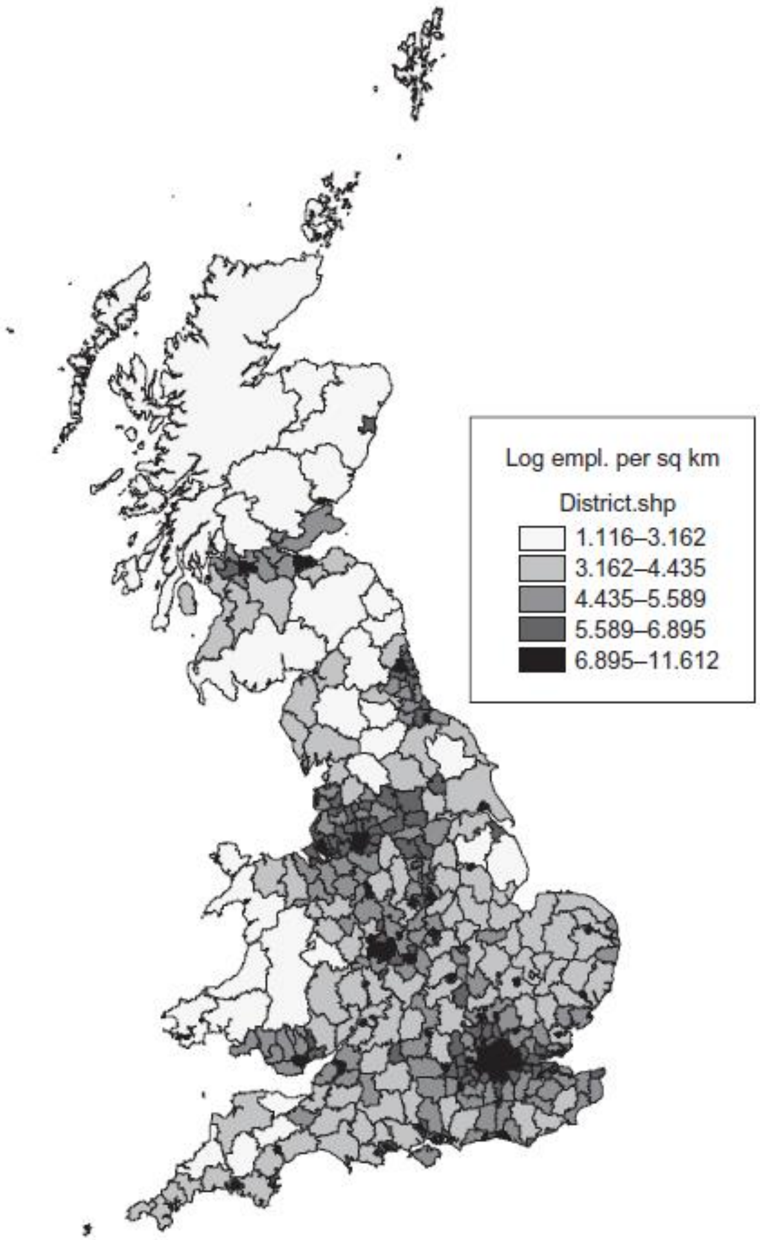
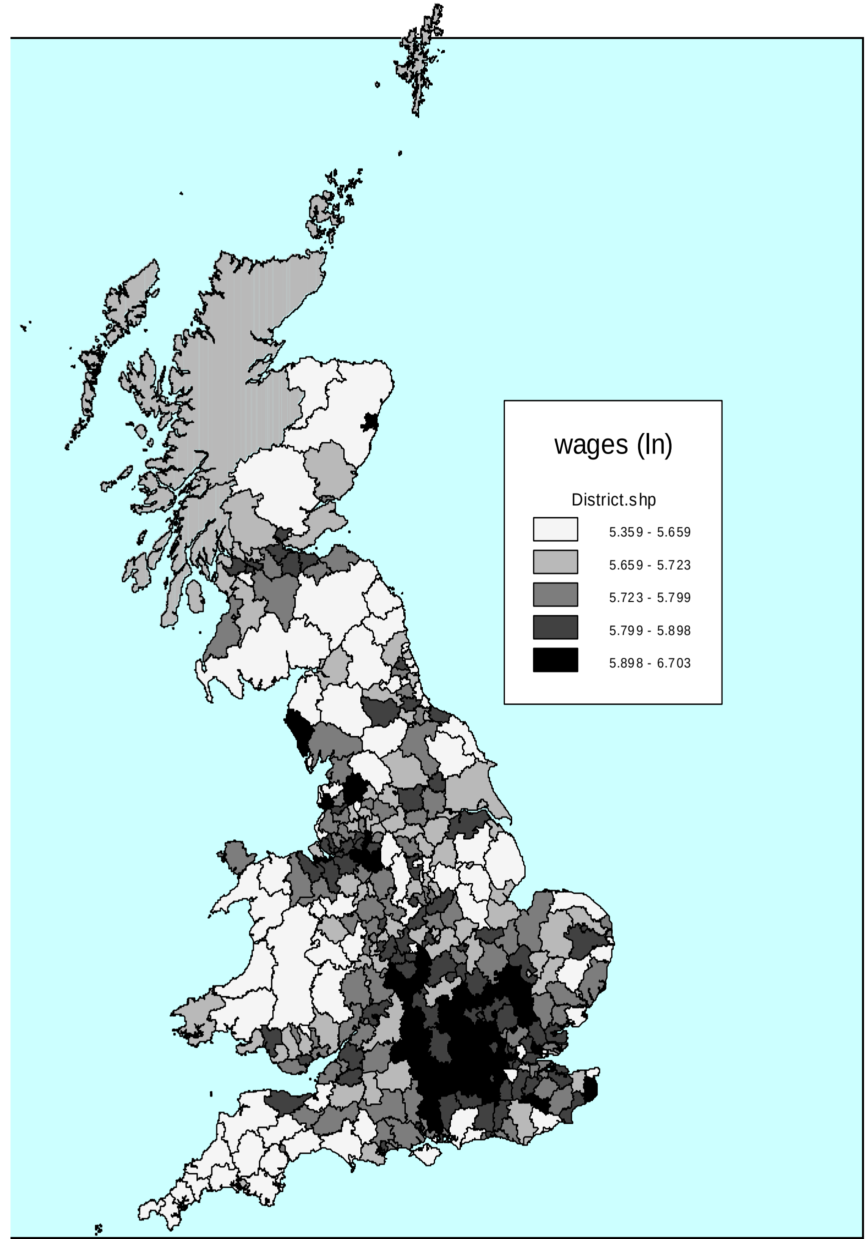
Evidence: UK local authorities

Log wage rate



Log Employment density ≈ city size


Log empl. per sq km
District.shp
1.116–3.162
3.162–4.435
4.435–5.589
5.589–6.895
6.895–11.612


wages (ln)
District.shp
5.359 - 5.659
5.659 - 5.723
5.723 - 5.799
5.799 - 5.898
5.898 - 6.703

Continuation….

- Read ahead, 3 more double lectures, slides will be available on the intranet (Camtools)
- Additional material (reading list etc) also available on Camtools
- Especially read (in advance of first supervision)

Continuation….

Glaeser, E., Kallal, H.D., Scheinkman, J.A. and Shleifer, A. (1992). Growth of Cities, *Journal of Political Economy*, 100(6), pp. 1126-1152.

Fingleton B. (2003) 'Increasing returns: evidence from local wage rates in Great Britain', *Oxford Economic Papers*, 55, 716-739

Arthur O'Sullivan (2009) *Urban Economics*, Chapter 3, "Why Do firms Cluster?".