Paper 11
Urban Economics

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Technological Externalities

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

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Technological externalities

- Glaeser et al (1992) "Growth of cities", Journal of Political Economy, 1992, vol.100, no. 6, 1126-1152
  - Urban economics ignores non-market interactions

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’

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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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Knowledge Spillovers

- There are benefits or costs due to transfers of information or knowledge
- Knowledge generated by one agent for its own benefit is not exhausted by use but persists and spreads, affecting other economic agents
- Following Glaeser et al (1992), It is useful to divide knowledge spillovers into three types
  - **MAR, Porter** and **Jacobs** externalities

MAR

- Marshall-Arrow-Romer externalities, or MAR for short
- knowledge spills over between firms within an industry
- firms acquire, at less than market cost to themselves, innovations and ideas generated by other firms within their industry

MAR

- In MAR models of externalities
- ‘innovators realize that some of their ideas will be imitated or improved on by their neighbours without compensation’
- ‘This lack of property rights to ideas causes innovators to slow down their investment in externality-generating activities, such as research and development’
- ‘If innovators had a monopoly on their ideas, or at least if they had fewer neighbours who imitated them immediately, the pace of innovation and growth would rise’
- Glaeser(1992)

Porter

- MAR suggests that growth is maximized when there is some form of monopoly over ideas so that firms can reap the benefits of their own R&D
- Porter (1990) argue that local competition is better
  - it causes firms to be better innovators or faster adopters of others' innovations than they otherwise would be, in order to survive, and that enhances the growth rate

Porter

- Information transmission is all-important
- Ensures access to spillovers from competitors within the sector
- so it is a good strategy for firms to locate near to each other in clusters

Jacobs

- in contrast to MAR and Porter externalities, Jacobs externalities involve spillovers between sectors
- benefits economic growth of a sector from the activities of other sectors within a city due to the ease of transmission of knowledge

Jacobs

- the crucial externality in cities is the cross-fertilization of ideas across different lines of work
- The variety of activity in a city adds to technological progress
- the diversity of urban activities encourages adoption in one sector of technological solutions found in other sectors

Modelling technology levels and growth

- Neoclassical growth theory assumes that
  - technological progress proceeds at a constant rate
  - Or at least it is exogenous, with unexplained variation
  - There is no attempt to account for any variation
- However, once we accept that the level of technology and its rate of growth (the technical progress rate) within a city or region will be strongly influenced by knowledge spillovers, then we accept that the rate of technical progress can no longer be considered to be exogenous

Externalities and Growth

- For instance
  - cities will be the source of more inter-sector spillovers than small towns, due to Jacobs externalities
  - regions with concentrations of firms in the same sector will experience more intra-sector spillovers, according to MAR and Porter externalities

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Modelling Externalities

- One of the reasons why there has been only limited attention given to knowledge spillovers is that it is very difficult to measure and model such phenomena

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Modelling Externalities

- despite the difficulties, some attempts have been made
- Researchers typically use some proxy measure of spillovers based on
  - input-output tables
  - patent and innovation data
    - proximity analysis shows innovations linked to nearby innovations

Modelling Externalities

- My approach : I start with a given technology level, and then look at the rate of technical progress, which changes the level of technology
- I then look at what determines the rate of technical progress in different cities and regions
    - Fingleton B(2003) Increasing returns : evidence from local wage rates in Great Britain *Oxford Economic Papers* 55 716-739
    - Fingleton B (2006) 'The new economic geography versus urban economics : an evaluation using local wage rates in Great Britain', *Oxford Economic Papers* 58 501-530

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Modelling Externalities

- The assumption is that spillovers determine
  - the rate of technical progress
  - and therefore the level of technology available to workers
  - So what is important is not just the number of units of labour (number of workers) but the number of labour efficiency units
- I link this to the model structure we have been looking at throughout this part of the course

Labour Efficiency Units

Units of industry labour at time *t*

Level of technology at time t

$$M_t = E_t A_t$$

Labour efficiency units at time *t* ; previously *M* was the amount of industry labour employed producing *Q*

Labour efficiency will vary across time and also across cities due to different labour and technology endowments

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Technology Level

Technology level at time *0*

Technology level at time *t*

$$A_t = A_0 e^{\lambda t}$$

Assume exponential growth From time = 0 to time = *t*

$$\frac{\partial A_t}{\partial t} = \lambda A_0 e^{\lambda t}$$

$$\frac{1}{A_t}\frac{\partial A_t}{\partial t} = \lambda$$

Proportional rate of growth of technology or rate of technical progress

Or

$$\ln A_t = \ln A_0 + \lambda t$$

$$\frac{\partial \ln A_t}{\partial t} = \lambda$$

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Efficiency Units and Tech Level

$$M_t = E_t A_t = E_t A_0 e^{\lambda t}$$

$$\ln(M_t) = \ln(E_t) + \ln(A_0) + \lambda t$$

With this revised definition of *M*, we can substitute for *M* in the model developed thus far and write our model in terms of the level of output per worker

Productivity Analysis

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

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

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

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

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

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

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Productivity Analysis

$M = \beta N$ hence

Industry productivity

Industry output

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

Substitute here replace labour by labour efficiency units

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Productivity Analysis

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

$$\ln Q - \ln M = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma-1}{\gamma}\right]\ln Q - \ln\beta$$

Since $\ln M = \ln E + \ln A_0 + \lambda t$

then $\ln Q - \ln E - \ln A_0 - \lambda t = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma-1}{\gamma}\right]\ln Q - \ln\beta$

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Productivity Analysis

Industry output per worker

Industry output

Initial technology level

$$\ln(Q_t / E_t) = \frac{\ln(\varphi)}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right]\ln(Q_t) - \ln(\beta) + \ln(A_0) + \lambda t$$

Rate of technical progress x period of time from time 0 to time t

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Explaining λ

- Up to now the rate of technical progress λ is an unexplained constant
- Now λ dependent on variables representing technological externalities
- Level of human capital/educational attainment (H)
    - Higher, faster rate of technical progress
- The technology gap (G)
    - Bigger, faster rate of technical progress
- spatial spillovers (S)
    - Closer to innovative places , faster rate of technical progress

Human Capital (*H*)

- The assumption is that higher educational attainment rates will boost the adoption and spread of innovations within the city
- New knowledge creation and knowledge spillovers will be higher whenever the level of human capital (*H*) is higher

Technology Gap (*G*)

- The technology gap *G* is assumed to be the level of technology in a city/region in relation to the highest possible level at time zero

- Two cities with the same educational attainment may have different technical progress rates because they have different technology gaps (*G*)

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Technology Gap (*G*)

- If *G* is large there is a big gap relative to the technological leaders
- This means that a city with large *G* has a much lower initial level of technology
- But much scope for faster technical progress due to adoption of already existing knowledge and innovations from more advanced cities/regions

Technology Gap (*G*)

- If a city is a technological leader, then *G* will be near zero
- The knowledge available globally will not make much of an impact, it is already known in cities using state of the art production techniques, which cannot be improved
- The small or zero *G* means that technical progress does not come from the diffusion of knowledge from research and development in other cities and regions at a superior level of technology

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Spatial spillovers (*S*)

- The third factor controlling the rate of technical progress is geographical proximity
- Despite modern communications, it remains true that knowledge diffusion will be spatially impeded
- Further more remote places will tend to be late or weak adopters of innovations

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Spatial spillovers (*S*)

- Typically knowledge will spread beyond the functional city, perhaps first to local and well-connected cities, then to remote and isolated ones
- New knowledge will diffuse more readily if you share a border with an innovating city or region
- But physical contiguity is not necessary, although it helps

Spatial spillovers (*S*)

- If a city has good or regular communications links with another remote city, then we might see knowledge being transmitted quite long distances
  - For instance the good air communications between London and New York and the low cultural and linguistic barriers between the two cities means that we will see knowledge spillovers between the two even though they are on either side of the Atlantic

Linear Model for λ

Spatial proximity or connectivity
To innovation centres

Human capital

$$\lambda = b_0 + b_1 H + b_2 G + b_3 S$$

Technical progress rate

Initial technology gap

The *b*'s are weights attributable to each source of technical Progress (with each zero, all that remains is an autonomous rate equal to b_0)

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Productivity Level

$$\ln(Q_t / E_t) = \frac{\ln(\varphi)}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right]\ln(Q_t) - \ln(\beta) + \ln(A_0) + \lambda t$$

$$\ln(Q / E) = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma - 1}{\gamma}\right]\ln Q - \ln\beta + \ln A_0 + (b_0 + b_1 H + b_2 G + b_3 S)t$$

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Productivity Growth

- While we are very interested in productivity level differences, we are also very much concerned with the dynamics of the economy, with differences in productivity growth rates
- Looking at growth rates also eliminates some terms from the equation since they are assumed to be constant over time
- This is shown if we turn our levels equation into a growth equation by differentiating with respect to time

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Productivity Growth

- In general for variable y, the growth rate is $\partial \ln(y)/\partial t$
- Differentiating the natural log of the level of industry productivity (Q/E) wrt time gives the productivity growth rate p
- Likewise differentiating $\ln(Q)$ wrt time gives industry output growth q

Productivity Growth

- the discrete time analogue of $\partial \ln(y)/\partial t$ is the difference in logs $\ln(y_{t+1}) - \ln(y_t)$
- Apply this to our model in levels, we calculate the difference in productivity level at two times t =1 and t =2

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Productivity Growth

$$\ln(Q/E)_t = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma-1}{\gamma}\right]\ln Q_t - \ln\beta + \ln A_0 + (b_0 + b_1 H + b_2 G + b_3 S)t$$

$$\ln(Q/E)_1 = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma-1}{\gamma}\right]\ln Q_1 - \ln\beta + \ln A_0 + (b_0 + b_1 H + b_2 G + b_3 S)1$$

$$\ln(Q/E)_2 = \frac{\ln\phi}{\gamma} + \left[\frac{\gamma-1}{\gamma}\right]\ln Q_2 - \ln\beta + \ln A_0 + (b_0 + b_1 H + b_2 G + b_3 S)2$$

$$\ln(Q/E)_2 - \ln(Q/E)_1 = \left[\frac{\gamma-1}{\gamma}\right](\ln Q_2 - \ln Q_1) + (b_0 + b_1 H + b_2 G + b_3 S)$$

Productivity Growth

$$\ln(Q/E)_2 - \ln(Q/E)_1 = \left[\frac{\gamma - 1}{\gamma}\right](\ln Q_2 - \ln Q_1) + b_0 + b_1 H + b_2 G + b_3 S$$

$$p = \frac{\gamma - 1}{\gamma} q + b_0 + b_1 H + b_2 G + b_3 S$$

and the estimation of this type of equation has been reported
In the scientific literature

1. Fingleton B (2000) ‘Spatial econometrics, economic geography, dynamics and equilibrium : a third way?’ *Environment & Planning A*, 32 1481-1498

The end!

- Thanks for your attention