Evidence on the linkages between productivity, agglomeration economies, and transport

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• Agglomeration economies and transport
• Estimating agglomeration economies
• Meta-analysis of previous empirical evidence
• Recent empirical evidence
• Agglomeration economies in transport appraisal
• Conclusions
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Agglomeration economies and transport

- Agglomeration economies are positive externalities that arise from the spatial concentration of economic activity.

- Main mechanisms that determine agglomeration economies (Marshall, 1920):
  - Knowledge spillovers.
  - Input-output linkages.
  - Labour market pooling spillovers.

- Traditionally, two types of agglomeration economies.
  - Localisation economies (importance of firm’s own “industry scale”).
  - Urbanisation economies (importance of “city/region scale”).
Agglomeration economies and transport

• Transport affects realization of agglomeration economies:
  – Transport affects access to economic activities (e.g. people-to-businesses, businesses-to-businesses).
  – Improved accessibility can reinforce agglomeration benefits.

• Transport impacts on productivity through agglomeration economies.

• Venables (2007; JTEP) shows there are productivity gains from urban transport improvements that arise through city size, which should be included in the cost-benefit appraisals of transport projects.
Figure 1c: Net gains from transport improvement with endogenous productivity

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Estimating agglomeration economies

(a) Wages and employment density
(306 employment areas, 1976-1996 average)

(b) TFP (Olley-Pakes) and employment density
(306 employment areas, 1994-2002 average)

Source: Combes et al. (2008) CEPR Discussion Papers 6728
Estimating agglomeration economies

Wages and employment density in UK Travel-to-Work Areas (average 1997-2006)

Source: Melo and Graham (2009).
Estimating agglomeration economies

Wages and market potential in UK Travel-to-Work Areas (average 1997-2006)

Source: Melo and Graham (2009).
Estimating agglomeration economies

- Some form of production function.

\[ y = g(A)f(L,K), \quad L: \text{labour}, K: \text{capital}, A: \text{agglomeration economies} \]

- Where \( g(A) \) measures agglomeration economies, which affect total factor productivity.

- The marginal effect of agglomeration on productivity is obtained from \( \frac{\partial y}{\partial g(A)} \); the elasticity of output w.r.t to agglomeration is obtained from \( \frac{\partial \ln y}{\partial \ln g(A)} \).
Estimating agglomeration economies

• Under the standard assumption that factors are paid the value of their marginal products, workers will be paid higher nominal wages in more productive areas.

• The theory is that labour productivity gains result from workers becoming more productive in more agglomerated areas.

• Estimate the marginal effect of agglomeration on workers’ productivity $\frac{\partial w_L}{\partial g(A)}$; elasticity of wage w.r.t agglomeration is $\frac{\partial \ln w_L}{\partial \ln g(A)}$. 
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Why a meta-analysis? (see Melo et al. 2009, RSUE)

- To explain the variability in the size of elasticities of productivity with respect to urban agglomeration.

What is a meta-analysis useful for?

- Nice way to summarise the key factors underlying the range of values found in the empirical literature (e.g. country, data, etc.).
- Can guide researchers in the choice of econometric method and model specification.
- Can provide an alternative measure for the measurement of wider economic benefits of transport projects.

Meta-analysis of elasticities of agglomeration
Meta-analysis of elasticities of agglomeration

• How is the meta-analysis performed?
  – Uses econometric models to identify sources of variation in the estimates of agglomeration effects.

\[
\hat{\varepsilon}_i = \varepsilon_0 + \sum_{j=1}^{J} \beta_j D_{ji} + \mu_i
\]

– Sources of variation \((D_{ji})\):
  • Period of analysis
  • Country
  • Measurement of urban agglomeration
  • Economic sector
  • Type of data
  • etc.
Meta-analysis of elasticities of agglomeration

• Results - main factors of variation relate to:
  
  – Not controlling for differences in human capital and localization tends to increase the size of elasticity.
  
  – The use of time invariant fixed-effects tends to reduce size of elasticity.
  
  – Service industries tend to have higher elasticities of urban agglomeration.
  
• There is some evidence supporting the presence of positive reporting bias in agglomeration estimates.
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Recent empirical evidence

• Firm level production functions.
  – UK (Dan Graham-IC, Ralf Martin & Steve Gibbons-LSE)
  – UK (Dan Graham, Kurt Van dender-ITF/OECD)
  – New Zealand (Dan Graham, Dave Mare-Motu)

• Worker level wage functions.
  – UK (Patricia Melo & Dan Graham)

• Agglomeration measured with *market potential* function of the type:

\[ MP_r = \sum_j \frac{\text{emp}_j}{d_{rj}^\alpha} \]
Recent empirical evidence

- Firm level production functions.
  - UK (Dan Graham-IC, Ralf Martin & Steve Gibbons-LSE)
  - UK (Dan Graham, Kurt Van denber-ITF/OECD)
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- Worker level wage functions.
  - UK (Patricia Melo & Dan Graham)
Estimating productivity effects of agglomeration

- Studies based on extensive firm level panel data.
- Production function estimation with agglomeration measured as in previous slide.
- Several different models and estimation methods used.
Uncertainties associated with the typical estimation approach

- **Black box** - doesn’t really tell us anything about the sources of agglomeration.

- So we need to be careful about
  - **Potential confounders** - key issue is heterogeneity in the functions of industries (need to compare like with like).
  - **Endogeneity** - agglomeration and productivity may be simultaneously determined.

- Several different ways of doing this - typically based around IV, dynamic panel GMM, and FE approaches.

- We use a control function approach (see Martin 2005):
Results I - production function estimates

<table>
<thead>
<tr>
<th>industry</th>
<th>UK</th>
<th>NZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>Retail</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td>Real estate</td>
<td>0.11</td>
<td>-</td>
</tr>
<tr>
<td>IT</td>
<td>0.07</td>
<td>-</td>
</tr>
<tr>
<td>Financial services</td>
<td>0.15</td>
<td>0.11</td>
</tr>
<tr>
<td>Business services</td>
<td>0.12</td>
<td>0.18</td>
</tr>
<tr>
<td>Whole economy</td>
<td>0.10</td>
<td>0.15</td>
</tr>
</tbody>
</table>

※ There is a positive association between productivity and agglomeration: service sector elasticities highest.
Recent empirical evidence

- **Firm level production functions.**
  - UK (Dan Graham-IC, Ralf Martin & Steve Gibbons-LSE)
  - UK (Dan Graham, Kurt Van dender-ITF/OECD)
  - New Zealand (Dan Graham, Dave Mare-Motu)

- **Worker level wage functions.**
  - UK (Patricia Melo & Dan Graham)
Empirical model and data (I)

- The econometric model:

\[
\ln w_{it} = \beta_0 + \sum_b \beta_b X_{b,it} + \sum_k \alpha_k Z_{k,rt} + \varepsilon_{it}
\]

- \(X_{b,it}\): age, age squared, gender, full-timer/part-timer, size of the firm where worker \(i\) works.

- \(Z_{k,rt}\): includes measures of agglomeration economies.

- In addition: indicator variables for occupations, years, industry groups.
Empirical model and data (II)

• Annual Survey of Hours and Earnings (ASHE)
  – Worker’s hourly wage, gender, age, work status, occupation, industry, employer’s firm size. No education!
  – Start with 1,559,719 observations: cleaning of missing records and errors reduces size to 1,378,048 observations.

• Final dataset:
  – Unbalanced panel of 289,729 workers.
  – On average each worker is observed 4.76 times.
Results - aggregate effects

• Doubling the market potential of a given labour market can increases worker earnings by around 2.8%.

• Effect of agglomeration externalities is sensitive to whether one accounts for (i) spatial sorting, (ii) reverse causality:
  I. Controlling for workers’ spatial selection more that halves the elasticity: 5.2% (POLS) vs. 2.1% (WG-FE).
  II. correcting for simultaneity endogeneity produces an instrumental variables elasticity estimate of 2.8%.
Results - sectoral heterogeneity

<table>
<thead>
<tr>
<th>industry</th>
<th>FE-IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary</td>
<td>-</td>
</tr>
<tr>
<td>manufacturing</td>
<td>0.010</td>
</tr>
<tr>
<td>electricity, gas &amp; water</td>
<td>-</td>
</tr>
<tr>
<td>construction</td>
<td>0.014</td>
</tr>
<tr>
<td>wholesale &amp; retail</td>
<td>-</td>
</tr>
<tr>
<td>hotels &amp; restaurants</td>
<td>-</td>
</tr>
<tr>
<td>transport, storage &amp; communication</td>
<td>0.026</td>
</tr>
<tr>
<td>financial intermediation</td>
<td>0.018</td>
</tr>
<tr>
<td>real estate</td>
<td>-</td>
</tr>
<tr>
<td>renting, IT, R&amp;D</td>
<td>0.026</td>
</tr>
<tr>
<td>other business activities</td>
<td>0.024</td>
</tr>
<tr>
<td>public services</td>
<td>0.028</td>
</tr>
</tbody>
</table>

- Effects of agglomeration economies on workers’ hourly wages are stronger for service industries.
Results - spatial decay of agglomeration effects

\[
\ln w_{it} = \beta_0 + \sum_b \beta_b X_{b, it} + \text{emp}_{j(it)} + \sum_{k=1}^{10} \alpha_k \sum_p w_{jp(k) \text{emp}_{p(it)}} + \varepsilon_{it}
\]

with \(d_{jp}(k)\) the distance in kilometres between each pair of wards and \(d_{jp}(0)=0\).

\[
w_{jp}(k) = \begin{cases} 
1 & \text{if } d_{jp}(k-1) < d_{jp} \leq d_{jp}(k) \\
0 & \text{otherwise}
\end{cases}
\]

\[
d_{jp}(k) = \begin{cases} 
5 (5) 25 \text{ kilometres for } k = 1 (1) 4 \\
25 (25) 150 \text{ kilometres for } k = 5 (1) 10
\end{cases}
\]
20-25 km
Results - spatial decay of agglomeration effects

• Effects are significant up to 15km: +100,000 jobs within 5km raises wages by 0.44%. The increase is 33% (60%) smaller if the additional jobs occur 5 (10) km away.

• Spatial scale? Spillover effects from agglomeration externalities are likely to occur within labour markets - knowledge spillovers & labour market pooling.

• Implications for transport policy? Can inform about the area of influence of transport schemes by offering a “boundary” for the real scope of the effects from agglomeration.
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Which Wider Impacts in Appraisal?

- Productivity Impacts from Agglomeration.
- Productivity Impacts from Labour Participation
- Productivity Impacts from Labour Relocation
- Welfare gains from Increased Output in Imperfectly Competitive Markets.

What else?
- FDI, Trade impacts on productivity

Source: Slides are from Vicky Cadman, Department for Transport (DfT). TEG Seminar March 2009.
How the evidence is used: agglomeration example

- Largest WIs – most work in developing evidence
- Cities – big ones in particular – are very productive
- Geographical aspect: so advice on where matters.

1. Estimate base and alternative generalised costs and trip numbers
2. Estimate base and alternative level of effective density - agglomeration
3. Estimate impacts of productivity – Dan Graham’s elasticity estimates
4. Land use changes (LUTI models)

Source: Slides are from Vicky Cadman, Department for Transport (DfT). TEG Seminar March 2009.
Agglomeration economies in transport appraisal

• To calculate the wider economic benefits due to agglomeration externalities we need:
  – Transport cost from & within areas with and without the scheme (from DfT transport models and trip matrices).
  – Changes in level of agglomeration (employment density/market potential measure) due to transport intervention (*idem*).
  – Elasticity of productivity with respect to agglomeration (from Dan Graham estimates).
  – The level of output in the agglomerated sectors (from ONS).

• Wider economic benefit of agglomeration =
  \[= \text{[elasticity of productivity w.r.t agglomeration]} \times \text{[variation in agglomeration due to transport intervention]} \times \text{[GDP]}\].
Advice on Appraisal Requirements: Maps built on transport data and economic relationships

- Considering appraisal burden

- Maps identify where to look for schemes with agglomeration

- Impacts may not be high for all schemes covering a blue area – ‘Decay function’ still captures decline across distance in the estimation.

- Not dealing with inter-urban schemes here.

- Focussed on ‘urbanisation’ economies. Care not to miss ‘localisation’.

Source: Slides are from Vicky Cadman, Department for Transport (DfT). TEG Seminar March 2009.
Agglomeration economies in transport appraisal

• Simulation analysis by DfT shows that transport intervention (e.g. - £0.01 in all journeys) produces different degrees of agglomeration benefits:
  – Effects are lower for seaports than for airports, in particular airports close to London.
  – Effects are stronger for financial business cluster in London than other businesses.
  – Effects are stronger for London and cities in and around largest conurbations in the UK.

• Limitations of the exercise:
  – No account for land use changes.
  – No consideration of costs of achieving transport improvement.
Applying the new appraisal to CrossRail (DfT calculations)

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Welfare (£ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business time savings</td>
<td>4,847</td>
</tr>
<tr>
<td>Commuting time savings</td>
<td>4,152</td>
</tr>
<tr>
<td>Leisure time savings</td>
<td>3,833</td>
</tr>
<tr>
<td><strong>Total user benefits (conventional)</strong></td>
<td>12,832</td>
</tr>
<tr>
<td>Agglomeration benefits</td>
<td>2,440</td>
</tr>
<tr>
<td><strong>Total benefits (inc agglom)</strong></td>
<td>15,272</td>
</tr>
</tbody>
</table>

*Source: DfT.*
Appraisal of additional benefits from agglomeration

<table>
<thead>
<tr>
<th>Mode</th>
<th>Scheme</th>
<th>Agglomeration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rail</td>
<td>Crossrail</td>
<td>19%</td>
</tr>
<tr>
<td>Road</td>
<td>Leeds to Bradford Improved Highway</td>
<td>21%</td>
</tr>
<tr>
<td>Road</td>
<td>Leeds Urban Area Improved Highway</td>
<td>22%</td>
</tr>
<tr>
<td>PT</td>
<td>Leeds to Bradford PT Improvements</td>
<td>15%</td>
</tr>
<tr>
<td>Bus</td>
<td>Intra Leeds bus subsidy</td>
<td>11%</td>
</tr>
<tr>
<td>Road</td>
<td>Leeds to Sheffield Improved Highway</td>
<td>19%</td>
</tr>
<tr>
<td>Road</td>
<td>M6 shoulder</td>
<td>12%</td>
</tr>
<tr>
<td>Bus</td>
<td>West Yorkshire County bus subsidy</td>
<td>9%</td>
</tr>
<tr>
<td>PT</td>
<td>Leeds Urban Area Major PT Investment</td>
<td>9%</td>
</tr>
<tr>
<td>Bus</td>
<td>South &amp; West Yorkshire Bus subsidy</td>
<td>7%</td>
</tr>
<tr>
<td>Bus</td>
<td>South Yorkshire bus subsidy.</td>
<td>3%</td>
</tr>
</tbody>
</table>

*Source: Steer Davies Gleave values.*
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Conclusions I

• Evidence confirms the existence of positive productivity gains from agglomeration economies.

• Effects of agglomeration are likely to be stronger within the borders of labour markets.

• Transport affects agglomeration and produces externalities that are not measured in a standard cost benefit appraisal.
Conclusions II

- Impact from agglomeration externalities differs across transport scheme and area and can be quite significant: e.g. Crossrail: increase conventional benefits by apr. 20%.

- Effects tend to be higher for urban network schemes, also relevant for international gateways, and smaller for inter-urban network schemes.
Directions for future research

• DfT interested in understanding the sources better because it provides guidance about which type of transport schemes to appraise for agglomeration effects.

• Identifying the relative importance of the difference sources of agglomeration externalities allows identifying the journey purpose transport policy makers should be focusing on:
  • If IO linkages are more important – focus on freight transport.
  • If LM pooling is more important – focus on commuting.
  • If KS are more important – focus on business trips.
References


MELO, P. C., GRAHAM, D. J. (2009) Agglomeration economies and labour productivity: evidence from longitudinal worker level data for Great Britain’s Travel-to-Work Areas. (ongoing work)

Thank you!

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