Imperial College London

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

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Contents

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

Contents

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.

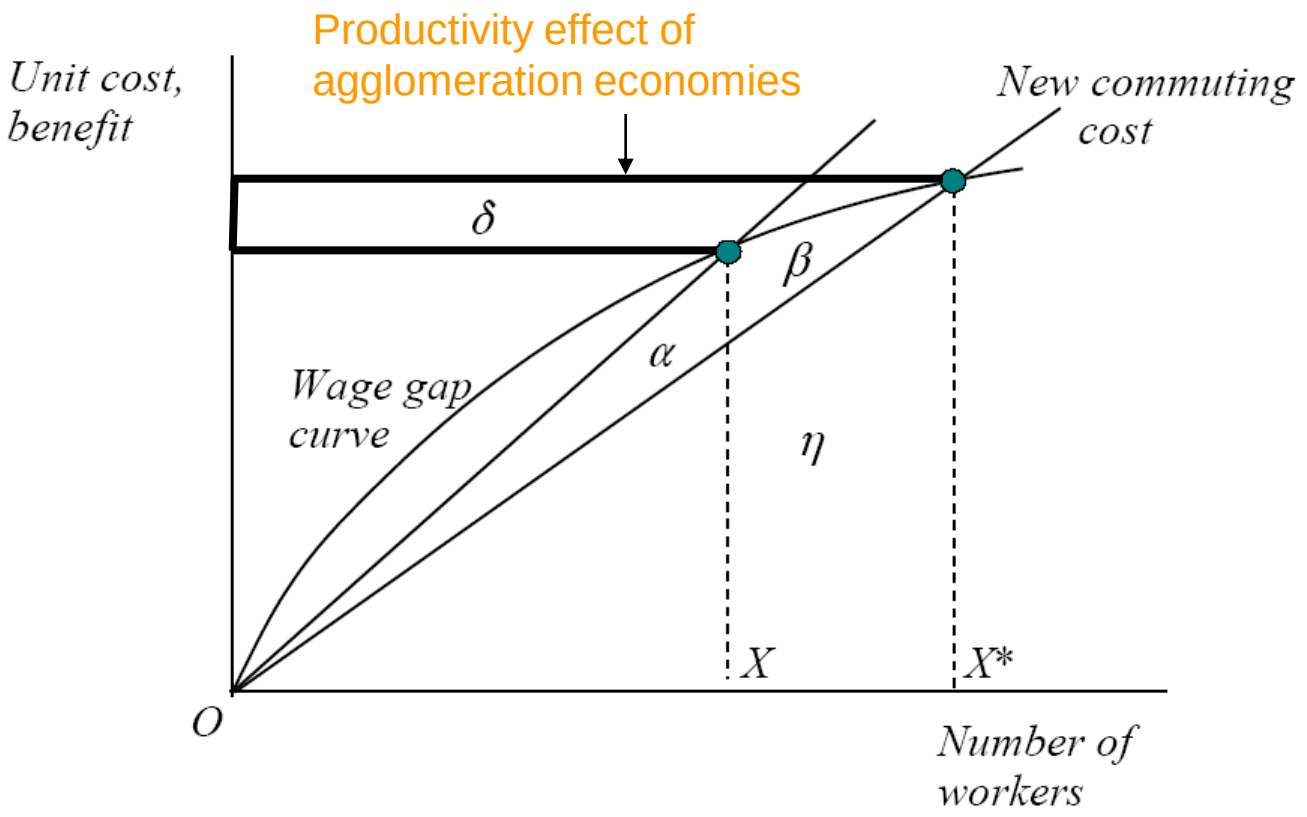

Figure 1c: Net gains from transport improvement with endogenous productivity

Source: Venables, T. (2007) Evaluating urban transport improvements: cost benefit analysis in the presence of agglomeration and income taxation. Journal of Transport Economics and Policy, 41, 173-188.

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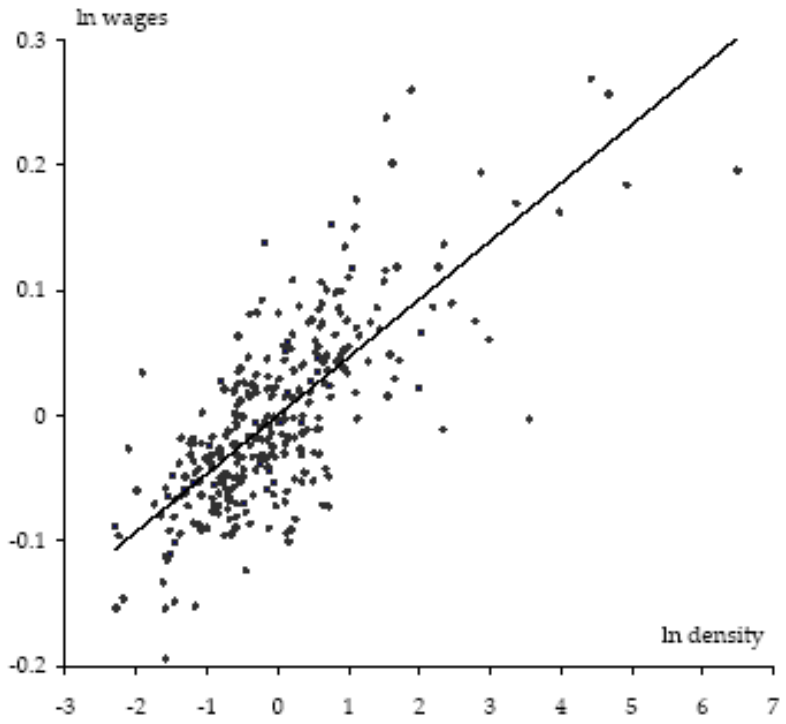
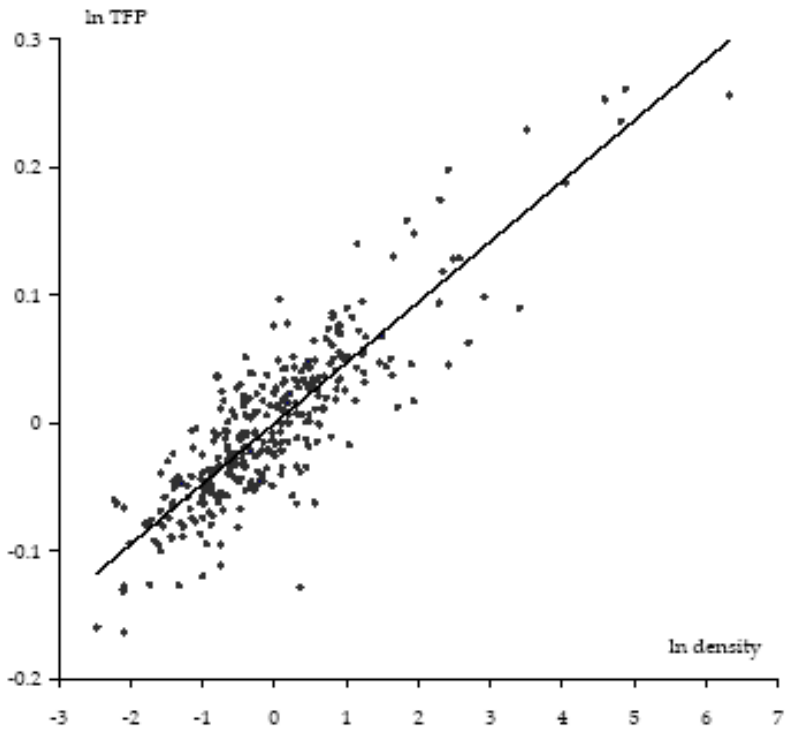
Estimating agglomeration economies



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

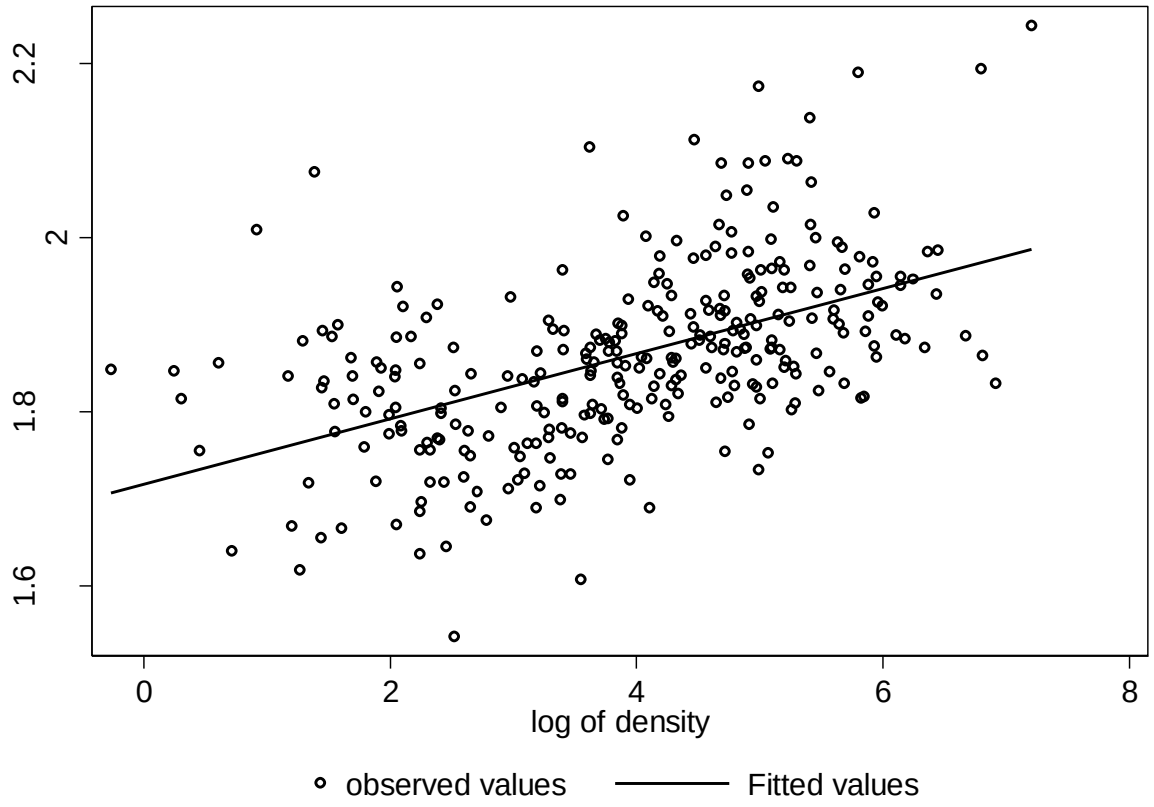


(b) TFP (Olley-Pakes) and employment density
(306 employment areas, 1994-2002 average)

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

Estimating agglomeration economies

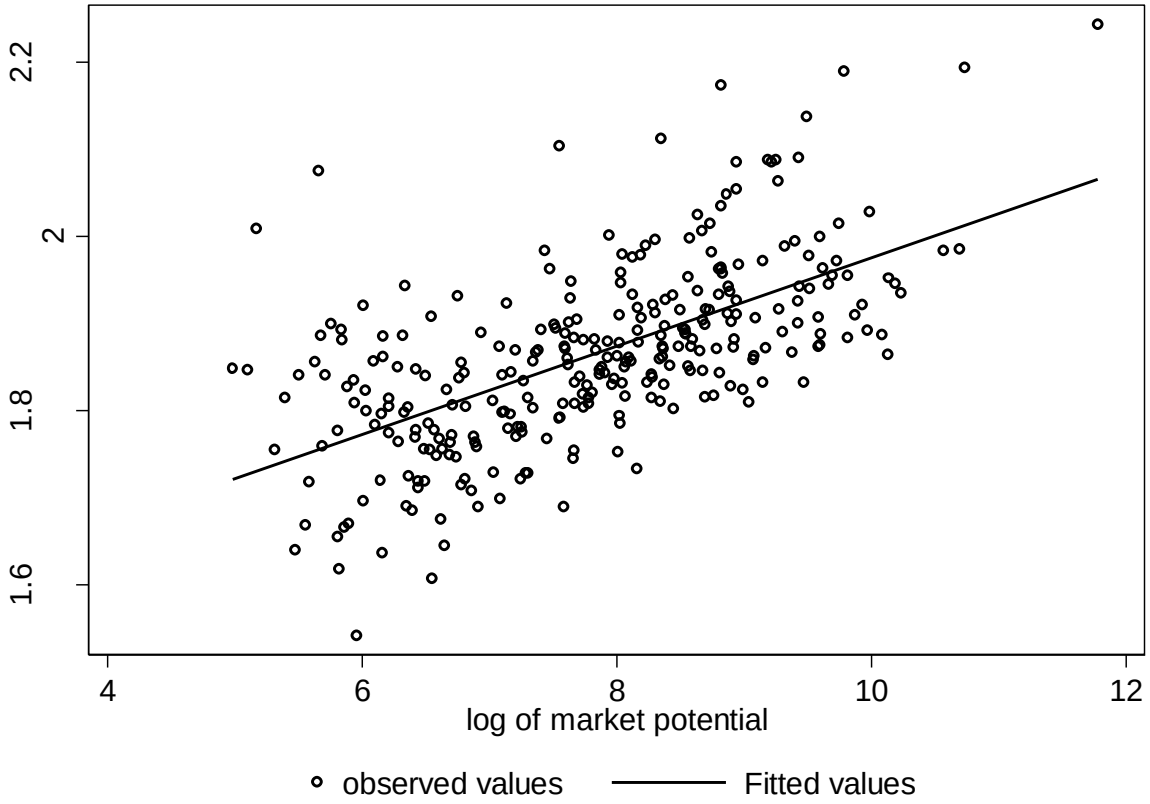
Wages and employment density in UK Travel-to-Work Areas (average 1997-2006)



Source: Melo and Graham (2009).

Estimating agglomeration economies

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



$$MP_r = \sum_j \frac{emp_j}{d_{rj}^{\alpha}}$$

Source: Melo and Graham (2009).

Estimating agglomeration economies

- Some form of production function.

$$y = g(A)f(L,K), \qquad L: labour, K: capital, A: agglomeration\ economies$$

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

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

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 $\partial w_L / \partial g(A)$; elasticity of wage w.r.t agglomeration is $\partial \ln w_L / \partial \ln g(A)$.

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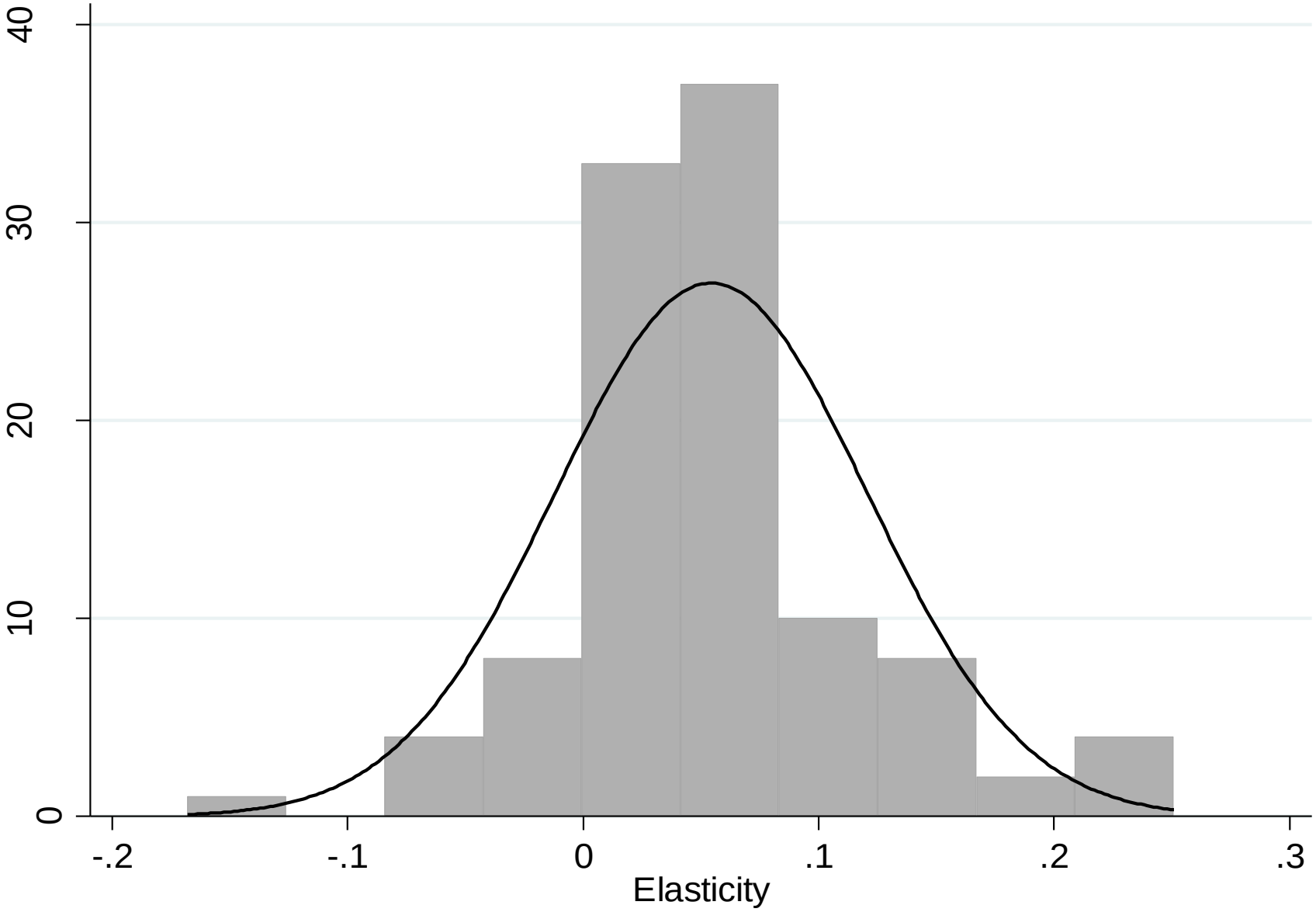
- Conclusions

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 diferences 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:

$$MP_r = \sum_j \frac{emp_j}{d_{rj}^{\alpha}}$$

Recent empirical evidence

- Firm level production functions.
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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

industry	*UK*	*NZ*
Manufacturing	0.06	0.06
Retail	0.04	0.05
Real estate	0.11	-
IT	0.07	-
Financial services	0.15	0.11
Business services	0.12	0.18
Whole economy	0.10	0.15

⋆ There is a positive association between productivity and agglomeration: service sector elasticities highest.

Recent empirical evidence

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Empirical model and data (I)

- The econometric model:

$$\ln w_{it} = \beta_0 + \sum_b \beta_b X_{b,it} + \sum_k \alpha_k Z_{k,r(it)} + \varepsilon_{it}$$

- $X_{b,it}$: 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.
  - Period covered: 1997 to 2006.
  - 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

industry	FE-IV
primary	-
manufacturing	0.010
electricity, gas & water	-
construction	0.014
wholesale & retail	-
hotels & restaurants	-
transport, storage & communication	0.026
financial intermediation	0.018
real estate	-
renting, IT, R&D	0.026
other business activities	0.024
public services	0.028

- Effects of agglomeration economies on workers' hourly wages are stronger for service industries.

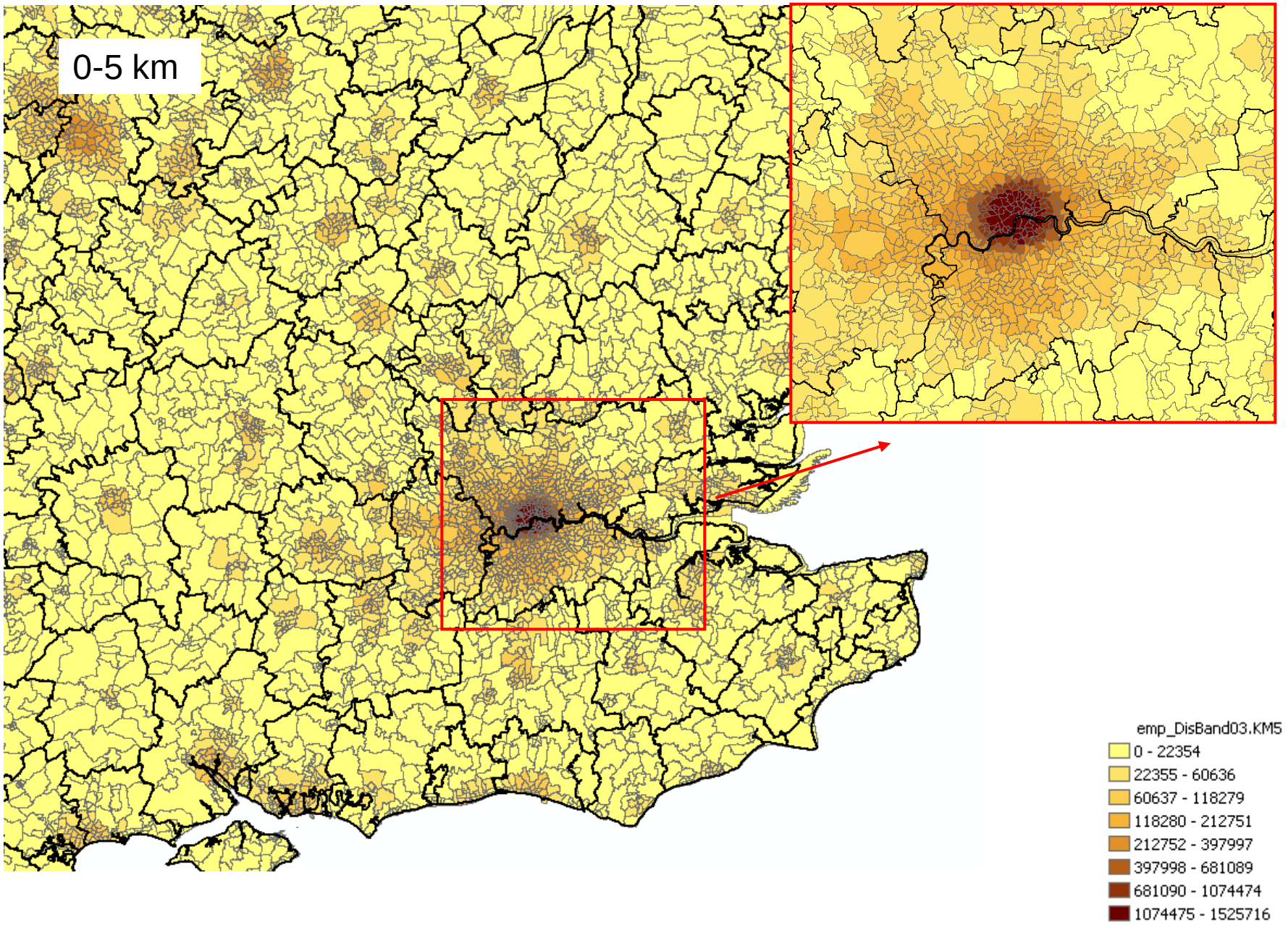
Results - spatial decay of agglomeration effects

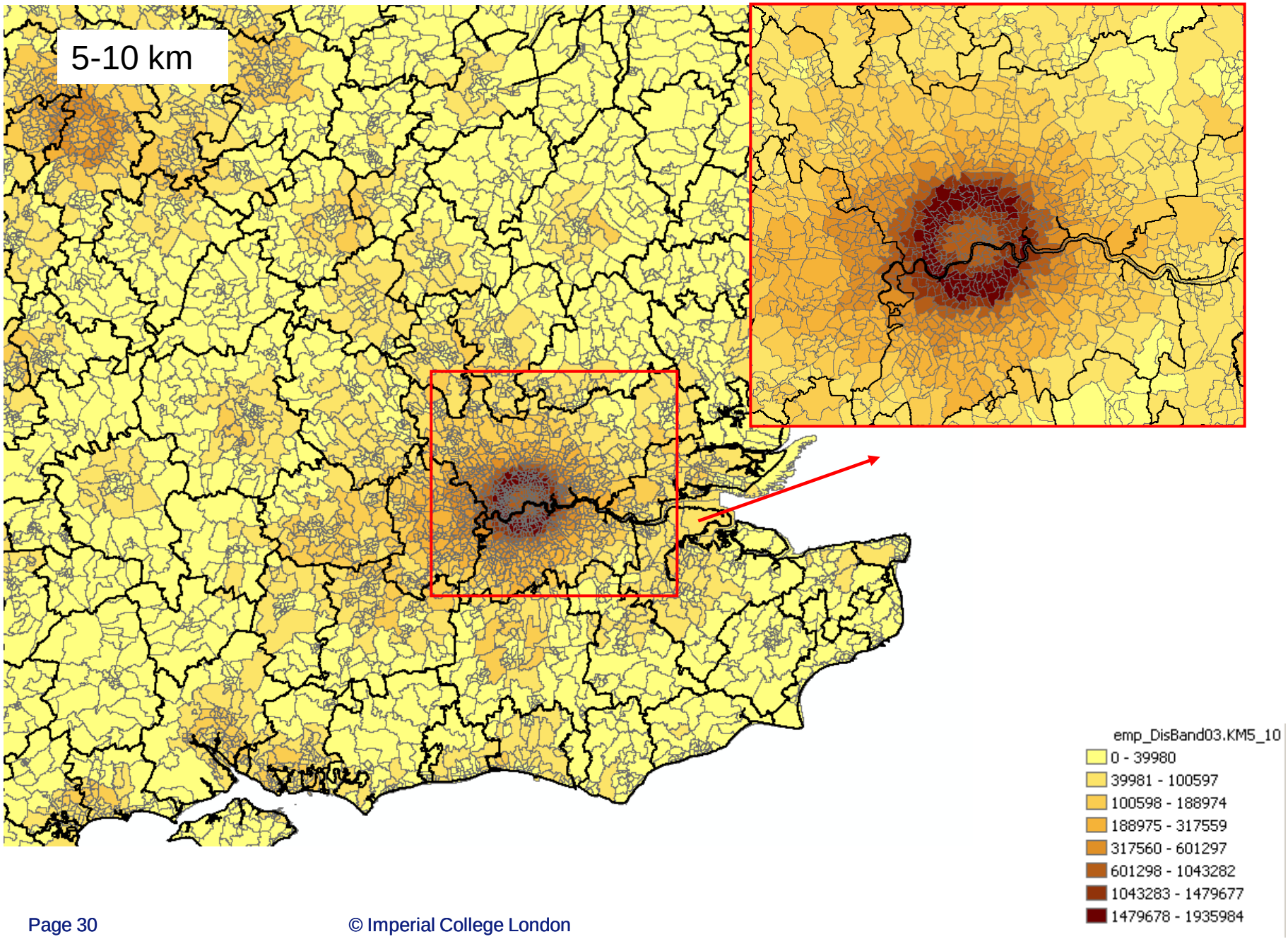
$$\ln w_{it} = \beta_0 + \sum_b \beta_b X_{b,it} + emp_{j(it)} + \sum_{k=1}^{10} \alpha_k \sum_p w_{jp}(k).emp_{p(it)} + \varepsilon_{it}$$

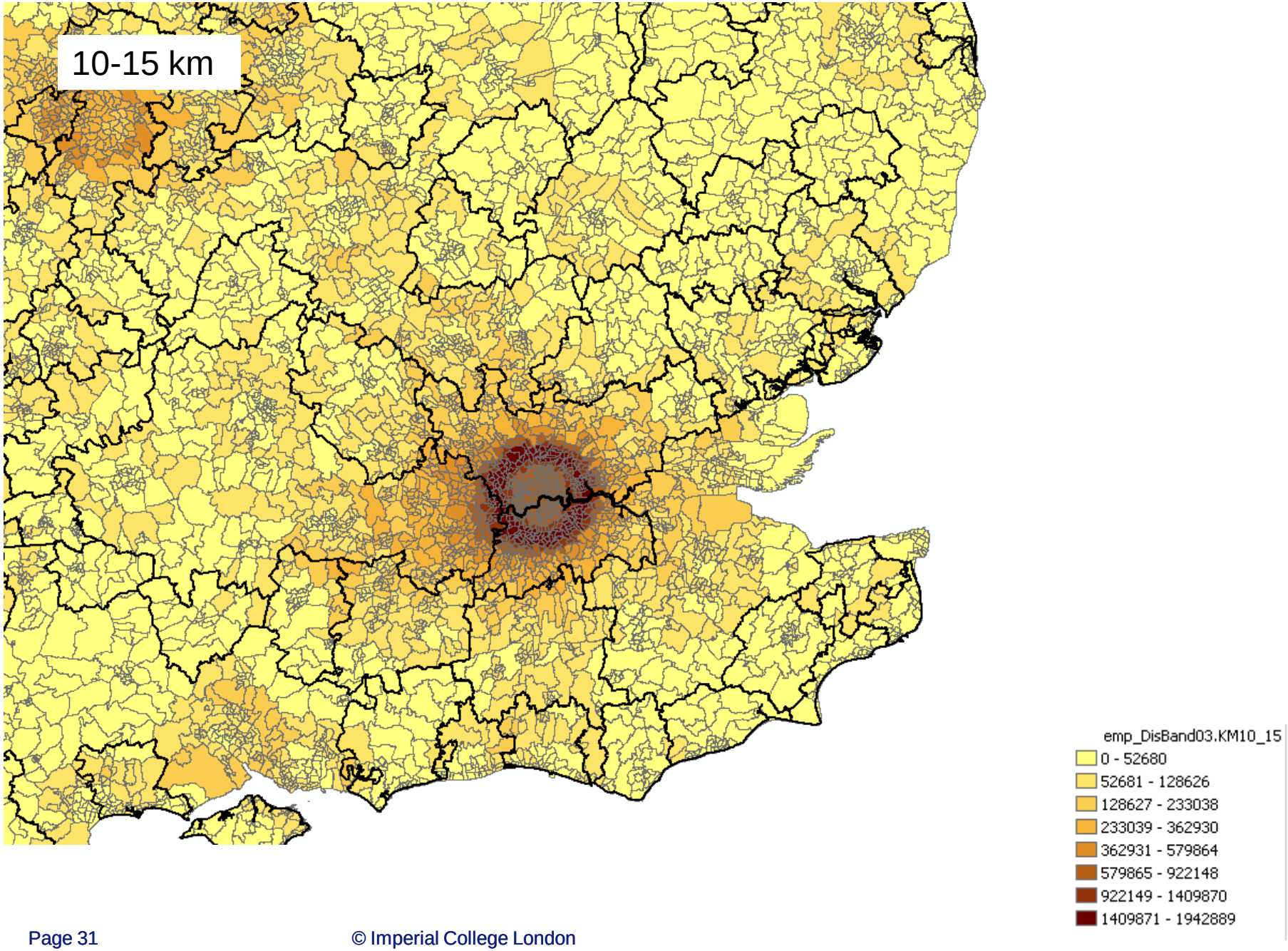
with $d_{jp}(k)$ the distance in kilometres between each pair of wards and $d_{jp}(0)=0$.

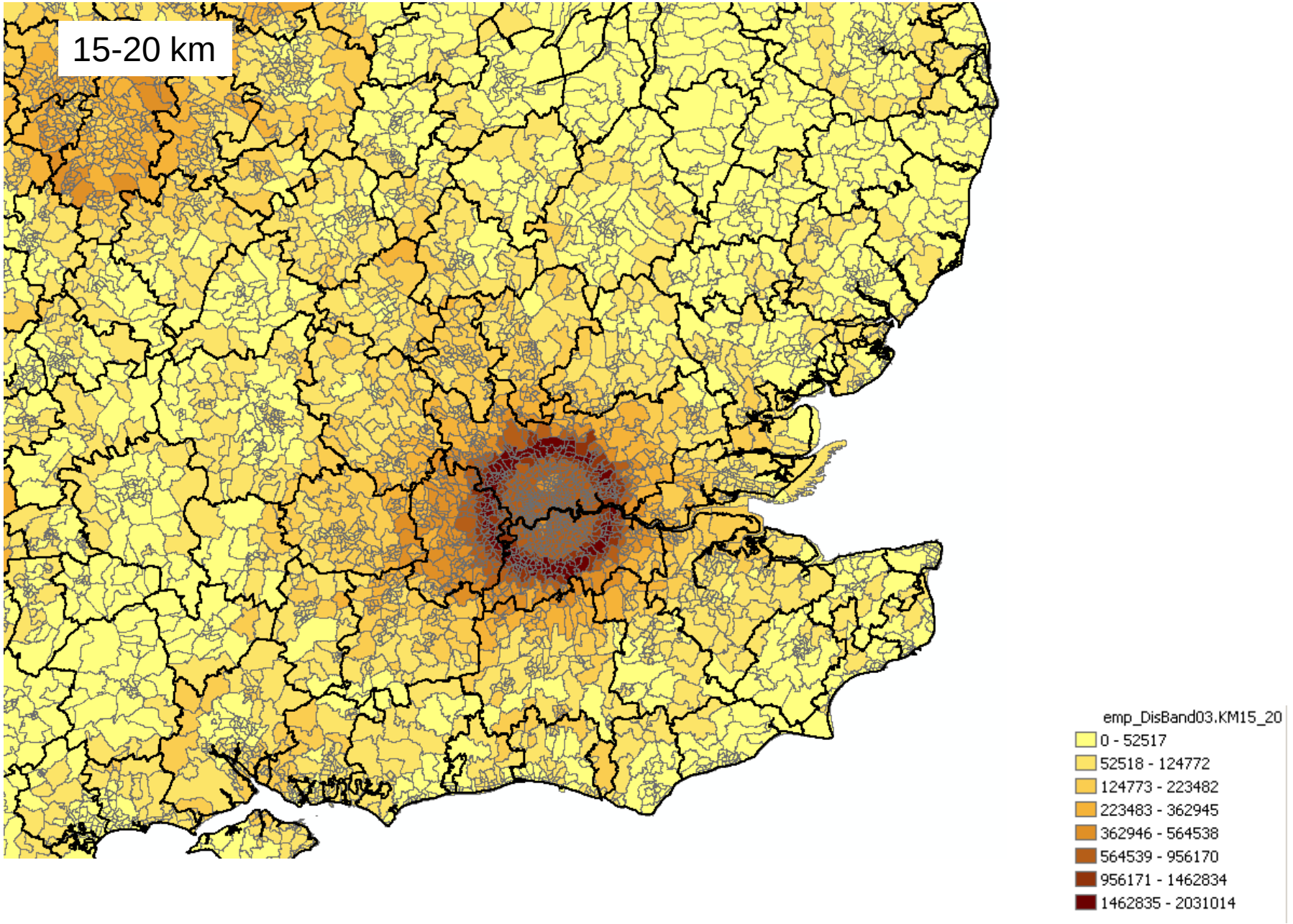
$$w_{jp}(k) = \begin{cases} 1 & \text{if } d_{jp}(k-1) < d_{jp} \leq d_{jp}(k) \\ 0 & \text{otherwise} \end{cases}$$

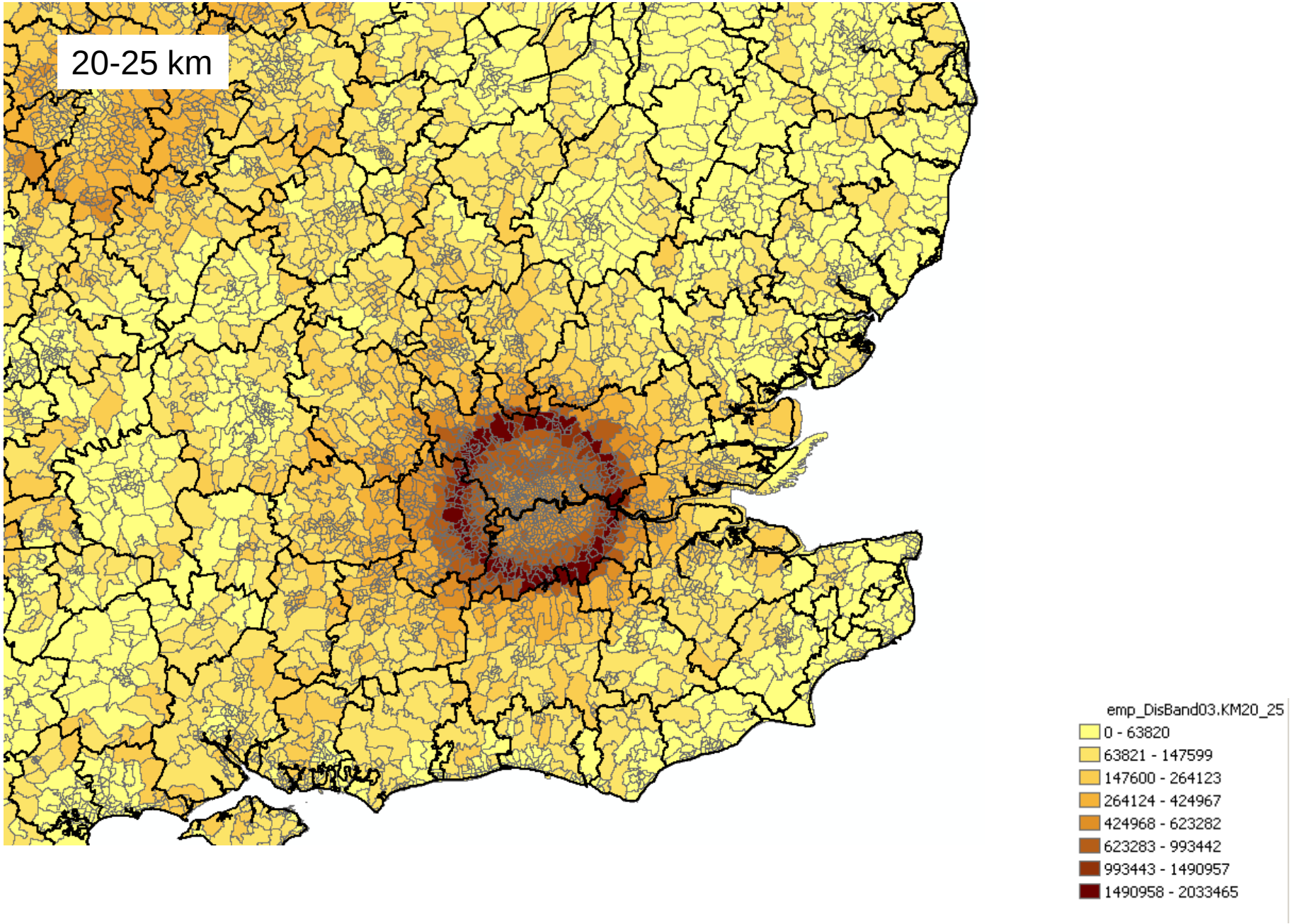
$$d_{jp}(k) = \begin{cases} 5\ (5)\ 25 & \text{kilometres for } k = 1\ (1)\ 4 \\ 25\ (25)\ 150 & \text{kilometres for } k = 5\ (1)\ 10 \end{cases}$$

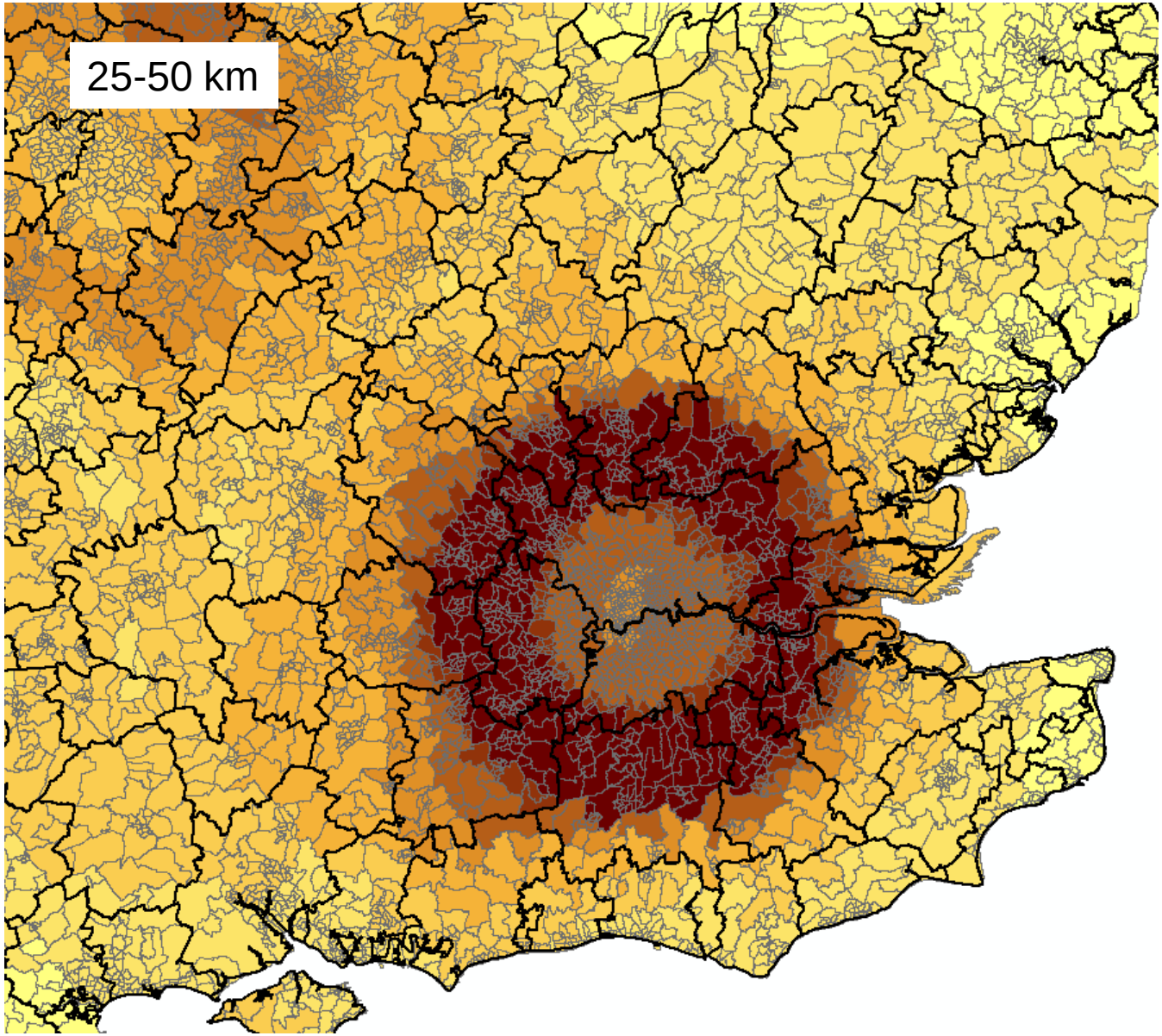












Results - spatial decay of agglomeration effects

- 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 likelly 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.

Contents

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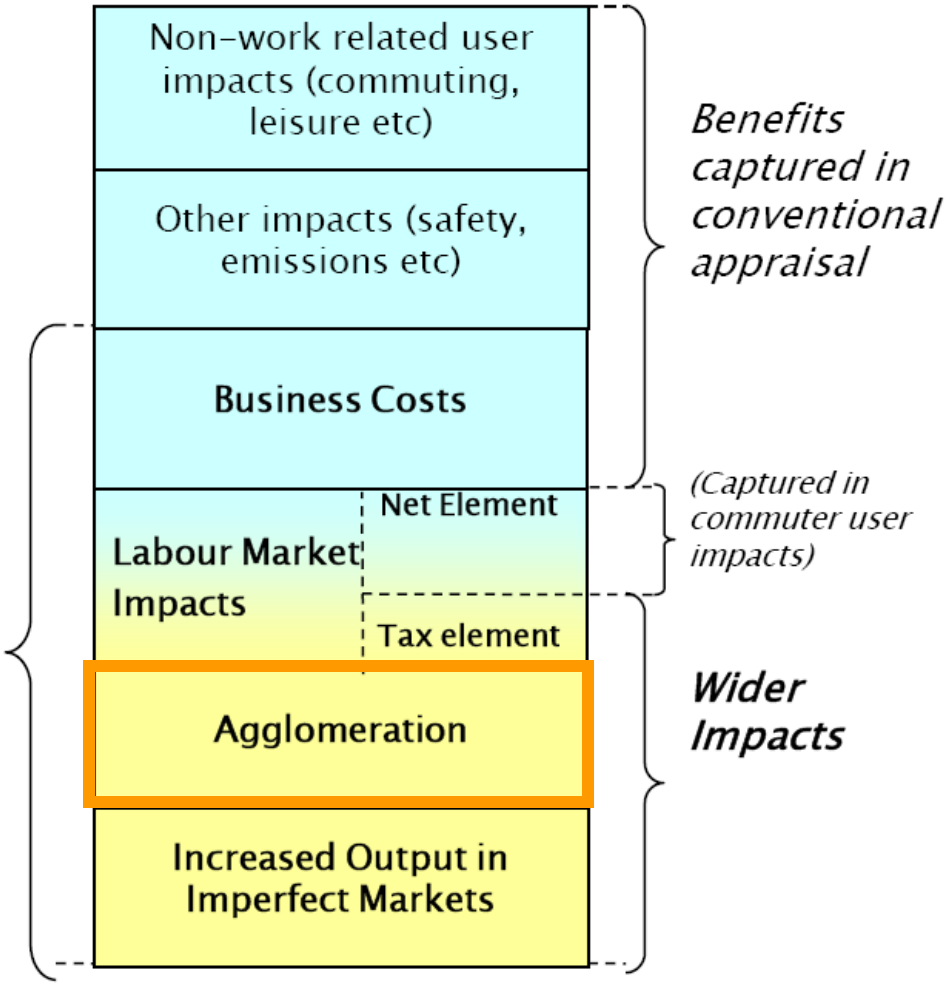
Which Wider Impacts in Appraisal?

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

Productivity gains

- 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

TEG_LOGO.bmp

Estimate base and alternative generalised costs and trip numbers

Estimate base and alternative level of *effective density* - agglomeration

Land use changes *(LUTI models)*

Estimate impacts of productivity – *Dan Graham's elasticity estimates*

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

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).

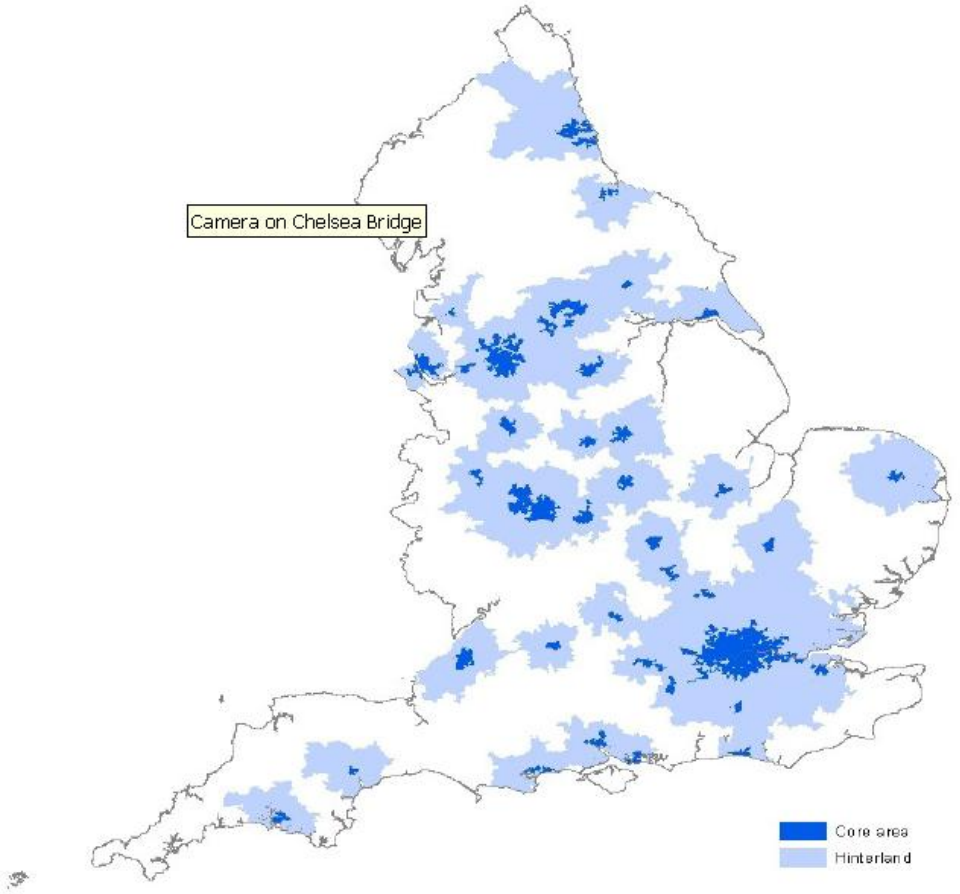
- Wider economic benefit of agglomeration =

  = [elasticity of productivity w.r.t agglomeration] x [variation in agglomeration due to transport intervention] x [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'.

Functional Urban Regions



Source: Office for National Statistics, Super Output Area Boundaries

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)

Benefits	*Welfare (£ million)*
Business time savings	4,847
Commuting time savings	4,152
Leisure time savings	3,833
Total user benefits (conventional)	**12,832**
Agglomeration benefits	2,440
Total benefits (inc agglom)	**15,272**

Source: DfT.

Appraisal of additional benefits from agglomeration

Mode	Scheme	Agglomeration
Rail	Crossrail	19%
Road	Leeds to Bradford Improved Highway	21%
Road	Leeds Urban Area Improved Highway	22%
PT	Leeds to Bradford PT Improvements	15%
Bus	Intra Leeds bus subsidy	11%
Road	Leeds to Sheffield Improved Highway	19%
Road	M6 shoulder	12%
Bus	West Yorkshire County bus subsidy	9%
PT	Leeds Urban Area Major PT Investment	9%
Bus	South & West Yorkshire Bus subsidy	7%
Bus	South Yorkshire bus subsidy.	3%

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 likelly 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.

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Thank you!

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