The Impact of Spatial Concentration on Total Factor Productivity in British Advanced Manufacturing, 1984-2016

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Context

- This work forms part of the ESRC-funded Manufacturing Renaissance in Industrial Regions project which has an overall objective of investigating the evolution of advanced manufacturing across Britain, to develop a better and more complete evidence-base for policy
- More specifically, we aim to understand:
  - The differential performance of advanced manufacturing industries across Britain
  - Whether traditional industrial regions provide a conducive context for advanced manufacturing to flourish
  - The potential for sectoral and spatial re-balancing
  - The role of clustering, horizontal and cross-sectoral agglomeration economies, and localised/regionalised 'ecosystems'

www.southampton.ac.uk/geography/research/projects/manufacturing-renaissance-in-industrial-regions.page

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Motivation

- While London and the surrounding areas perform well relative to the EU average, the productivity levels of some other UK regions are among the worst in the EU
  - McCann (2016) uses OECD data to show that UK interregional inequality levels are more similar to low productivity central and eastern European countries and developing countries than high-productivity northern and western European countries
- The recent industrial strategy lists the creation of Local Industrial Strategies with the aim of delivering 'economic growth across the UK, helping to develop high growth clusters where appropriate' as one of the policies that aim to reduce regional disparities
- This paper therefore seeks to estimate whether the creation of clusters in advanced manufacturing will help to achieve this

Literature Review

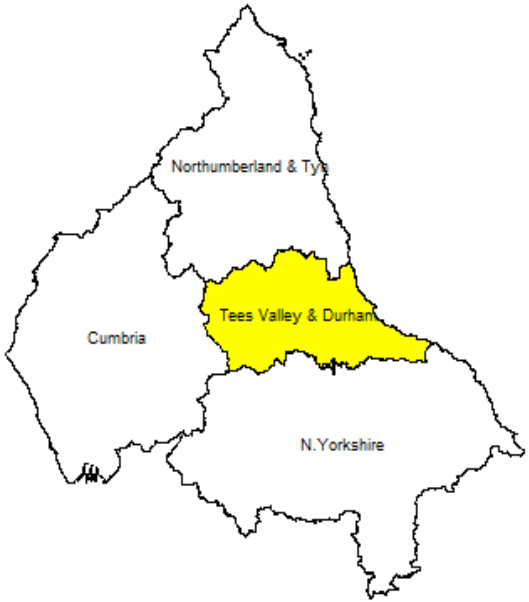
- Specialisation/localization externalities (Marshall, 1890; Arrow, 1962; Romer, 1986)
  - These are an intra-industry phenomenon arising from:
    - Sharing of resources (e.g. facilities, input suppliers)
    - Better matching of firms and workers
    - Diffusion of knowledge
  - These are the main focus of the paper
- Diversification/urbanization externalities (Jacobs, 1969)
  - These are an inter-industry phenomenon arising from spillovers of complementary knowledge across industries
  - However, excessive urbanisation may lead to congestion diseconomies

Literature Review

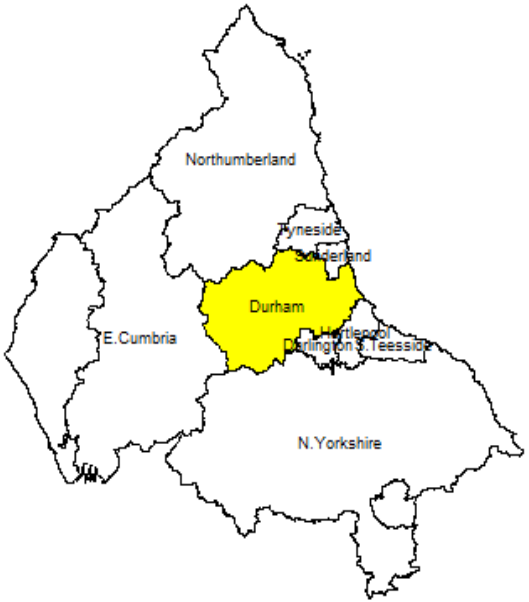
- De Groot et al. (2016), conclude their review of the literature by saying that ‘No clear-cut favourite was found for the effects of specialization, where significantly positive and significantly negative estimations are roughly of equal number. Apparently, both effects exist, but under different circumstances.’
- However, there are a number of difficulties relating to the measurement of spatial concentration. One of these is the modifiable areal unit problem (MAUP) which is caused by the use of boundaries to define the scope of spillovers
- In this paper, we address the MAUP using geo-coded data at the postcode district level

Modifiable Areal Unit Problem

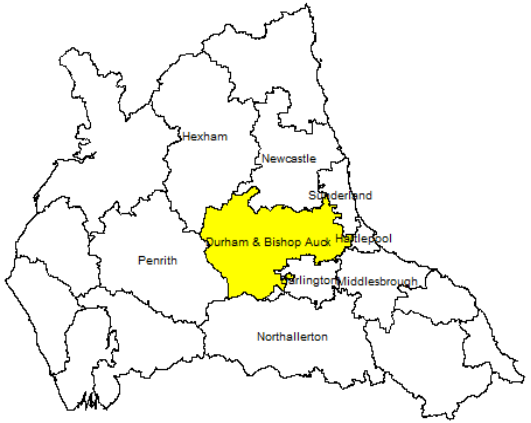
NUTS2 Regions



NUTS3 Regions



TTWA Regions



Data

- Plant-level data covering 1984-2016 from the Annual Respondents Database/Annual Business Survey is used
- This provides information on postcodes which is aggregated to the postcode district level for computation of distances
  - There are around 1.8 million postcodes and over 3,000 postcode districts in the United Kingdom
- Information on employment is available at the plant level

Spatial Concentration

- Following Scholl and Brenner (2016), measures of spatial concentration are calculated for 3-digit standard industrial classification industries as follows:

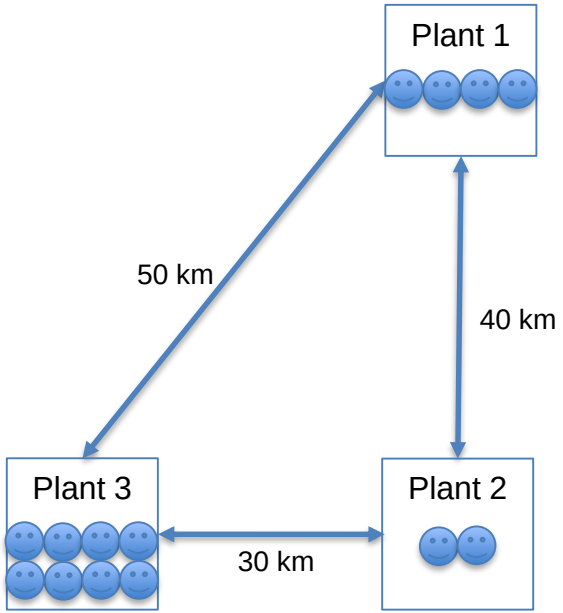
$$D_i = \sum_{j=1, j \neq i}^{J} \frac{E_j}{\sum_{k=1, k \neq i} E_k} e^{-\alpha d_{i,j}}$$

where E_j is employment in plant j, $\sum_{k=1,k\neq i} E_k$ is the sum of employment in all plants in an industry except plant i, α is the distance decay factor (set equal to 0.05 unless otherwise stated) and $d_{i,j}$ is the distance between plant i and plant j, measured in kilometres

- If plants i and j are located in the same postcode district, $d_{i,j}$ is assumed to be half of the distance between that postcode district and the closest (distinct) postcode district

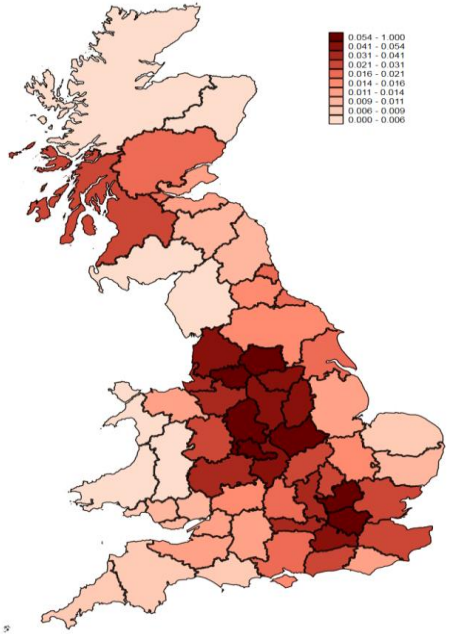
Spatial Concentration

- In the hypothetical industry of three plants, each of which has different employment levels, the values of spatial concentration are:
  - $D_1 = 0.093$
  - $D_2 = 0.194$
  - $D_3 = 0.129$

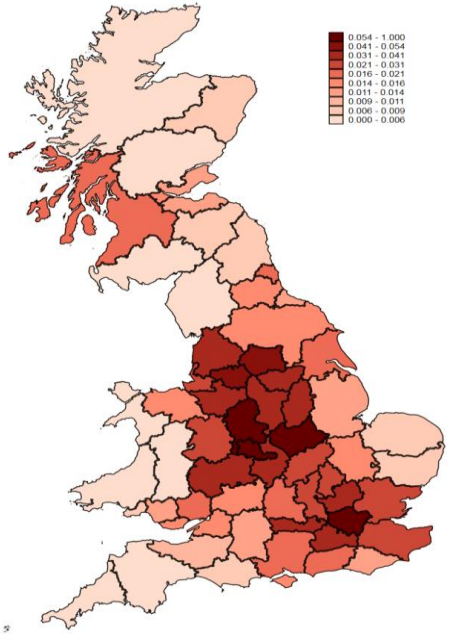


Mean of D_i, Manufacturing

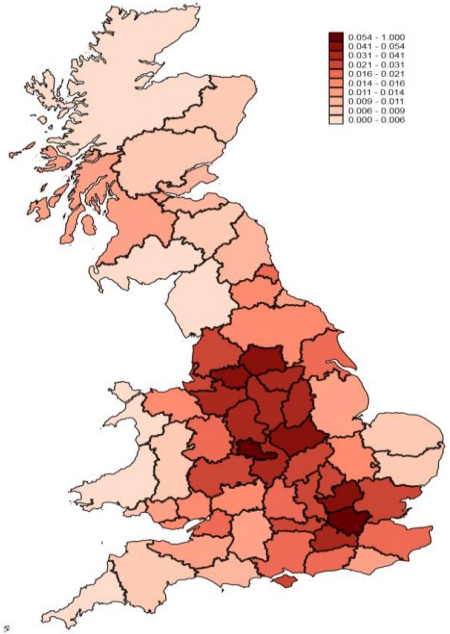
1984



2000

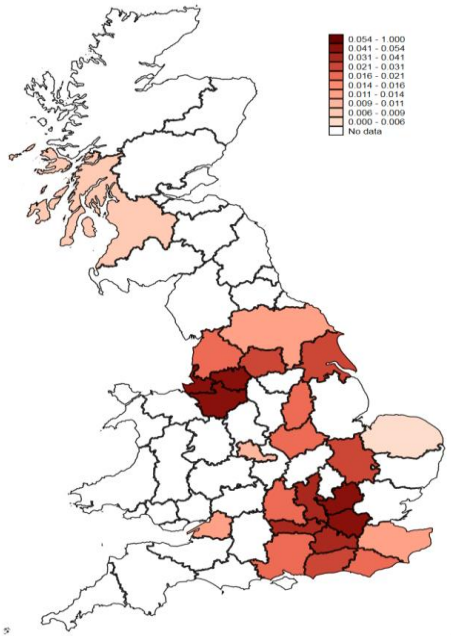


2016

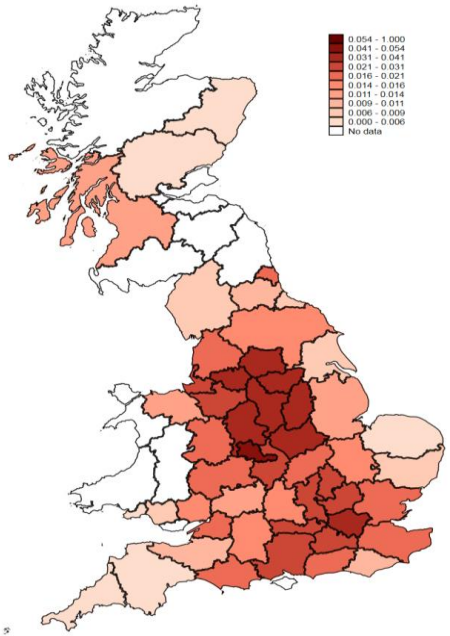


Mean of D_i, Advanced Manufacturing Sectors

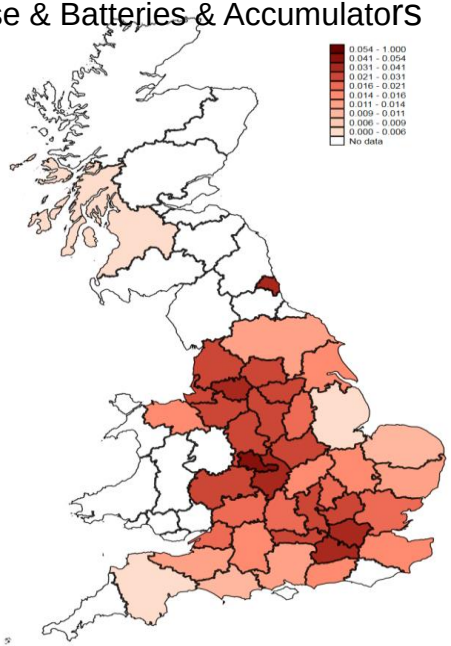
Pharmaceutical Products



Basic Electric Equipment

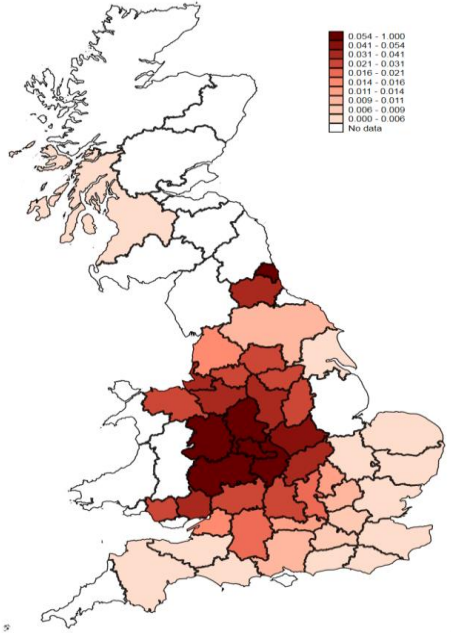


Electrical Equipment for Industrial Use & Batteries & Accumulators

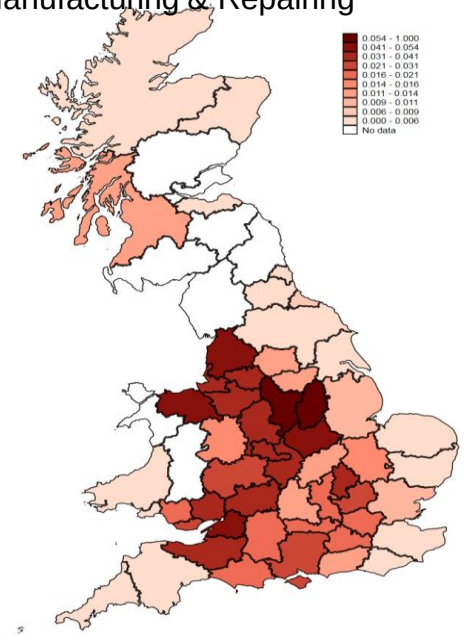


Mean of D_i, Advanced Manufacturing Sectors

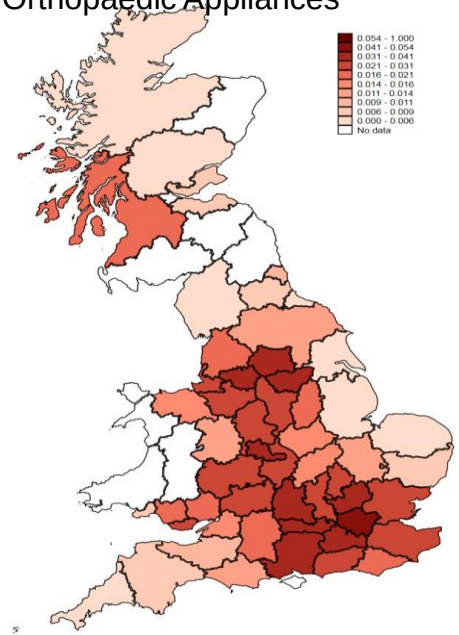
Motor Vehicle Parts



Aerospace Equipment Manufacturing & Repairing



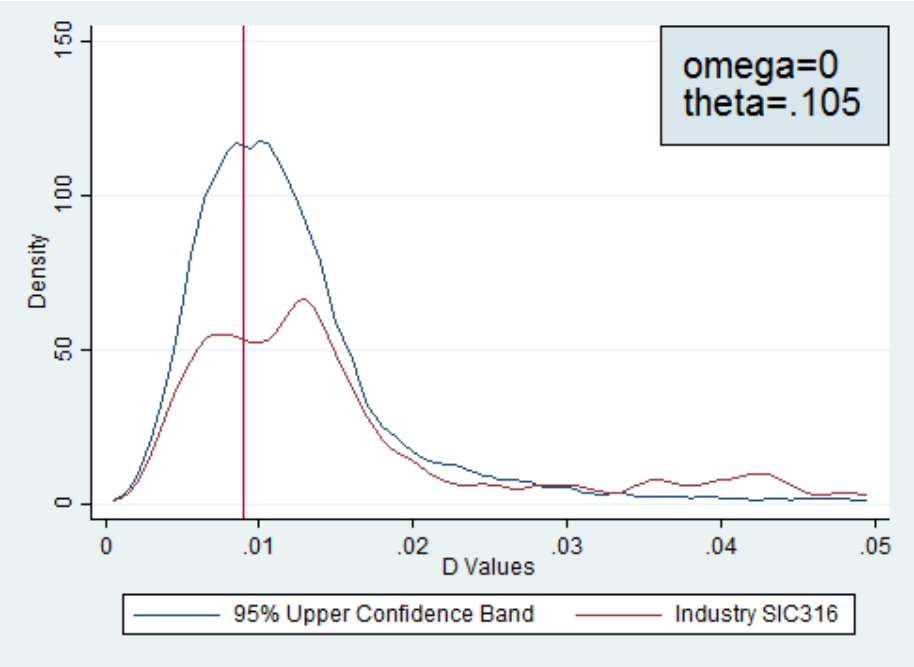
Medical & Surgical Equipment & Orthopaedic Appliances



Identification of Clusters

- The measures of spatial concentration presented so far should not be used to identify clusters as they do not control for the overall agglomeration of manufacturing (Duranton and Overman, 2005)
- In order to identify the location of clusters, the method of Scholl and Brenner (2016) is used
- In brief, this method involves the following steps:
  - Calculation of the kernel density function of D_i for a given industry
  - Calculation of global confidence bands from the kernel density functions of random samples of plants from the population of plants
  - To the right of the median of the benchmark values, values of D_i at which the kernel density function for the industry lies above the upper global confidence band indicate clustering

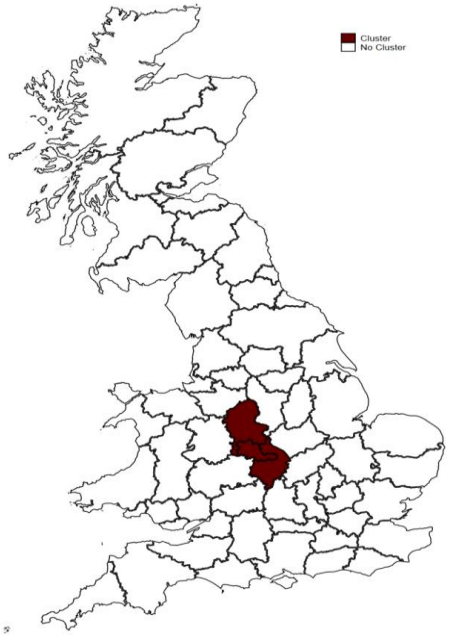
Example of Kernel Density Function



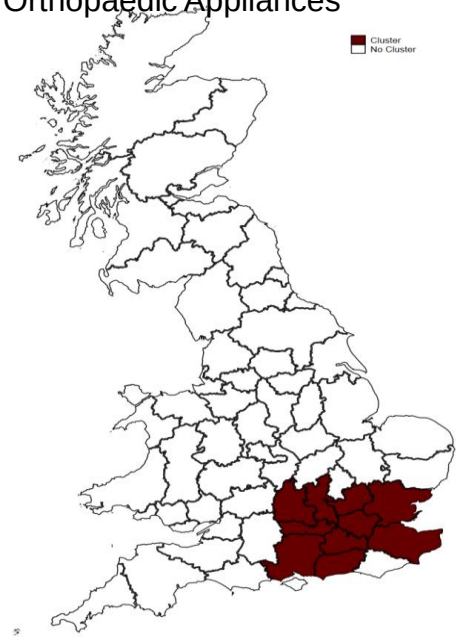
Location of Clusters

Pharmaceutical Products

Motor Vehicle Parts



Medical & Surgical Equipment & Orthopaedic Appliances



Empirical Strategy

- The empirical model is the following augmented log-linear Cobb-Douglas production function:

$$y_{it} = \alpha_i + \alpha_E e_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha_D d_{it} + \alpha_X X_{it} + \alpha_T t + \varepsilon_{it}$$

- This provides estimates of effects on total factor productivity since:

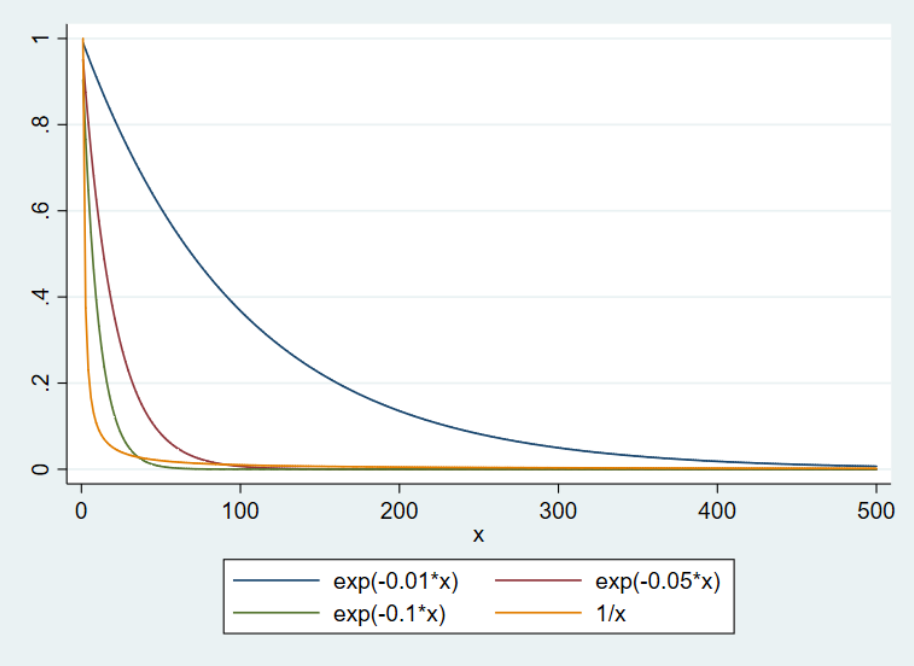
$$tfp_{it} \equiv y_{it} - \alpha_E e_{it} - \alpha_M m_{it} - \alpha_K k_{it} = \alpha_i + \alpha_D d_{it} + \alpha_X X_{it} + \alpha_T t + \varepsilon_{it}$$

- The model is estimated using system GMM which allows for fixed effects, autoregressive processes in the error term and endogeneity of the factor inputs and d_{it}

Empirical Strategy

- The model is estimated:
  - Including and excluding 11 region and 11 city dummies
    - NUTS3 regions are defined as cities if they met any of the following criteria:
      - They are capitals
      - They had employment of 250,000+ and population density of 20+ persons per hectare (in 2001)
      - They had employment of 100,000+ and population density of 30+ persons per hectare (in 2001)
  - Using D_i calculated from 3-digit SIC industries and groupings of related industries defined according to Delgado et al. (2016)
    - For example, Pharmaceutical Products (257) is 'related' to Basic Organic Chemicals except Specialised Pharmaceutical Chemicals and Miscellaneous Chemical Products for Industrial Use
  - Using D_i calculated with distance decay factors (α) of 0.01, 0.05 and 0.1

Decay Functions



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Variables

Variable	Definition
Gross output	Sales deflated by 2-digit producer price (output) indices
Intermediate inputs	Intermediate inputs deflated by 2-digit producer price (input) indices
Employment	Number of employees in plant
Capital	Plant and machinery capital stock plus value of hires (deflated by 2-digit producer price input index)
D	Spatial concentration index (see earlier slide)
Age	Number of years that plant has been in operation
Single-plant enterprise	Dummy coded 1 if plant comprises a single-plant enterprise
Multi-region enterprise	Dummy coded 1 if plant belongs to an enterprise operating in more than one UK region
Multi-industry enterprise	Dummy coded 1 if enterprise has plants in more than one industry
Foreign-ownership	Dummy coded 1 if plant is US-owned/EU-owned/other foreign-owned
Herfindahl index	Herfindahl index of industry concentration
Region	Dummies coded 1 if plant is located in particular region
City	Dummies coded 1 if plant is located in particular city

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Pharmaceutical Products

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
ln Intermediate Inputs	0.668***	0.649***	0.653***	0.617***	0.646***	0.630***	0.656***	0.618***	0.624***	0.589***	0.619***	0.605***
	(8.605)	(7.012)	(8.877)	(6.528)	(9.246)	(7.767)	(7.794)	(5.917)	(6.449)	(6.194)	(7.334)	(6.698)
ln Employment	0.295***	0.347***	0.325***	0.388***	0.323***	0.360***	0.305***	0.381***	0.369***	0.412***	0.353***	0.384***
	(2.954)	(2.786)	(3.164)	(3.829)	(3.278)	(3.296)	(3.312)	(3.896)	(4.027)	(4.632)	(3.992)	(3.826)
ln Capital	0.148***	0.112**	0.122**	0.108*	0.134**	0.124**	0.152***	0.122*	0.100*	0.126*	0.126**	0.132**
	(3.058)	(2.140)	(2.000)	(1.839)	(2.458)	(2.444)	(2.792)	(1.749)	(1.936)	(1.892)	(2.275)	(2.291)
Time	0.013***	0.013***	0.012***	0.013***	0.011**	0.013***	0.013***	0.014***	0.012***	0.015***	0.011**	0.013***
	(3.575)	(3.250)	(2.882)	(3.261)	(2.585)	(2.624)	(3.620)	(3.784)	(3.128)	(3.651)	(2.506)	(2.889)
ln D	0.426	0.451	0.041	-0.092	-0.020	-0.056	0.291	-0.006	-0.130	-0.198	-0.152	-0.180
	(1.201)	(0.955)	(0.180)	(-0.597)	(-0.241)	(-0.625)	(0.709)	(-0.010)	(-0.702)	(-0.968)	(-1.121)	(-1.186)
Hansen	37.888	38.498*	42.848**	42.654**	40.702*	41.325*	38.396*	38.280*	43.231**	40.907*	40.031*	39.924*
Spatial Dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Distance Decay	0.01	0.01	0.05	0.05	0.1	0.1	0.01	0.01	0.05	0.05	0.1	0.1
Industry Definition	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Wide	Wide	Wide	Wide	Wide	Wide
Plants	788	788	788	788	788	788	788	788	788	788	788	788
Observations	4,013	4,013	4,013	4,013	4,013	4,013	4,013	4,013	4,013	4,013	4,013	4,013

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Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Pharmaceutical Products (n=4,013)												
ln D	0.426	0.451	0.041	-0.092	-0.020	-0.056	0.291	-0.006	-0.130	-0.198	-0.152	-0.180
	(1.201)	(0.955)	(0.180)	(-0.597)	(-0.241)	(-0.625)	(0.709)	(-0.010)	(-0.702)	(-0.968)	(-1.121)	(-1.186)
Basic Electric Equipment (n=6,122)												
ln D	0.124	0.258	0.001	0.030	0.024	0.042	0.265	0.290	-0.096	-0.035	-0.089	0.000
	(1.566)	(0.955)	(0.015)	(0.329)	(0.624)	(0.863)	(1.063)	(0.892)	(-1.234)	(-0.201)	(-1.300)	(0.004)
Electric Equipment for Industrial Use & Batteries & Accumulators (n=3,699)												
ln D	-0.222	-0.899*	0.196	0.397*	0.304**	0.239*	-0.089	-0.248	0.106	0.831*	0.284**	0.458
	(-0.713)	(-1.722)	(0.913)	(1.711)	(2.096)	(1.721)	(-0.211)	(-0.366)	(0.867)	(1.790)	(2.361)	(1.383)
Spatial Dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Distance Decay	0.01	0.01	0.05	0.05	0.1	0.1	0.01	0.01	0.05	0.05	0.1	0.1
Industry Definition	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Wide	Wide	Wide	Wide	Wide	Wide

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Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Motor Vehicle Parts (n=6,876)												
ln D	-0.068	-0.068	0.060	0.117**	0.040	0.070**	-0.094	0.026	-0.062	-0.063	-0.128	0.115
	(-0.917)	(-0.158)	(1.221)	(2.126)	(1.551)	(2.267)	(-1.034)	(0.066)	(-0.774)	(-0.367)	(-0.864)	(0.418)
Aerospace Equipment Manufacturing & Repair (n=4,766)												
ln D	-0.028	-0.053	0.056	0.161*	0.056	0.083*	-0.080	0.005	0.119	0.184*	0.124*	0.185**
	(-0.388)	(-0.362)	(0.808)	(1.847)	(1.466)	(1.877)	(-0.778)	(0.030)	(1.152)	(1.682)	(1.758)	(2.024)
Medical & Surgical Equipment & Orthopaedic Appliances (n=2,834)												
ln D	-0.608*	-0.303	-0.344***	-0.441**	-0.320***	-0.305***	-0.555	-0.227	-0.550**	-0.419**	-0.594**	-0.581***
	(-1.924)	(-1.186)	(-3.053)	(-2.960)	(-3.211)	(-2.729)	(-1.312)	(-1.045)	(-2.411)	(-2.543)	(-2.519)	(-3.156)
Spatial Dummies	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Distance Decay	0.01	0.01	0.05	0.05	0.1	0.1	0.01	0.01	0.05	0.05	0.1	0.1
Industry Definition	Narrow	Narrow	Narrow	Narrow	Narrow	Narrow	Wide	Wide	Wide	Wide	Wide	Wide

Summary

- This paper has investigated the effect of spatial concentration on productivity in advanced manufacturing
- Positive and significant effects are obtained in three of the sectors considered
- However, the estimated effects are sensitive to the inclusion of other spatial variables and the specification of the measure of spatial concentration

Future Steps

- Calculate measures of spatial concentration constructed at lower levels of industrial classification
- Construct distance-based measures of diversification/urbanisation to replace region and city dummies
- Consider alternative strategies for identifying the effect of spatial concentration