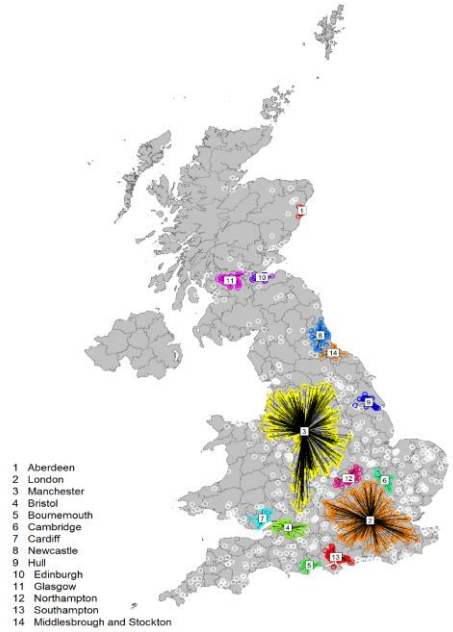
Micro-data findings on proximity, productivity and innovation in Advanced Manufacturing



Presentation

By

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Main motivation

- It is generally assumed that spatial proximity positively impacts on a plant's performance, leading to higher productivity.

> "Clustering is viewed as beneficial to firms (particularly to small firms) because they can access a shared pool of expertise and labour, suppliers, and information or contacts." (HC BP7682, 4 April 2018)

- Here we use a distance index for each 4-digit SIC and conduct two separate studies:
  - In terms of productivity (TFP), find that such Marshallian spillovers are by no means universal, and in many cases only benefit larger plants (with sufficient absorptive capacity).
  - In terms of undertaking R&D and innovating, we formally test the relative importance of absorptive capacity and proximity finding the former very important, and the latter mostly unimportant

Some background on agglomeration externalities

- Spatial spillovers or agglomeration externalities are:
  - benefits that accrue to plants from being located in the vicinity of large concentrations of other plants:
  - in the same industry – Marshiallian *localisation* externalities
  - in related industries – the latter often but not exclusively being referred to as ‘clusters’
  - in a diverse set of industries as often found in urban locations – Jacobian *urbanisation* externalities (economies of scope rather than scale).
  - Duranton and Puga (2004) describe the mechanisms that give rise to agglomeration externalities
    - viz: ‘sharing’, ‘matching’ and ‘learning’
  - Empirical literature (especially micro-level) tends to favour localisation over urbanisation externalities

- Role of absorptive capacity (AC)
  - Firm's ability to internalise potential external knowledge spillovers
    - if firms are not able to learn, then new strategies or technology that are designed to help firms become more productive are likely to have only limited impact
  - The results presented in regarding TFP effects show that in many industries colocation of plants within the same industry have negative or insignificant effects for mostly *small* plants
    - while positive and large benefits accrue to larger plants
  - we attribute this to the likely absorptive capacity of the plant as proxied by their size
- As to the role and importance of AC and co-location/proximity in determining the likelihood of firms undertaking R&D/innovating:
  - We confirm the major importance of AC in determining the underlying drivers of TFP considered here
  - We find co-location to be largely unimportant (where significant, small and negative)
  - We do find some limited evidence that for some advance manufacturing sectors the joint effect of AC and proximity has a positive influence

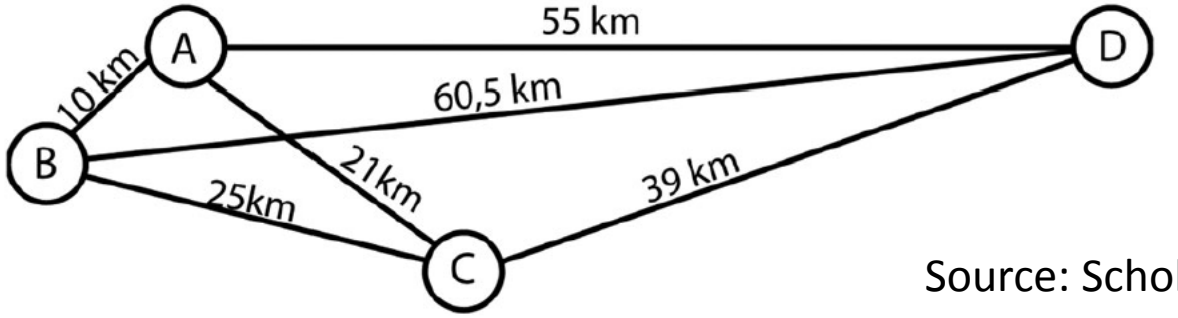
Measuring proximity

- Use a Distance index
  - based on mapping the location of every plant to every other plant in an industry
- Obtained by calculating the distance in kilometres between all pairs of (weighted by employment) plants in each 4-digit SIC80, using the plant's postcode district (first 4-digits of the UK postcode) and the following formula:

$$D_i = \frac{1}{J-1}\sum_{j=1,j\neq i}^{J}\left(e^{-0.05(d_{i,j})} \times \frac{E_j}{\sum_{k=1,k\neq i} E_k}\right)$$

  - where D_i is the sum of inverted distances from plant *i* to all other plants in the same 4-digit industry;
  - *J* is the number of observations;
  - $d_{i,j}$ is the distance between plant *i* and *j*;
  - E_j is the number of employees in plant *j*; and
  - $\sum_{k=1,k\neq i} E_k$ is the total employment in all other plants, except plant *i*, in the observed industry.

Simple example



Source: Scholl and Brenner (2016)

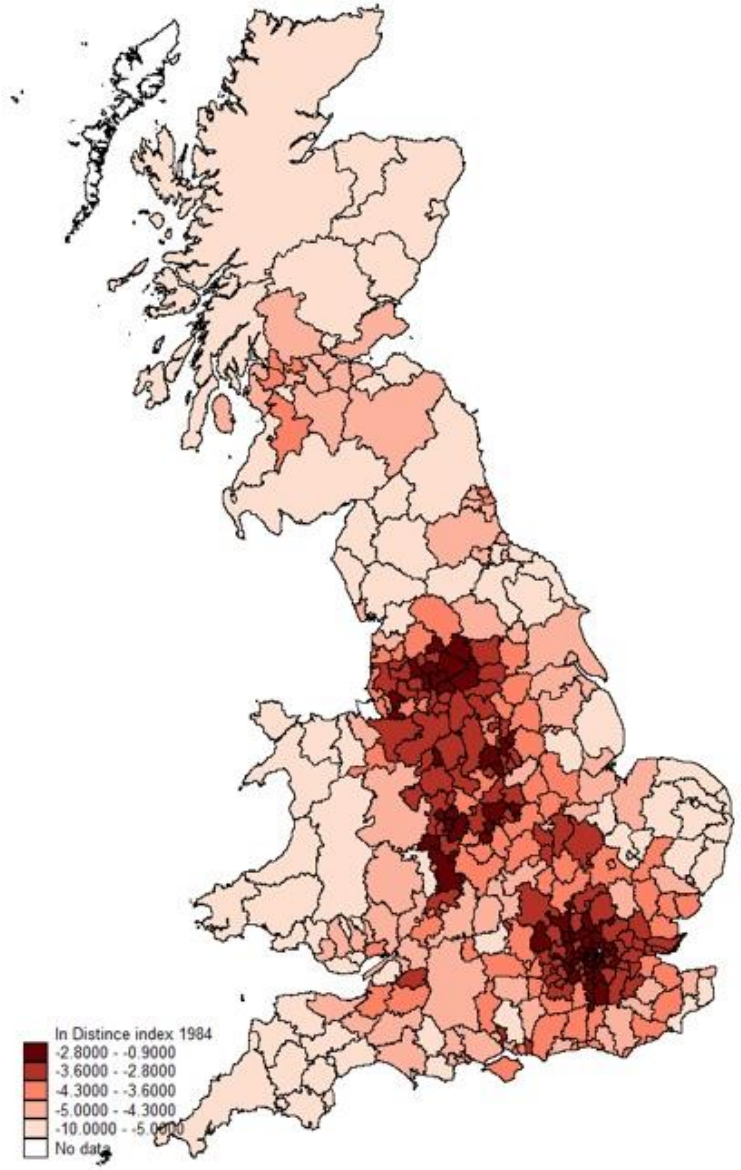
- Consider 4 plants (A-D). Assuming all plants are of equal size, for plant *A* its D_i value is:

$$\frac{1}{3}\left(e^{-0.05(10)} + e^{-0.05(21)} + e^{-0.05(55)}\right) = 0.34$$

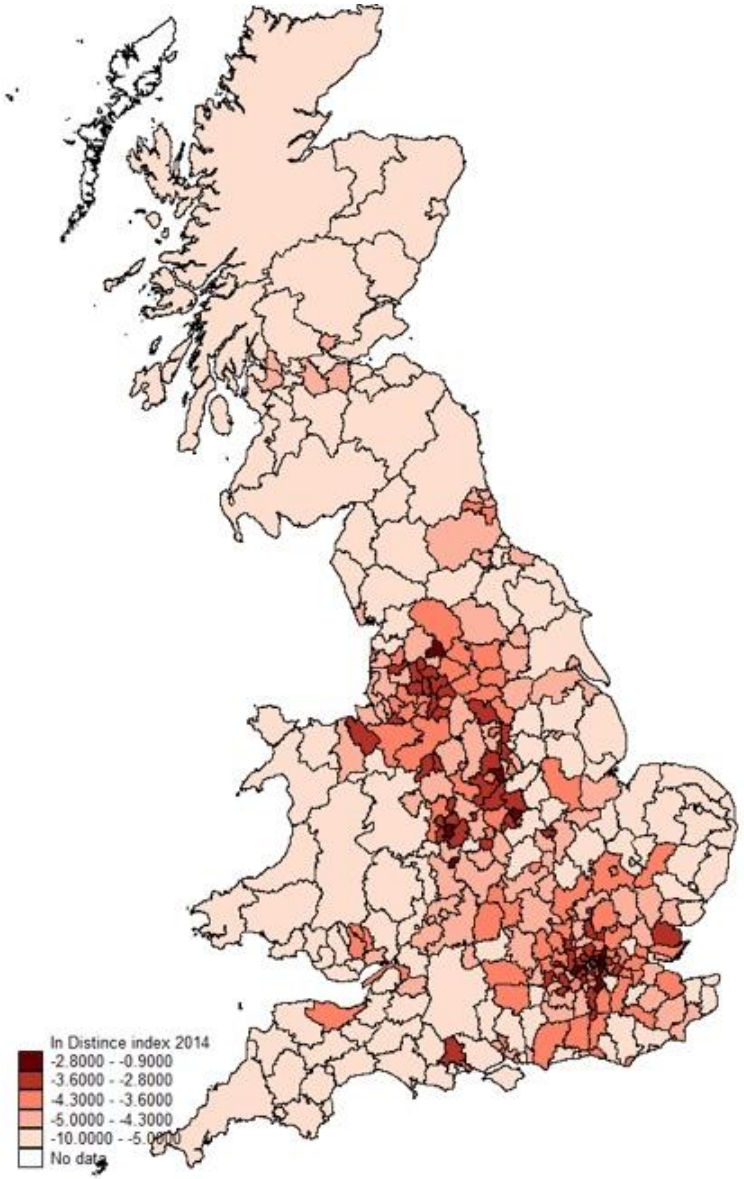
- The values for plants *B, C, D* are: 0.31, 0.26 and 0.08, respectively.
- The higher is D_i value, the more a plant is located in spatial proximity to other plants in the same industry.

Figure 1: Average *ln* Distance index by local authority, 1984 and 2014: all manufacturing plants

1984

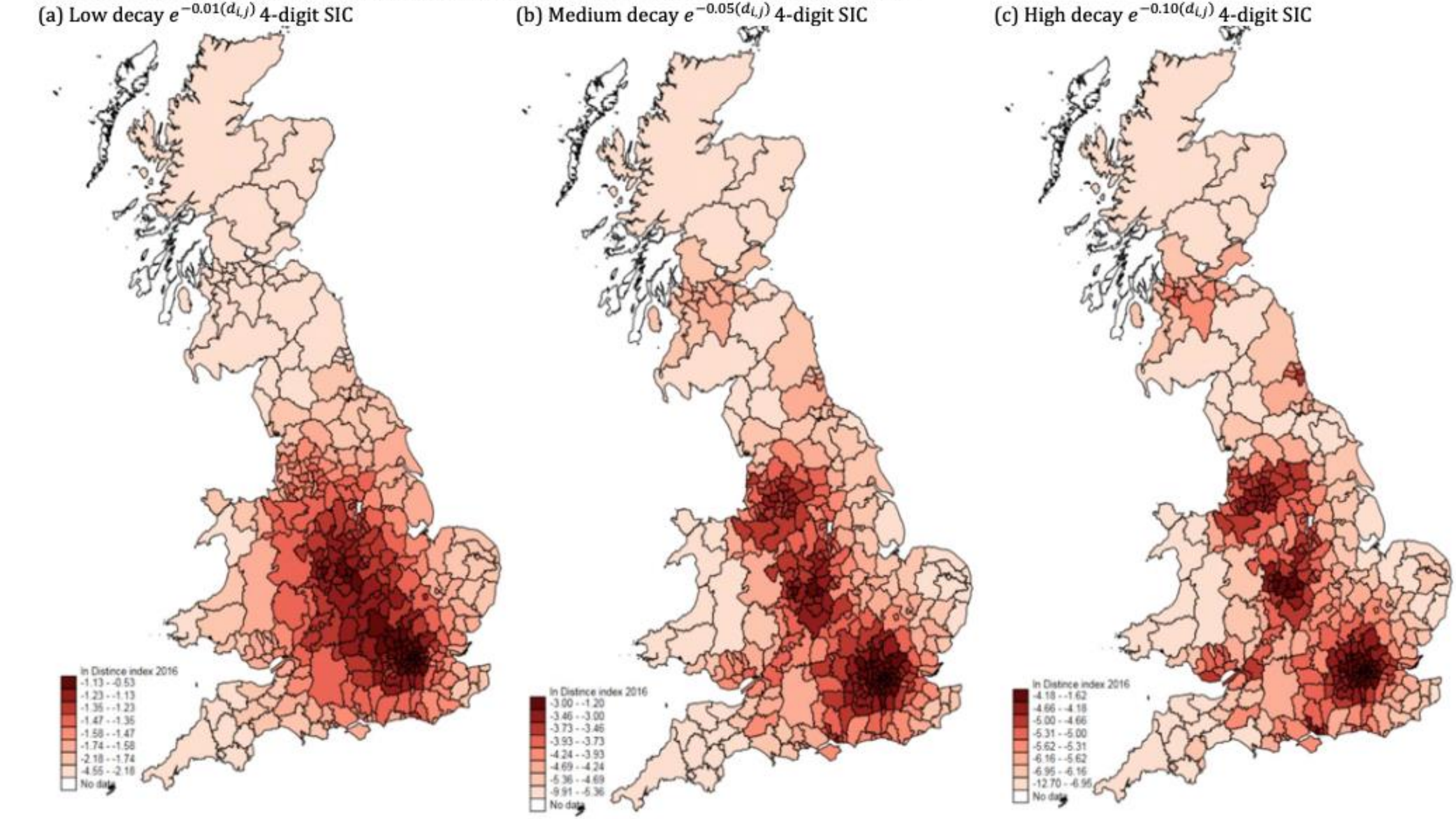


2014



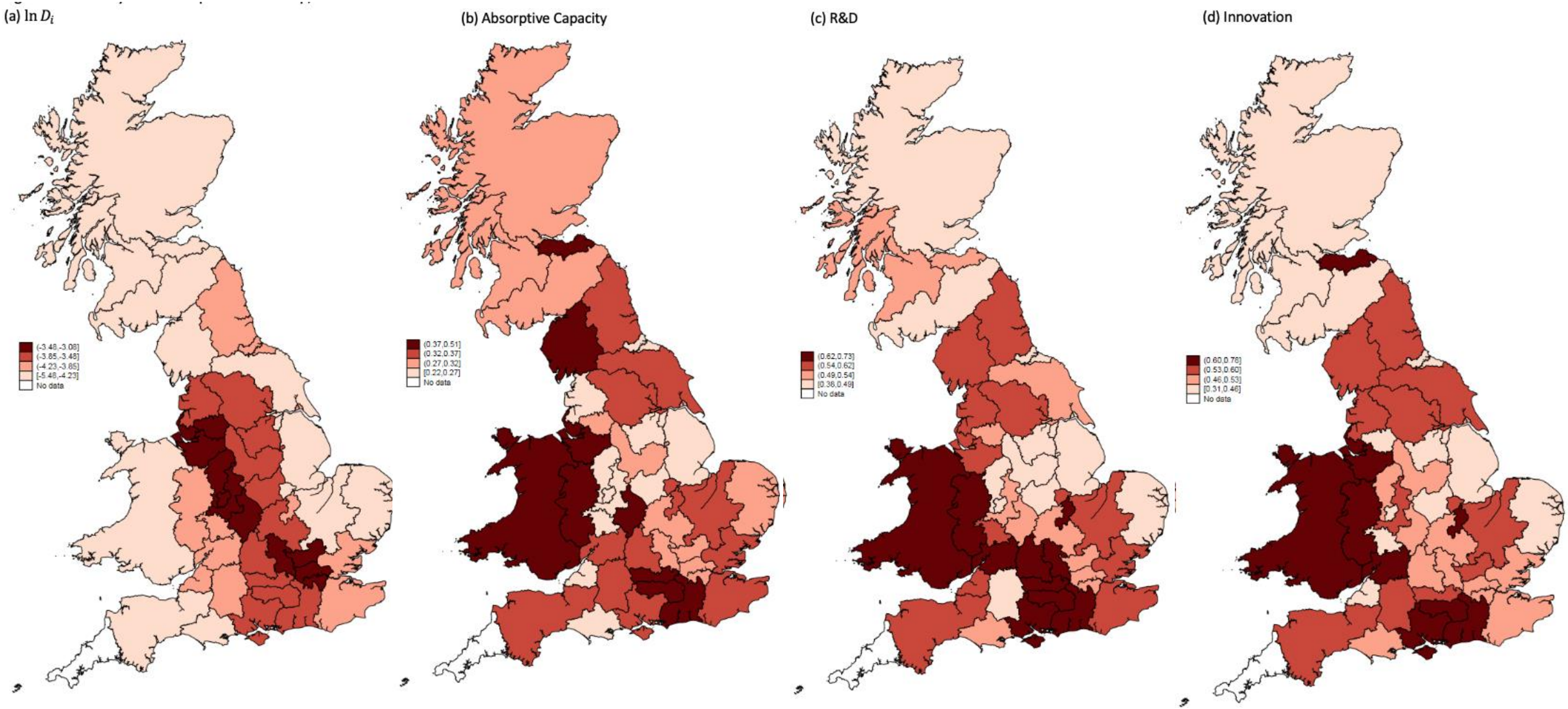
'No data' indicates less than 10 firms Source UK Annual Business Survey/Inquiry (full population), 2014 and 2016

Figure 2: Average *ln* Distance by local authority, 2016: 6 sectors in manufacturing



'No data' indicates less than 10 firms Source UK Annual Business Inquiry (full population), 2016

Figure 3: Means by Local Enterprise Partnership, Advanced Manufacturing, 2004-2016



'No data' indicates less than 10 firms Source UK Innovation Survey, 1994-2016

Table 1: Person correlation between certain variables, 2004-16, by sector

Rest of Chemicals

	R&D	Innovation	*ln* distance
R&D	1.000		
Innovation	0.546	1.000	
ln distance	0.085	0.112	1.000
AC	0.554	0.494	0.035

Telecoms

	R&D	Innovation	*ln* distance
R&D	1.000		
Innovation	0.692	1.000	
ln distance	-0.027	-0.079	1.000
AC	0.580	0.566	-0.083

Pharmaceuticals

R&D	1.000		
Innovation	0.509	1.000	
ln distance	0.175	0.082	1.000
AC	0.531	0.539	0.158

Instruments

R&D	1.000		
Innovation	0.587	1.000	
ln distance	-0.049	-0.073	1.000
AC	0.557	0.544	-0.056

Office Machines

R&D	1.000		
Innovation	0.550	1.000	
ln distance	0.029	-0.165	1.000
AC	0.575	0.489	0.028

Motor vehicles

R&D	1.000		
Innovation	0.474	1.000	
ln distance	0.032	0.024	1.000
AC	0.491	0.471	0.002

Electrical

R&D	1.000		
Innovation	0.615	1.000	
ln distance	0.011	0.038	1.000
AC	0.595	0.572	-0.028

Aircraft

R&D	1.000		
Innovation	0.498	1.000	
ln distance	0.055	0.184	1.000
AC	0.612	0.560	0.116

Source: CIS firm-level data

(1) Estimating TFP with *ln* Distance included

- Estimate:

Gross output: y_{it}; employment: e_{it}; Capital stock: k_{it}; Time trend: t; Intermediate inputs: m_{it}; Other factors: X_{it}; Other (random) effects: ε_{it}

$$y_{it} = a_i + a_E e_{it} + a_M m_{it} + a_K k_{it} + a_X X_{it} + a_T t + \varepsilon_{it}$$

- To obtain:

Output minus: y_{it}; Factor inputs: $\hat{a}_E e_{it} - \hat{a}_M m_{it} - \hat{a}_K k_{it}$

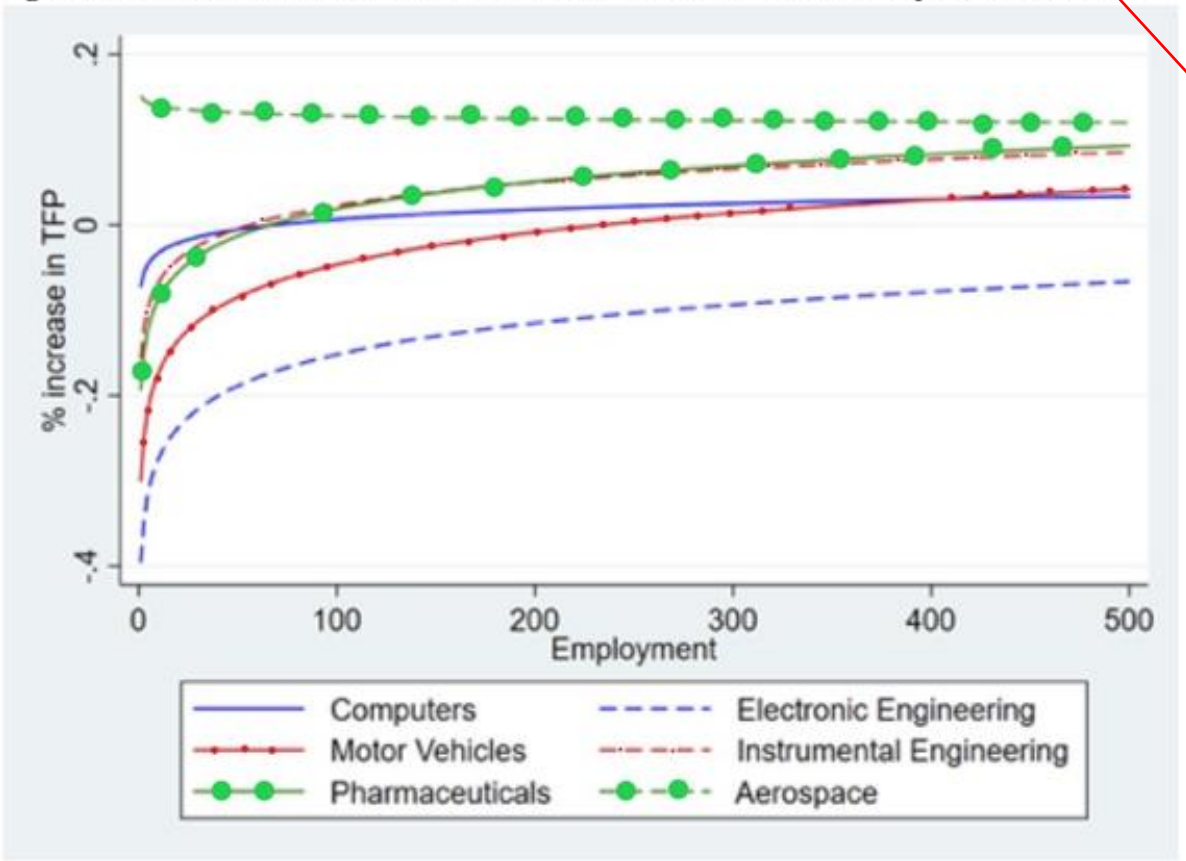
$$\ln \hat{TFP}_{it} = y_{it} - \left(\hat{a}_E e_{it} - \hat{a}_M m_{it} - \hat{a}_K k_{it}\right) = \hat{a}_i + \hat{a}_X X_{it} + \hat{a}_T t + \hat{\varepsilon}_{it}$$

- Efficiency shifters X_{it} include:
  - *ln* Distance and *ln* Distance × *ln* Employment (i.e., size of plant)
  - Host of covariates such as plant age, ownership (foreign, multi-region, single-plant), urbanization index, location dummies)

Table 2: Long-run (weighted) impact of *ln* Distance based on 4-digit industry (medium decay, $e^{-0.05(d_{i,j})}$) on TFP by size of plant, 1984-2016 (Great Britain)

	Computers SIC33	Electronic Engineering SIC34	Motor Vehicles SIC35	Instrumental Engineering SIC37	Pharmaceuticals SIC257	Aerospace SIC364
ln Distance	-0.072**	-0.396***	-0.300*	-0.157***	-0.193	0.151***
ln Distance × *ln* employment	0.017*	0.053***	0.055**	0.039***	0.046*	-0.005
Distance × 5 employees	-0.044**	-0.310***	-0.211*	-0.094***	-0.119	0.143***
Distance × 50 employees	-0.005	-0.188***	-0.085	-0.004	-0.013	0.131***
Distance × 500 employees	0.035	-0.065	0.042	0.087***	0.094	0.119***

Figure 4: Effect of a 1% increase in distance index on TFP for different sized plants, 1984-2016



Source: based on model estimates in Table 2

Summary:

- in all industries (except aerospace) more agglomerated, much larger plants had significantly higher TFP
- Generally positive TFP effects for larger plants were small except in Aerospace/Instruments
- Negative TFP effects for small plants were large in electronic engineering and motor vehicles

(2) Estimating R&D/innovation with *ln* Distance included

- Estimate:

R&D (0/1) Distance index Absorptive capacity

$$R\&D_{it} = \alpha_i + \alpha_D lnD_{it} + \alpha_{AC} lnAC_{it} + \alpha_I (lnD_{it} \times lnAC_{it}) + \alpha_X X_{it}$$

Interaction effect Other factors

- Covariates X_{it} include:
  - firm age, firm size, capital-to-labour ratio, ownership (foreign, multi-region, single-plant), urbanization index, location (sector) and time dummies
- Model estimated using random-effects probit, in aggregate and sector by sector
  - Marginal effects of the impact of changes in distance/AC on the probability of doing R&D/innovation calculated in two ways:
    - (correctly) solving out for effect of distance/AC given interaction
    - Assuming interaction effect is independent of changes in distance/AC so as to see importance of this interaction

Results aggregated across all 8 advanced manufacturing sectors

Table 3: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Advanced manufacturing

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.423	142.94	0.446	152.01
ln distance[a]	0.015	3.11	-0.003	-0.60
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.427	109.04	0.446	88.21
ln distance[b]	0.018	3.41	-0.003	-0.63
Absorptive capacity × *ln* distance[b]	0.006	1.12	-0.001	-0.11
N obs	4,962		4,962	
N Reporting Units	2,823		2,823	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Results for separate advanced manufacturing sectors

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Rest of Chemicals

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.359	50.70	0.385	60.16
ln distance[a]	0.077	7.51	0.047	3.98
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.390	52.68	0.396	42.78
ln distance[b]	0.105	10.62	0.052	4.50
Absorptive capacity × *ln* distance[b]	0.046	8.64	0.013	1.36
N obs	687		687	
N Reporting Units	404		404	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Pharmaceuticals

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.296	17.64	0.394	22.46
ln distance[a]	-0.109	-1.71	0.050	1.38
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.239	18.19	0.443	13.13
ln distance[b]	-0.101	-2.21	0.069	1.76
Absorptive capacity × *ln* distance[b]	-0.067	-8.30	0.041	2.05
N obs	166		166	
N Reporting Units	97		97	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Office Machinery

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.356	2.83	0.372	19.54
ln distance[a]	0.091	0.60	-0.227	-8.63
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.335	3.22	0.215	1.81
ln distance[b]	0.128	8.67	-0.231	-8.95
Absorptive capacity × *ln* distance[b]	0.035	0.95	-0.051	-2.53
N obs	151		151	
N Reporting Units	111		111	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Electrical

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.456	69.71	0.466	73.24
ln distance[a]	0.001	0.05	0.038	2.44
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.364	5.17	0.456	33.73
ln distance[b]	-0.024	-1.79	0.025	1.82
Absorptive capacity × *ln* distance[b]	-0.079	-5.46	-0.033	-1.96
N obs	1,021		1,021	
N Reporting Units	586		586	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Telecoms

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.336	34.17	0.376	39.53
ln distance[a]	-0.023	-1.36	-0.118	-4.03
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.360	19.27		
ln distance[b]	-0.004	-0.20		
Absorptive capacity × *ln* distance[b]	0.038	2.63		
N obs	486		486	
N Reporting Units	285		285	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Instruments

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.383	68.38	0.410	67.66
ln distance[a]	-0.019	-1.92	-0.032	-3.04
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.417	39.70	0.457	51.70
ln distance[b]	-0.013	-1.20	-0.023	-1.91
Absorptive capacity × *ln* distance[b]	0.023	3.04	0.037	6.23
N obs	1,003		1,003	
N Reporting Units	621		621	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Motor vehicles

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.505	69.50	0.531	66.96
ln distance[a]	-0.021	-1.58	-0.047	-3.55
(b) Solving out with interaction effect assumed to be independent				
Absorptive capacity[b]	0.494	27.97	0.498	17.22
ln distance[b]	-0.025	-1.81	-0.052	-3.98
Absorptive capacity × *ln* distance[b]	-0.011	-0.89	-0.021	-1.70
N obs	1,112		1,112	
N Reporting Units	623		623	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

[b] The second set of results of the impact of absorptive capacity/*ln* distance treat their effects as independent and a third term involving the interaction between the two variables in included (see text for details)

Table 4: (Weighted) marginal effects of changes in variables on probability that RU undertook R&D/Innovated, 2004-2016 (based on random effects probit models): Aircraft

	R&D		Innovation	
	$\partial\hat{p}/\partial x$	z-value	$\partial\hat{p}/\partial x$	z-value
(a) Solving out with interaction effect taken into account				
Absorptive capacity[a]	0.456	20.90	0.509	15.51
ln distance[a]	-0.132	-3.29	0.019	0.48
N obs	333		333	
N Reporting Units	175		175	

[a] Increase in probability of R&D/innovation when absorptive capacity/*ln* distance changes from median to 99 percentile values

Summary: impact of *ln* Distance on likelihood of doing R&D/innovating

Sector	R&D	Innovation
Rest of Chemicals	+	+
Pharmaceuticals	–	
Office Machinery		–
Electrical		+
Telecoms		–
Instruments	–	–
Motor Vehicles	–	–
Aircraft	–	

Summary and conclusions

- It is generally assumed that spatial proximity positively impacts on a plant's performance, leading to higher productivity.

Clustering is viewed as beneficial to firms (particularly to small firms) because they can access a shared pool of expertise and labour, suppliers, and information or contacts. (HC BP7682, 4 April 2018)

- This approach uses a distance index for each 4-digit SIC and finds that such Marshallian spillovers are by no means universal, and in many cases only benefit larger plants (with sufficient absorptive capacity).
- We also find for two important underlying drivers of TFP (R&D and innovation) that proximity effects are mostly small and more often negative.