Centre for Market and Public Organisation

Geographic proximity and firm-university innovation linkages

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What I'll talk about

1. Evidence on the co-location of private sector R&D facilities with university research
2. Evidence on geographic proximity and firm-university interactions

Background: why might geographic proximity be important?

- Survey-based evidence: research base an important source of knowledge for business
- Beneficial pure spillovers may increase with proximity (codified versus non-codified knowledge)
- Knowledge also transferred through formal collaboration agreements; spin-out companies; consultancy; and the supply of skills
- Extensive empirical literature on the existence of geographically mediated spillovers and on proximity to research institutions as determinant of innovative activity - most for US
  - E.g.: Jaffe (1989); Feldman (1999); Harhoff (1999)

Policy background

- Commercial exploitation of the research base a topical policy issue in the UK and elsewhere
- UK: Lambert Review; DTI Innovation Review
- Recommendations included:
  - greater government support for collaborative R&D
  - funding for research should encourage technology transfer
- HEFC university funding allocations depend on Research Assessment Exercise scores
  - emphasis on publications rather than collaboration with business?
- HEIF – third stream funding for universities aimed at knowledge transfer activities

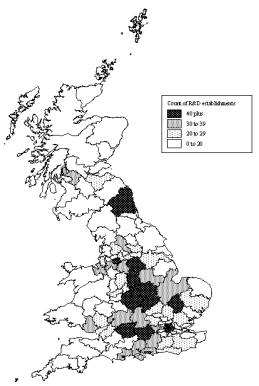
Co-location

Do firms locate their R&D facilities close to (high-quality) university research departments?

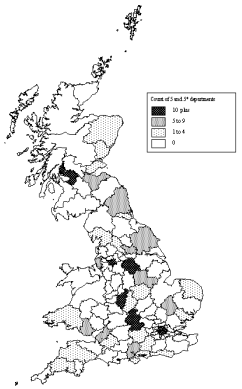
To answer this: combine data on population of R&D establishments in GB with information on the presence and quality of university research departments

Improve on the methods used in Abramovsky, Harrison and Simpson (2007)

Distribution R&D establishments



Distribution 5 and 5* departments



Data: R&D

- Micro Business Enterprise Research and Development (BERD) data, collected by ONS
- Population of R&D-doing establishments in GB
- Use 2000-2003
- BERD provides information on R&D expenditure (intramural, extramural, basic and applied), R&D employment etc., but only for a sample
- Use basic information (available for the whole population):
  - location (postcode)
  - product group/industry code

Data: R&D

- Counts of establishments conducting intramural R&D at the *postcode district* level (e.g. OX1)
  - average over period 2000-03
  - for each of 7 product groups
  - Assume that all establishments are located at the centre of the relevant postcode district
  - Use around 2,300 postcode districts in estimation
- Abramovsky, Harrison and Simpson (2007)
  - ownership (foreign v. UK)
  - entrants

Descriptive statistics: R&D, 2003

Product group	Expenditure		Establishments	
	£bn	%	Number	%
Pharmaceuticals	3.24	24%	158	2%
Aerospace	1.65	12%	72	1%
Motor vehicles	1.17	9%	236	2%
Machinery	0.97	7%	782	7%
TV and radio equipment	0.93	7%	250	2%
Chemicals	0.54	4%	382	4%
Electrical machinery	0.44	3%	442	4%
Precision instruments	0.40	3%	558	5%
R&D services (natural science and engineering)	0.33	2%	1,584	15%
Other	3.91	29%	6,028	57%
Total	13.57	100%	10,492	100%

Source: Authors' calculations using BERD (Source: ONS)

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Electrical machinery	0.44	3%	442	4%
Precision instruments	0.40	3%	558	5%
R&D services		57%		26%
(natural science and engineering)	0.33	2%	1,584	15%
Other	3.91	29%	6,028	57%
Total	13.57	100%	10,492	100%

Source: Authors' calculations using BERD (Source: ONS)

Descriptive statistics: R&D, estimation samples

Count of establishments in postcode district in product group:	Mean	No. postcode districts (out of c.2,300) with one or more
Pharmaceuticals	0.095	155
Chemicals	0.228	429
Machinery	0.411	747
Electrical machinery	0.235	447
TV and radio equipment	0.151	281
Motor vehicles	0.132	265
Precision instruments	0.285	527

Source: Authors' calculations using BERD (Source: ONS)

Data: RAE

- Research Assessment Exercise (RAE)
  - produces ratings of research quality used to allocate government grants
- Data from (most recent) RAE 2001: refer to research outputs produced over 5 years to the end of 2000
- University departments voluntarily make submissions on their corresponding subject research area and are graded 1,2,3,4,5,5*
- We use full postcode of central admin office to locate universities

Data: RAE

Create range of variables from RAE 2001

Relative to centre of each postcode district:

- University-level variables
  - Count of universities within 10km
  - Count of universities between 10km and 50km
- Research-field level variables (e.g. medicine, materials science):
  - Count of departments within 10km
  - Count of departments between 10km and 50km
  - Count of 5 and 5* rated departments within 10km
  - Count of 4 and below rated departments within 10km

Data: Define *relevant fields* (RAE & R&D)

- Use the Carnegie Mellon Survey (1994) of R&D managers, which reports for firms in different industries the relevancy of different research fields
- Research field *relevant* if rated very or moderately important by at least 50% industry respondents

  Pharmaceuticals → biology, chemistry, medicine

  Chemicals → chemistry, materials science

  Machinery → materials science, mechanical engineering

Descriptive statistics: RAE

Variable	Mean	No. postcode districts with zero	Maximum
Count universities within 10km	2.99	1,231	39
Count unis between 10km and 50km	12.36	74	55
Count within 10km			
Biology	0.79	1,573	9
Chemistry	0.48	1,663	4
Medicine	4.15	1,430	50
Count between 10km and 50km			
Biology	3.69	231	17
Chemistry	2.34	382	8
Medicine	16.43	240	69

Mean is average across c. 2,300 postcode districts
Source: authors' calculations using RAE data

Empirical approach

- Relate geographic distribution of R&D facilities to geographic distribution of university research departments
- BERD data contain mix of firms
  - Some that have chosen *where* to locate their R&D labs, e.g. multinationals
  - Some (individuals) deciding *whether* to start an R&D facility, e.g. university spin-outs
- Estimate a negative binomial count model

Empirical approach

$$E(count\ of\ \ R\&D\ establishments_{ij}) = \exp(DEP_{ij}'\alpha_i + Z_j'\gamma_i + X_{ir}'\beta_i)$$

i: product group, j: postcode district; r: postcode area

DEP_{ij} vector of number of departments:
- within 10km
- between 10km and 50km
- rated 5 or 5* within 10km, rated 1-4 within 10km

Z_j vector of university-level variables:
- number of universities within 10km
- number of universities between 10km and 50km

X_{ir} additional controls at the postcode area level
- log of total manufacturing employment
- % of manufacturing employment in the relevant industry
- % of economically active population with degree or above

Results: relevant departments within 10km

	(1) pharma	(2) chem	(3) mach
Bio 10km	0.080		
Chem 10km	0.711**	0.029	
Med 10km	-0.028		
MatSci 10km		0.168*	0.003
MechEng 10km			-0.028
Unis 10km	-0.059	-0.046**	-0.037*
Log(man_emp)	0.007	0.274**	0.349**
% ind emp	0.080**	0.054**	0.044**
% prop4	0.079**	-0.011	-0.011
Observations	2269	2273	2280

Values shown are incident rate ratios minus one. + significant at 10% level, * at 5% level, ** at 1% level.
Source: Authors' calculations using BERD (Source: ONS), RAE and NOMIS data.

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Source: Authors' calculations using BERD (Source: ONS), RAE and NOMIS data.

Results: relevant departments within 10km

- Electrical machinery, tv and radio, motor vehicles, precision instruments
  - Coefficients on relevant departments statistically insignificant
- Pharmaceuticals, chemicals – excluding central london
  - Coefficients on chemistry departments and materials science departments only significant at the 10% level
- Add in relevant departments located between 10km and 50km……

Results: relevant departments within 10km, and between 10km and 50km

	(1) pharma	(2) chem	(3) mach
Bio 10km	0.062		
Bio 10km to 50km	-0.003		
Chem 10km	1.022**	0.101	
Chem 10km to 50km	0.180+	0.027	
Med 10km	-0.046		
Med 10km to 50km	-0.021		
MatSci 10km		0.096	-0.066
MatSci 10km to 50km		0.122**	0.059**
MechEng 10km			0.014
MechEng 10km to 50km			0.097**
Other university and area controls?	Yes	Yes	Yes
Observations	2269	2273	2280

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Bio 10km to 50km	-0.003		
Chem 10km	1.022**	0.101	
Chem 10km to 50km	0.180+	0.027	
Med 10km	-0.046		
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MatSci 10km to 50km		0.122**	0.059**
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Bio 10km	0.062		
Bio 10km to 50km	-0.003		
Chem 10km	1.022**	0.101	
Chem 10km to 50km	0.180+	0.027	
Med 10km	-0.046		
Med 10km to 50km	-0.021		
MatSci 10km		0.096	-0.066
MatSci 10km to 50km		0.122**	0.059**
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Results: relevant departments within 10km, and between 10km and 50km

	(4) elec	(5) tv	(6) mot	(7) inst
Med 10km				0.037
Med 10km to 50km				0.020
MatSci 10km		0.018	-0.055	
MatSci 10km to 50km		0.006	0.118**	
MechEng 10km		-0.055	0.006	
MechEng 10km to 50km		-0.065	0.032	
ElecEng 10km	-0.027	-0.288		-0.176
ElecEng 10km to 50km	0.085*	-0.005		-0.004
Comp 10km		0.091		-0.093
Comp 10km to 50km		0.019		0.019
Phys 10km		0.078		
Phys 10km to 50km		0.04		
Other university and area controls?	Yes	Yes	Yes	Yes
Observations	2271	2271	2268	2274

Values shown are incident rate ratios minus one. + significant at 10% level, * at 5% level, ** at 1% level.
Source: Authors' calculations using BERD (Source: ONS), RAE and NOMIS data.

Results: relevant departments within 10km, 5 and 5* RAE-rated versus 1-4 RAE-rated

	(1) pharma	(2) chem	(3) mach
Bio 10km 5,5*	-0.414		
Bio 10km 1-4	-0.072		
Chem 10km 5,5*	3.008*	-0.062	
Chem 10km 1-4	0.719*	0.063	
Med 10km 5,5*	0.100		
Med 10km 1-4	-0.097+		
MatSci 10km 5,5*		0.010	-0.048
MatSci 10km 1-4		0.372*	0.016
MechEng 10km 5,5*			0.038
MechEng 10km 1-4			-0.074
Other university and area controls?	Yes	Yes	Yes
Observations	2269	2273	2280

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Med 10km 1-4				-0.048
MatSci 10km 5,5*		0.012	-0.121	
MatSci 10km 1-4		-0.036	0.129	
MechEng 10km 5,5*		0.259	0.014	
MechEng 10km 1-4		-0.273	-0.006	
ElecEng 10km 5,5*	-0.072	-0.362		-0.412*
ElecEng 10km 1-4	-0.160	-0.062		-0.085
Comp 10km 5,5*		-0.040		0.347+
Comp 10km 1-4		0.023		-0.116
Phys 10km 5,5*		0.477		
Phys 10km 1-4		-0.148		
Other university and area controls?	Yes	Yes	Yes	Yes
Observations	2271	2271	2268	2274

Values shown are incident rate ratios minus one. + significant at 10% level, * at 5% level, ** at 1% level.
Source: Authors' calculations using BERD (Source: ONS), RAE and NOMIS data.

Co-location: conclusions

- Evidence of co-location with relevant research departments in some industries
- Depts within 10km:
  - Pharmaceuticals R&D located near to chemistry departments, in particular 5,5*
  - Chemicals R&D located near to materials science departments, in particular 1-4
  - Precision instruments R&D located near to medical depts (5,5*), but not near to electrical engineering (5,5*)
- Depts between 10km and 50km:
  - R&D in chemicals, machinery, motor vehicles more likely to be located in areas with materials science depts located between 10km and 50km

Other issues addressed in Abramovsky et al. (2007)

- Dealing with unobserved heterogeneity across areas

  1. Additional controls
     - No. research students
     - Regional dummies
     - Proportion of science and technology professionals
     - Presence of science parks

  2. Estimate on entrants
     - Relate pattern of entry to change in RAE score 1996-2001
- Foreign versus UK-owned
- R&D services

Geographic proximity and firm-university interactions

- Does proximity to university research departments matter for the likelihood that firms interact with the university sector?
- Use data from the 3rd and 4th Community Innovations Surveys for GB

  "Did your enterprise co-operate with universities or other HEIs on any of your innovation activities (during the last 3 years)?"
  - *Local/regional*
  - *within 100miles (CIS4), within 50 miles (CIS3)*
- Together with data from the 2001 RAE
- Use postcode information to calculate distances between enterprises and HEIs

Evidence on firm-university interactions

- Estimate probit for enterprises in different sectors

  Dependent var =1 if co-operate with local university

  Control variables:
  - Enterprise characteristics
  - Area characteristics

  - Same RAE variables as in previous analysis
  - No. depts: within 10km; between 10km and 50km; rated 5 or 5* within 10km, rated 1-4 within 10km
- Estimate on innovative enterprises only
- Sampling and weights

Descriptive statistics: chemicals

202 enterprises	Co-operate (8%)	Don't co-operate (92%)
Log(emp)	4.37	3.90
% sci/eng degree	25.3	10.62
Financial support	0.62	0.13
R&D intensity	0.11	0.01
Count within 10km:		
Chemistry	0.38	0.41
Chemistry 5,5*	0.36	0.18
Chemistry 1-4	0.02	0.22
Materials science	0.67	0.34
Materials science 5,5*	0.51	0.12
Materials science 1-4	0.17	0.21
Count between 10km and 50km:		
Chemistry	2.87	2.86
Materials science	2.17	2.88

Source: Authors' calculations using CIS, RAE data.

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Co-operative R&D and proximity to university research

	(1) chem	(2) mach	(3) mot	(4) inst
Log(emp)	0.0065	0.0077	-0.0011	0.0227**
%sci eng	0.0006	0.0013**	0.0001	0.0006
Public Funding	0.1055**	0.0364	0.1560**	0.0966**
R&D intensity	0.0521*	0.1204	0.0130	-0.0378
share degree	-0.2008^{+}	-0.2687	-0.0728	0.1675
Log (pop)	-0.0126	-0.0008	0.0005	-0.0177
No. unis 10km	0.0003	0.0033	-0.0023	-0.0033
Chem 10km	-0.0179			
MatSci 10km	0.0200**	-0.0276	0.0014	
Med 10km				-0.0066
ElecEng 10km				0.0454^{+}
Comp 10km				0.0114
MechEng 10km		0.0126	0.0097*	
Observations	202	480	321	284
R^2	0.341	0.128	0.374	0.199

Values shown are marginal effects. $^{+}$ significant at 10% level, * at 5% level, ** at 1% level. Source: Authors' calculations using CIS, RAE and NOMIS data.

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Co-operative R&D and proximity to university research

	(1) chem	(2) mach	(3) mot	(4) inst
Chem 10km	-0.0117^{+}			
Chem 10km to 50km	0.0033			
MatSci 10km	0.0173**	-0.0283	0.0020	
MatSci 10km to 50km	-0.0058	0.0006	0.0003	
Med 10km				-0.0066
Med 10km to 50km				0.0006
ElecEng 10km				0.0495^{+}
ElecEng 10km to 50km				0.0157^{+}
Comp 10km				0.0102
Comp 10km to 50km				-0.0097
MechEng 10km		0.0108	0.0074^{+}	
MechEng 10km to 50km		0.0048	-0.0011	
Enterprise and area controls?	Yes	Yes	Yes	Yes
Observations	202	480	321	284
R^2	0.379	0.137	0.384	0.215

Values shown are marginal effects. $^{+}$ significant at 10% level, * at 5% level, ** at 1% level. Source: Authors' calculations using CIS, RAE and NOMIS data.

Co-operative R&D and proximity to university research

	(1) chem	(2) mach	(3) mot	(4) inst
Chem 10km 5,5*	-0.0058			
Chem 10km 1-4	-0.0166			
MatSci 10km 5,5*	0.0181*	-0.0548*	-0.0013	
MatSci 10km 1-4	-0.0043	-0.0130	0.0018	
Med 10km 5,5*				-0.0115
Med 10km 1-4				-0.0089
ElecEng 10km 5,5*				0.0690*
ElecEng 10km 1-4				0.0076
Comp 10km 5,5*				0.0266
Comp 10km 1-4				0.0244
MechEng 10km 5,5*		0.0201	0.0076	
MechEng 10km 1-4		0.0065	0.0121*	
Enterprise and area controls?	Yes	Yes	Yes	Yes
Observations	202	480	321	284
R2	0.475	0.136	0.377	0.215

Values shown are marginal effects. ˚ significant at 10% level, * at 5% level, ** at 1% level. Source: Authors' calculations using CIS, RAE and NOMIS data.

Firm-university interactions: conclusions

- Some evidence that likelihood of co-operation related to proximity to relevant departments
  - Relationship with departments within 10km stronger than with departments between 10km and 50km
- Some findings in line with those on location
  - E.g. enterprises in chemicals more likely to co-operate with local universities if near to materials science department (but in this case 5,5*)
- But not completely consistent with evidence on co-location
- Next steps:
  - Sourcing information from universities; non-local co-operative R&D
  - Measures of university technology transfer activity