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Externalities and the UK Regional Divide in Innovative Behaviour

Suma Athreye and David Keeble

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***Copies may be obtained from**:*
Economics Department
Faculty of Social Sciences
The Open University
Walton Hall Milton Keynes MK7 6AA
Telephone: 01908 654437
Email: Socsci-economics-support-list@open.ac.uk
Fax: 01908 654488

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Externalities and the UK Regional Divide

in Innovative Behaviour

Suma S Athreye*
David Keeble

January 2001

*corresponding author/presenting author

The Economics Discipline The Economics Discipline
The Faculty of Social Sciences
The Open University
Walton Hall
MK7 6AA

ESRC Centre for Business Research
Department of Geography
University of Cambridge
Cambridge CB2 3EN
Fax: (01223) 333392

Abstract

This empirical paper investigates the impact of different sources of increasing returns on firm innovative behaviour in two regions of the UK in the period of the 1990s when the new economy is believed to have emerged. We pay particular attention to the impact of the intermediation in the form of the emergence of a market for specialised business services as a possible externality that influences regional innovation. Other influences on regional innovation such as knowledge spillovers due to public R&D in UK counties and dynamic economics to scale due to learning weithin a firm are also considered.

JEL classification RO, R3, 03, H4, L8.

KEYWORDS: Increasing returns and innovation, specialised markets, public R&D, innovation by firms, regional innovation, regional development.

Introduction

Endogenous growth theories have highlighted the importance of different sources of increasing returns in explaining cumulative and self-sustaining patterns of economic growth through productivity-raising innovation. Three main sources of externalities to economies and to firms have been particularly highlighted: those due to greater intermediation and industrial deepening in the economy, due to the externalities created by knowledge spillovers from public and private R&D, and due to the existence of dynamic economies of scale resulting from learning within the firm. The link between these sources of increasing returns and the pattern of innovative activity is itself a matter of some interest. We explore this link in the present study using data for regional economies in the UK.

Of the different sources of externalities, the impact of the emergence of new specialised markets upon the innovative behaviour of firms is of particular interest to this paper. The existing secondary evidence on regional development in the UK strongly suggests that South East England has many features of an economy that is growing with an increasing division of labour such as in the emergence of the specialised business services market. These markets are less developed in other UK regions such as in the Industrial Heartland areas. The more abstract arguments linking intermediation and innovation can thus be tested using data on innovative behaviour in the two regions.

We hypothesise that the emergence of specialised markets produces a systemic tendency for *innovative activity through markets* in the South East economy. Imperfect (non-price) competition between firms may be an important determinant of innovation by firms in such a regional environment. In contrast, smaller regional markets and barriers to market extension may result in a limited growth of intermediate markets, and in the internalisation of the missing intermediate markets by firms. Larger firms may dominate productive activity when small market size and barriers to market extension exist. Market structure arguments would still predict that considerable incentives would exist for *innovation activity within the firm* in such an economic situation. This second pattern of innovative activity is hypothesised as characteristic of innovation in the group of smaller UK industrial regions collectively labelled here as the Industrial Heartland (the West Midlands, Northwest England, and Yorkshire and Humberside).[i] We also investigate the impact of other sources of externalities such as public R&D and firm specific dynamic economies of scale on innovative behaviour.

The remainder of the paper is organised in the following way: Section 1 draws upon the literature on the determinants of innovative activity by firms in order to conjecture some links between the sources of increasing returns and patterns of innovation. These conjectures are then empirically tested using a unique longitudinal data set on UK small and medium sized enterprises (SMEs), to which we added data at the county level on relevant variables from secondary sources. Our hypotheses, data and methodology are described in Section 2. Section 3 discusses the empirical results and Section 4 concludes with some implications of our results especially for the possibility of growing inequalities between the North and the South of the UK.

1 Sources of increasing returns and their impact on innovative activity

1.1 Specialisation and innovation

Rosenberg (1963) emphasised the value of specialised sub-sectors to patterns of innovative activity. In his study of the emergence and existence of the machine tool sector in the late nineteenth century in America, he noted the external economies conferred by the new sector on other industries both in production and in innovating activities. The externality in innovating activities came about because improvements in one area of mechanical engineering technology were transmitted across the industrial sector through product improvements to other capital goods and to several industrial goods that shared the common technological base. The commonality of the intermediate good to a wide range of industries meant that the trajectory or direction of technological change in the economy was also affected. Innovative activity came to possess systemic qualities and worked through a deepening of exchange and market relations within existing production filieres in the economy. Arora *et al* (1998) observes similar benefits in the chemicals sector with the growth of Specialised Engineering Firms.

Where intermediate goods sectors do not emerge, or intermediate markets are poorly developed, regional economies tend to become more dependent on imports from other regions and integration externally, into wider national and international systems. At the firm level, additionally, there is a marked tendency for vertically integrated production and internalisation of the markets that are missing. Division of labour develops more within firms than across firms, with the consequent increasing returns to scale that such firms may enjoy as a consequence. More recently, transactions costs economics has shown that internalisation and vertical integration are advantaged when intermediate markets are 'thin' or populated by small numbers of firms. The locus of innovation in vertically integrated markets tends to be contained within firms and due to imitative entry may at best spill over to particular industrial sectors.

Specialisation and vertical disintegration are not frequently observed economic processes,[ii] and may also vary between different regions. Since the 1980s the mushrooming growth of the business services industry is seen by many to be an important source of productivity improvement in OECD countries and a consequence of increasing specialisation (Antonelli 1998). The availability of UK SIC employment data for management and business consultancy services, which are sold primarily to other firms, provides a rough (under) estimate of intermediation in the regional economy.

UK shows great regional variation in the distribution of such professional and business services, and hence the local availability of intermediate services to other firms in the economy. In 1998, advanced 'producer services' employment as a whole (all financial, professional and business services) accounted for 23.7% of total employment in South East England, compared to only 14.8% in the Industrial Heartland.[iii] Wood *et al* (1993, 691-2) argue that the South East also offers a much greater variety of specialised intermediate business services than the Industrial Heartland.[iv] Athreye and Keeble (2001) also show that this difference in the availability of intermediate business services between the two regions is associated with different behaviour towards technology transfer and acquisition. Markedly higher proportions of firms report the buying and selling of technological innovations in the South East, while vertical collaborations are more frequently reported by firms in the Industrial Heartland.

1.2 Market structure and innovation

A fairly distinct and separate tradition argues that pre-innovation market structure, at a point of time, impacts on the propensity and ability to innovate by firms. This latter tradition has argued that the departure of markets from pure exchange and price competition towards non-price competition and monopolistic rivalry contains important incentives and rewards for firms undertaking innovative activity. The important incentives for the firm in such market structures are related to the need to differentiate themselves from their rivals, and the rewards lie in the expectation of higher than normal profits. In addition, when innovation needs a commitment of resources, firms in imperfect markets may also have greater abilities to invest in innovation generating activities such as R&D.

'What is the linkage between market structures, at a point of time, and the occurrence or non-occurrence of specialisation?' We conjecture that while oligopolistic market structures may or may not occur with specialised markets, they almost certainly will occur with the lack of specialisation. When specialisation does occur the existence of barriers to entry, the strength of imitative competition and the scale of homogenous demand will determine if the resulting market structure will be imperfect (with easy entry and exit) or oligopolistic.[v] Thin markets in intermediate goods and services in an economy or sector always favours the internalisation of such activities. The existence of larger integrated firms may also prevent smaller specialised suppliers from emerging. Market structures may thus be less competitive, and oligopolistic in such economies.

Again the differences in the regional economies of the South East and the Industrial Heartland are striking in this respect. More rapidly growing markets and a relatively more competitive market structure characterise the South East economy. DTI (1998) figures show that between 1994 and 1997, the South East recorded a net growth of +19,715 new firms, compared with a decline of -14,035 in the stock of firms in the Industrial Heartland regions. Even in the late 1980s, Keeble and Bryson (1996) reported that the South East's annual firm creation rate averaged 9.2 new enterprises per 1000 of the labour force, compared with only 6.4 in the North West and Yorkshire/Humberside, and 6.6 in the West Midlands. Other indications of the importance of markets and competition in the South East come from the more intense competition faced by South East SMEs and a more outward-looking orientation of its firms.[vi]

1.3 Firm learning, Dynamic economies of scale and Innovation

Firm innovativeness may also reflect dynamic economies of scale due to knowledge accumulation and learning within the firm. To the extent that learning within a firm depends upon past experience in production and innovation, firms that were successful in innovation before may also be successful in innovation again. The locus of innovation is likely to be persistently in particular firms and sectors as outlined by such authors as Nelson and Winter (1982) and Dosi (1988). There is also wide empirical support from case studies and statistical studies for the importance of cumulative learning for innovation by the firm.

In turn, these arguments also imply that all else being equal, older and larger firms, with greater firm specific resources in the form of human capital, organisational abilities and accumulated knowledge and expertise, are more likely to be successful innovators than small firms are.

1.4 Public R&D, universities and innovation by firms

Specialisation and market formation processes break down in the presence of public goods. Both basic research and education are two such public goods and economic theory suggests that the market mechanism will under-invest resources in the provision of these goods, and hence the need for public funding of basic research and education, and the establishment of quasi-public

institutions to undertake R&D. Once such basic R&D is undertaken, and there is greater investment in educational skills, the benefits of this expenditure – in the form of research results and a well-trained work force – are potentially available to all firms in the region/economy.
In contrast to basic research and education, applied R&D and firm specific training of the work force are more efficiently carried out by firms themselves so that they can be tailored to the needs of product development, and the growth of the firm. Private R&D may depend upon the profitability and other calculations of a firm, and is associated with large firms.

Public R&D is largely a policy variable and though recent policies in the UK appear to see the two types of R&D as substitutes, a case can be made for strong complementarities between the two types of R&D. Public R&D is an economic externality that should increase the opportunities for private (applied) R&D. Similar arguments apply to the provision of education and training in universities and higher education institutes.

The extent of public expenditure on R&D differs markedly between the South East and the Industrial Heartland, though there is little difference between the two regions in terms of the volume of output of university graduates and postgraduates.[vii] Expenditure on R&D performed within the South East's universities and other higher education institutions at £1,268 million was over twice that in the Industrial Heartland regions. Differences in R&D expenditure in government research laboratories and the National Health Service were even greater, with £1,216 million (0.46% of regional GDP) in the South East, but only £307 million (0.15% of regional GDP) in the Industrial Heartland.[viii] These differences may have had important consequences for the level of support provided by the regional economic environment to firms with innovative potential in these two different regions of the UK.

2 Hypotheses, Data, Variables, and Empirical methodology

2.1 Hypotheses

Several factors might affect the innovative potential of firms in particular regions. First, we have argued that there is a set of factors that reflect the extent of intermediation (or specialisation) due to division of labour in a region, which works through market activity to induce innovation by firms. Second, pre-innovation market structures and the extent of competition any one firm faces, and firms' cumulative learning, are likely to have a positive impact on innovative behaviour. Third, firms in different industries may have different propensities to innovate because the technological opportunities available to industries can be quite different. Lastly, we argue that patterns of public spending on R&D and education across regional economies might also affect the innovative abilities of private firms.

In line with our central hypothesis, we expect different sets of factors to explain innovation among Industrial Heartland and South Eastern firms. In particular we expect to see market and competition related factors identified as important determinants of innovation in the South East while firm and industry specific factors are likely to be important explanatory variables for the Industrial Heartland.

We assume that South East England and the Industrial Heartland can be regarded as two distinct regional markets. This seems justified by previous empirical work on regional development noted in Section 1. Additionally we assume that SMEs within each region are principally engaged in supplying their own regional market. The considerable distances between the two regions support this assumption. In addition, Curran and Blackburn (1994:77) found that small firms in different British localities on average sold almost two thirds of their output locally, within a radius of 10 miles. Thus, treating regions as regional markets is reasonable for our data-set which comprises small and medium sized manufacturing and business/professional services firms.

2.2 Data and variables

To assess our hypotheses empirically we use firm level longitudinal survey data collected by the ESRC Centre for Business Research at the University of Cambridge. Details about the data and how they were collected are contained in Cosh and Hughes (1996). Here it is pertinent to note that the data relate to innovations reported by the same group of SMEs in two time periods, 1986–91 and 1992–95. In our empirical analysis we will use a simple model, which primarily uses the cross-sectional nature of the data. We use explanatory variables drawn from data in the earlier period (1987–90), while the dependent variable is drawn from the data on the most recent period (1992–95), to overcome potential problems of endogeneity. The valid sample (excluding missing values for any variable) used in our empirical analysis comprises 454 firms in all, with 294 firms in the South East and 160 firms in the Industrial Heartland. More details about our sample of firms are provided in Appendix A.

Our empirical analysis focuses on the determinants of product rather than process innovation, because the regional development impact of these different types of innovation probably also differs significantly. Vivarelli *et al* (1996) use Italian innovation survey data to argue that product innovation develops new markets and increases employment and growth, whereas process innovations tend to displace labour and have a smaller impact on overall economic growth and a negative impact on employment. Table 1a describes the product innovation measure that we use as the dependent variable in our analysis.

Table 1a: Variables used in the empirical analysis

Factor	Variable Name	Description	Data source	Expected sign of coefficeint
Dependent variables	PROD3	Firm introduces a product innovation in 1992-95	CBR innovation survey	
Explanatory variables	COMPS11	Number of serious competitors faced by the firm in 1990		–
Market structure (pre-innovation)	FORCOMP	% serious competitors faced by a firm that were foreign firms		+
Complementary strategies	SIZE1	Logarithm of turnover of the firm in 1990		+
	FINANCE1	Dummy variable taking value 1 if a firm sought external finance in 1990.		+
	PROF11	% of employees that are professionals in 1995		+
Extent of Intermediation	FINDEM	% of firms sales to final consumers and government in 1990		+
	LOCQUO	Location quotient measuring the intensity of producer services in every county. Computed as: County's share of employment in SIC 8395/ County's share of total employment in all industries. SIC 8395 is other business (management and business consultancy) services	Keeble et. al.(1997)	+
Knowledge generating institutions	PUBRD93	% of county level GDP that is spent on R&D in higher education institutes and government in each county.	Office of National Statistics	+
Industry factors	DGRP1-11.	11 industry dummies based on firms' SIC field.		

It also details measures of the explanatory factors and variables, as well as indicating the direction in which we expect the explanatory variables to impact on innovation. Thus, we measure the effect of intermediation in two ways. We use a location quotient (locquo) variable that varies across the 26 counties included in our sample as a measure of the extent of intermediation. Locquo measures the share of total employment in a county due to employment in 'other business services', which includes management and business consultancy.[ix] This measure underestimates the full extent of intermediation inasmuch as it includes only producer services and not producer goods.[x]

To measure the importance of intermediate firms providing business services within the two regional samples themselves, and whether such firms are more likely to be innovative, we included a variable called findem, which measures the proportion of total sales by a firm to the government, retailers and final consumers. If there is relatively high proportion of intermediate goods producers in a region we may expect a lower average value for this variable. Further, if this variable is negatively related to innovative behaviour then it indicates that intermediate producers are more likely to be innovators. However, a positive coefficient on this variable is

consistent with the importance of final demand (by consumers and government) in influencing innovative activity. Thus the variable also controls for the effect of the growth of final demand that we expect is important in explaining intermediation.

To examine the impact of policy induced expenditures in public R&D upon innovative activity we constructed Pubrd93, which varies over the 26 counties. Pubrd93 measures the percentage of a county's GDP that is spent on R&D in government research laboratories, universities and higher education institutes in 1993. We expect higher values of this variable to be associated with more innovative activity in the later period.

Several variables have been included that vary across firms to measure their impact on a firm's innovative behaviour. Some of these are factors emanating from the regional environment and others are firm specific factors. We measure pre-innovation market structure by the number of serious competitors faced by a firm in 1990 (comps11). Small values of this variable reflect imperfectly competitive environments, which may induce firms to be innovative. A further variable, forcomp, measures the intensity of foreign competition facing a firm. Foreign competition is likely to be based on firm specific advantages which overtime may stimulate innovative behaviour among domestic firms. The ability of a firm to undertake innovation is captured through three variables: Size1 measuring the logarithm of a firm's turnover in 1990, Finance1 indicating that a firm sought external finance in 1990 and Prof11 measuring is the percentage of total employees in a firm that were professionals in 1990.

The CBR sample contains a substantial number of firms located in the two study regions of the Industrial Heartland and South East England. In grouping the firms into the two regions we avoided including the contiguous counties of Warwickshire, and Hereford and Worcester. Firms in these counties have links with both regional groupings and we would like to isolate the effect on the firm's innovative potential of belonging to one regional group rather than the other. Industries are grouped into 10 groups, and industry specific effects in explaining innovative behaviour are controlled for by the use of dummy variables for each industry group. The counties and industry groups included are detailed in Tables 1b & 1c.

Table 1b Industry groups based on SIC categories

variable name	Description	sic classification (1980) codes
Dgrp1	**Chemicals**	25, 48
Dgrp2	Metal Goods	31, 32, 35
Dgrp3	Electrical	33, 34, 37
Dgrp4	Food, Drink	41, 42
Dgrp5	Textiles	43, 44, 45
Dgrp6	Timber	46
Dgrp7	Paper	47
Dgrp8	Metals production	22, 24, 49
Dgrp9	Advertising services	8380, 8395
Dgrp10	Technical services	835, 836, 837, 8394, 94

Table 1c Counties included in the two regional groupings

South East	Industrial Heartland
Greater London	Humberside
Bedfordshire	North Yorkshire
Berkshire	South Yorkshire
Buckinghamshire	West Yorkshire
East Sussex	Cheshire
Essex	Greater Manchester
Hampshire	Lancashire
Hertfordshire	Merseyside
Isle of Wight	Shropshire
Kent	Staffordshire
Oxfordshire	West Midlands
Surrey	
West Sussex	

2.3 Empirical Methodology

We model the determinants of innovative behaviour by firms, statistically, as a Probit model. Thus, we assume that there is an unobservable latent variable, the innovative potential of firms (y*), which is triggered by a vector of factors (X). This vector of factors would include the sorts of influences on innovation that we have considered above, and consists of firm specific factors, industry specific factors proxied by the use of industry dummies, and regional factors.
When the innovative behaviour of a firm is triggered, we observe a firm reporting a product or a process innovation. This observed product or process innovation is then the dependent variable (y) that proxies for the unobservable y*.
Thus, we assume:

$$y^* = \beta' X + \varepsilon \qquad (1)$$

where, ε is a random error term ~N (0,1). Further, X is any (k x 1) vector of explanatory variables, and ß is the associated vector of coefficients. At some critical value of the index of factors a firm is observed to introduce an innovation. Though the latent innovativeness of the firm is itself unobservable, we can and do observe the occurrence (y=1) or non-occurrence (y=0) of innovation (product or process).

We may write (1) as:

$$\text{Prob}\ (y=1) = \beta' X + \varepsilon \text{ , when } y^* > 0 \qquad (2)$$

And y=0 otherwise.

Equation (2) underlies the Probit model and is estimated using maximum likelihood methods. The results of estimating equation (2) are contained in Table 4. This table reports the statistical findings on the determinants of product innovation for the two study regions separately.
We have included two specifications of the vector X. The first specification includes firm effects and effects that are due to the regional environment. The second specification includes in addition industry-specific effects. Variable names can be read from Table 1a:

$$X = \{\text{comps11, forcomp, size1, finance1, prof1, findem, locquo, pubrd93}\} \qquad (3)$$

$$X = \{\text{comps11, forcomp, size1, finance1, prof1, findem, locquo, pubrd93; Dgrp1-10}\} \qquad (4)$$

The arguments in Section 1 suggest that a vector X of the kind in Equation (4) should characterise the determinants of innovative behaviour of Industrial Heartland firms. However, a vector X of the kind in Equation (3) is sufficient to capture the main influences upon the innovative behaviour of firms in the South East. Since (3) is a nested hypothesis in (4), we employ the Lagrange Ratio (LR) test to decide on the right specification - (3) or (4) above.

For each of the two groups of firms the results for the two specifications are reported in Table 4. The results of the LR tests are reported in Table 3.

3 Empirical results

Our empirical results provide strong support for several of the conjectures made in the earlier sections. Table 2 confirms most of the observations about differences in the regional environment noted in Section 1. Pubrd93 and locquo have higher average values in the South East region. Levels of competition measured by Forcomp and comps11 are noticeably higher for the South East region. Size1 has a higher average value for the Industrial Heartland.

Table 2 Descriptive statistics for variables used

	South east (1)			**Industrial Heartland (2)**			**All firms (1) +(2)**		
Variable	Mean	Std.dev	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N
PROD3	0.53	0.50	424	0.53	0.50	210	0.53	0.50	634
PROC3	0.43	0.50	424	0.48	0.50	210	0.45	0.50	634
COMPS11	14.82	24.66	377	8.94	14.92	194	12.82	22.01	571
FORCOMP	16.97	31.00	368	11.06	25.70	194	14.93	29.39	562
FINDEM	36.17	36.94	416	37.54	38.29	203	36.62	37.36	619
SIZE1	6.94	1.46	390	7.10	1.51	201	6.99	1.48	591
PROF1	29.30	31.85	393	19.86	26.20	190	26.22	30.43	583
FINANCE1	0.61	0.49	416	0.61	0.49	206	0.61	0.49	622
LOCQUO	1.63	0.76	430	0.57	0.21	212	1.27	0.80	642
FIDENS94	63.89	66.13	427	17.25	11.72	212	48.42	58.72	639
HEIRD93	0.45	0.43	430	0.27	0.21	212	0.385	0.38	642
PUBRD93	1.02	0.72	430	0.38	0.25	212	0.80	0.68	642
DGRP1	0.04	0.21	430	0.08	0.26	212	0.05	0.23	642
DGRP2	0.13	0.33	430	0.23	0.42	212	0.16	0.37	642
DGRP3	0.06	0.24	430	0.06	0.24	212	0.06	0.24	642
DGRP4	0.01	0.11	430	0.04	0.19	212	0.02	0.14	642
DGRP5	0.03	0.16	430	0.10	0.30	212	0.05	0.22	642
DGRP6	0.04	0.195	430	0.06	0.24	212	0.05	0.21	642
DGRP7	0.09	0.29	430	0.05	0.22	212	0.08	0.27	642
DGRP8	0.03	0.17	430	0.04	0.19	212	0.03	0.18	642
DGRP9	0.33	0.47	430	0.20	0.40	212	0.29	0.45	642
DGRP10	0.22	0.41	430	0.13	0.33	212	0.19	0.39	642

Note: The means and standard deviations reported above exclude missing values for each variable separately

The right specification of variables that should constitute the vector X depends on the regional grouping. Thus we see in Table 3 that a specification including industry dummies is accepted for

the Industrial Heartland firms, while a specification including only firm specific and regional environmental factors is sufficient to characterise innovative behaviour for South East firms. This confirms our conjecture that lower levels of intermediation would tend to make the locus of innovation reside more strongly in firms and particular industrial sectors in the Industrial Heartland.[xi] In contrast, the presence of a large intermediate sector confers general externalities to other firms, in turn stimulating innovation by them.

Table 3 LR tests of specification for the inclusion of industry specific effects

Region/	Results of testing specification (3) v/s (4)	LUR	LR	LR statistic (k=9)	P (χ2)
South East	Product innovation: (3) is accepted	-182.537	-187.442	9.81	0.366
Industrial Heartland	Product innovation: (4) is accepted	-88.588	-97.722	18.266	0.032

Notes:

(1) The null hypothesis is that there are no industry effects and thus the restricted model is that specified as Equation (3) in the text.

(2) The LR statistic follows a chi-squared distribution with k degrees of freedom, where k is the number of restrictions. It is computed as : -2 (LR- LUR).

(3) Since there are 9 industry dummies k=9 for all tests.

(4) The LR test of specification for process innovations also found that specification (3) best explained innovation in the South East while specification (4) best explained innovation in the Industrial Heartland.

We grouped firms by region, and considered Equation (3) as the more appropriate specification for the South East and Equation (4) as the more appropriate one for the Industrial Heartland. All estimations are reported in Table 4.

Table 4 Determinants of innovative behaviour by firms

	South East		**Industrial**	**Heartland**
Eqn	(3)	(4)	(3)	(4)
Constant	-1.979***	-1.642	-1.438**	-0.482
	(0.467)	(0.532)	(0.679)	(0.896)
COMPS11	-0.006*	-0.006*	-0.002	-0.001
	(0.003)	(0.003)	(0.007)	(0.007)
FORCOMP	0.007***	0.007**	0.018***	0.016**
	(0.002)	(0.003)	(0.007)	(0.007
SIZE1	0.184***	0.186***	0.125	0.155*
	(0.054)	(0.057)	(0.078)	(0.088)
FINDEM	0.002	0.003	0.002	0.003
	(0.002)	(0.002)	(0.003)	(0.003)
PROF1	0.001	0.002	0.004	0.007
	(0.002)	(0.003)	(0.004)	(0.005)
LOCQUO	0.175*	0.285**	0.048	0.028
	(0.104)	(0.114)	(0.544)	(0.603)
FINANCE1	0.237	0.242	0.085	0.249
	(0.160)	(0.165)	(0.219)	(0.238)
PUBRD93	0.205*	0.255**	0.866*	1.201**
	(0.112)	(0.116)	(0.464)	(0.501)
DGRP1		-0.328		-0.854
		(0.440)		(0.748)

DGRP2		-0.401		-1.369**
		(0.355)		(0.630)
DGRP3				
DGRP4		-0.293		-2.100***
		(0.807)		(0.805)
DGRP5		-1.027		-1.996***
		(0.778)		(0.692)
DGRP6		-0.675		-1.217*
		(0.494)		(0.715)
DGRP7		-0.539		-1.211
		(0.409)		(0.809)
DGRP8		-1.091**		-1.798**
		(0.496)		(0.821)
DGRP9		-0.819**		-1.731***
		(0.340)		(0.619)
DGRP10		-0.627*		-1.917***
		(0.361)		(0.676)
N	294	294	160	160
Log likelihood	-187.442	-182.537	-97.722	-88.588
d.f.	8	17	8	17
P (χ2)	0.000	0.001	0.002	0.001
% correct predictions	63.27	65.99	66.88	67.5

Notes:

(1) Levels of significance: ***1%, **5%, *10%
(2) Figures in parentheses are standard errors.
(3) Group 3 is the omitted dummy for both regions
(4) LIMDEP v7 was used for all computations. Pairwise deletion of missing observations makes the number of cases in Table 4 smaller than that in Table 2.

In both regions increasing firm size increased the probability of product innovation by a firm. Since other variables in the statistical model control for the intensity of competition we interpret size as a proxy both for the resources that a firm has to undertake the range of strategies that may be required for innovation, and as a measure of cumulative learning.[xii] In addition to the size of the firm, the probability of product innovation is increased by greater foreign competition and by a greater proportion of county GDP spent on public R&D.[xiii] The employment of professionals was an important explanatory variable whose statistical significance however vanished when public spending on R&D was included as an explanatory factor.

Comparison of the two regions however also reveals interesting differences in the determinants of innovative behaviour by firms. In the Industrial Heartland, we find, in addition to the factors already discussed, that the probability of observing product innovation was markedly concentrated in a particular industrial group. Thus, in Table 4, relative to this (omitted) sector, electronics and instrumentation, the following industries were significantly less innovative: metal goods and mechanical engineering, textiles, metals, minerals and other manufacturing, food, drink and tobacco, advertising services, and technical services. None of the other factors are identified as significant influences on innovation by Industrial Heartland firms.

In contrast, in the South East firm innovativeness is also significantly associated with two different explanatory variables, namely, the nature of competition, and the extent of intermediation. Smaller numbers of serious competitors (in 1990) increased the probability of product innovation in 1995. We suggest that this finding linking smaller numbers of competitors and innovative behaviour shows the importance of non-price rivalry in determining innovative

behaviour as explained in Section 1.2. Niche markets may be one context in which such non-price rivalry takes place.[xiv]
The second specific influence that significantly increases the probability of product innovation by SMEs in the South East is the relative local provision of (intermediate) business services (LOCQUO). We interpret this finding as support for our conjecture that greater development of specialised markets stimulates innovation by firms. The importance of LOCQUO for explaining firm's innovative behaviour in the South East alone also suggests that there may be regional threshold effects after which the extent of intermediation begins to matter for explaining innovation.

Some business service firms are also included in our SME sample. But the absence of any significant association between the FINDEM variable, included to pick up intermediate firms in our sample that sell a high proportion of their output to other firms, and product innovation by firms, shows that such firms are not themselves especially innovative. Rather it is the geographical concentration of intermediate business services, as measured by LOCQUO, which appears to provide significant regional externalities encouraging product innovation by South East SMEs.

5 Implications

Our research suggests that all the three sources of externalities and increasing returns discussed in the endogenous growth literature, which have a key role to play in the new economy, do have a strong impact on firms' propensity to innovate. Firm specific dynamic economies of scale strongly encourage product innovation. County level public sector R&D (universities, higher education institutions and government laboratories) increases innovation by local firms. In the larger and more economically successful South East, intermediation and non-price nature of competition also stimulate innovative behaviour, while industry specific factors were important to explaining innovation in the Industrial Heartland.

The fact that more sources of externalities enter the explanatory set for product innovations in the South East suggests that innovative behaviour may be more easily triggered for firms in this region when compared to the Industrial Heartland. To put into perspective the impact of these externalities on the probability of innovating, we report the marginal effects for Equation (3) of Table 4, for South East firms, in Table 5. A unit increase in firm sales (a proxy for firm specific dynamic economies of scale) increases the probability of observing product innovation by more than 7%. But a unit (1% of GDP) increase in county level spending on public sector R&D has a marginally greater impact: it increases the probability of observing a product innovation by a firm in the region by more than 8%. Similarly a unit increase in Locquo raises this probability by 6.9%. Unlike the first source, the latter two sources constitute externalities whose benefits are potentially available to all firms in the region. Their importance suggests that innovative behaviour may be more easily triggered for firms in the South East economy. Particular industries are less important to an explanation of innovative behaviour in this region. The smaller regional economies of the Industrial Heartland are handicapped in that they do not enjoy the benefits of one important source of externality, namely the growth of intermediate markets.

Table 5 The impact of externalities on the probability of innovation in The Open University South East region

Variable	Marginal effect	Mean of X
	-0.787	
Constant		
COMPS11	-0.002	13.93
FORCOMP	0.003	15.84
SIZE1	0.073	6.95
FINDEM	0.001	35.89
PROF1	0.000	29.95
LOCQUO	0.069	1.60
FINANCE1	0.094	0.64
PUBRD93	0.081	1.03

Notes:

1 The coefficients of the probit model do not give us any knowledge of the marginal effects. In order to compute the marginal effect of equation (2) we need to evaluate:

$\delta E[y/X]/ \delta X=\phi(\beta'X)\ \beta$

where $\phi( )$ is the standard normal density.

2 The marginal effect (equation 3) is evaluated at the point of means reported above.

Innovative behaviour in both regions appears to be positively influenced by local levels of public sector R&D. This finding seriously questions the validity of recent government policy that has restricted and reduced the funding of university and other public research in the belief that it is not efficient and is unimportant to innovative activity. While direct technology transfer from government research laboratories and higher education institutions may not have a measurable impact in increasing firm level innovation, a region in which more is spent on public R&D provides a significantly better environment for innovation by local firms. Advances in research in public institutions are usually in the public domain and can be exploited by firms. Further, R&D in higher education institutions often creates a pool of potential entrepreneurs and highly qualified workers that are important for the creation and growth of innovative firms.

Appendix A:

The data-set used in our empirical analysis is a subset of a larger longitudinal survey of UK SMEs undertaken in three successive rounds by the ESRC Centre for Business Research, at the University of Cambridge. The data were collected, in the main by the use of a postal questionnaire and resulted in observations on 998 UK SMEs. Details about how the surveys were performed as well as an analysis of rates of attrition and non-response in the sample is contained in Bullock, Duncan and Wood (1996). Here we will highlight some characteristics of the subset of firms that we analyse, i.e. the firms in two regional groupings of the South East and the Industrial Heartland.

Our sample contained 642 firms in all, after excluding firms belonging to the industrial group 'other services' (SIC 61, 64, 67, 77, 84, 85, 92, 95, 96) and those located in the counties of Warwickshire and Worcester and Hereford. These were distributed as shown in Table A1 below.

Table A1 Distribution of sample of firms by region (% of all firms in a region)

	South East	Industrial Heartland
Number % of total sample	430	212
In manufacturing	44.3	66.3
In services	55.7	33.7
Size distribution		
0-9 employees	28.4	18.5
10-49 employees	39.6	39.5
50-99 employees	13.5	16.9
100-249 employees	17.1	23.4
250-499 employees	1.5	1.6

In estimating the Probit equations, using LIMDEP software an observation was excluded from analysis if even one variable, of the 10 variables described in Table 1a, had a missing value. Due to this the total number of observations dropped from 642 firms in all to 454 firms in all: 294 in the South East and 190 in the Industrial Heartland.

The dependent variable (PROD3) was constructed using a firm's response to the following question included in the postal questionnaire. To quote from the questionnaire:

> 'In this section we would like you to tell us about your innovative activity. We are interested in innovations in products and processes which are new to your firm.
>
> In answering your questions…, please count innovation as occurring when a new or changed product is introduced to the market (product innovation) or when a new or significantly improved production method is used commercially (process innovation), and when changes in knowledge or skills, routines, competence, equipment or engineering practices are required to make the new product or introduce the new process.
>
> Please do not count as product innovation, changes which are purely aesthetic (such as changes in colour or decoration), or which simply involve product differentiation (that is minor design or presentation changes which differentiate the product while leaving it technically unchanged in construction or performance)

Has your firm introduced any innovations in products (goods or services) or processes during the last three years which were new to your firm? (Please tick only one box in each row)

	Yes	No
Products		
Processes		

If you ticked NO for both products and processes please skip….'

(CBR (1995): Business Innovation Survey questionnaire)

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Notes:

i Scotland, North East England and Wales represent smaller manufacturing based regions and are not included in the analysis.

ii This is probably because specialised markets can only emerge when both the separability of a production process into smaller elementary components is possible (Scazzieri 1993) and the volume of demand becomes large enough to justify the specialised investment. The conjunction of the two factors happens uncommonly.

iii Labour Market Trends, August 1998.

iv It could be argued that the mushrooming of business services in London and South East England is related to the existence of London as a major financial centre. Data presented in Keeble, Bryson and Wood (1992: Table 3) shows however that financial sector clients account for only a small share (13% on average) of turnover by business service SMEs, manufacturing and other service sectors being much more important.

v Atomistic or perfectly competitive market structures are usually not compatible with increasing returns.

vi See Keeble (1996, 1998) and O'Farrell *et al* (1992, 1993).

vii In 1995/96, 29.0% of UK higher education students were studying at institutions in the Industrial Heartland regions, and 33.2% at institutions in South East England/East Anglia (Office for National Statistics, 1997, table 4.10).

viii Office for National Statistics, 1997, table 13.11.

ix 'Other business services' (activity 8395 of the1980 UK SIC) covers management and business consultants, personnel and public relations consultants, design consultants, market research and a range of other specialised business services: see Bryson, Keeble and Wood (1997).

x We also tried to separate the influence of clustering from the influence of the degree of specialisation by including a crude measure of firm density in a region, as measured by the ratio of the stock of firms in 1994 to the total area (in square kilometres) of a county. There was a very high level of correlation (r~0.8) between LOCQUO and this variable.

xi We did not perform additional tests to ascertain the pooling of data of the two regions. The expectation of different specifications for the different groups of firms makes the use of LR tests for slope homogeneity invalid.

xii We tried to introduce the age of the firm as a variable that could control for learning and experience alone. However, age was very highly correlated with size and this multicollinearity affected the estimated results.

xiii A larger size of firm significantly increased the probability of process innovations in both regions. However, public spending on R&D did not have any significant impact on the probability of process innovations. This is because process innovations tend to be quite specific to the technology in use by a firm.

xiv Bresnehan and Reiss (1991) showed that 5 competitors are sufficient for firms to behave as if they were price competitive firms.

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