SOURCES OF INCREASING RETURNS AND REGIONAL INNOVATION IN THE UK

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Suma S. Athreye
MANCHESTER SCHOOL OF MANAGEMENT

RESEARCH

UMIST

PO Box 88
MANCHESTER

M60 1QD

CB2 3EN

Phone: 0161 2003481
Fax: 0161 2003505
E-MAIL: SUMA.ATHREYE@UMIST.AC.UK

David Keeble
ESRC CENTRE FOR BUSINESS

AND DEPARTMENT OF GEOGRAPHY

University of Cambridge
DOWNING PLACE

CAMBRIDGE

Phone: 01223 33386
Fax: 01223 33392
E-MAIL: DEK1@CUS.CAM.AC.UK

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Abstract

This empirical paper investigates the impact of different sources of increasing returns on firm innovative behaviour in different regions of the UK. Of the different sources of increasing returns, the impact of intermediation and the emergence of specialised markets on the probability of innovation is of particular interest to this analysis. The existing literature on regional development in the UK strongly suggests that the South East has many features that may characterise an economy growing with a greater division of labour. These are less evident in the Industrial Heartland region of northern England. Other influences on innovation such as the impact of regional public R&D and dynamic economies to scale due to learning within a firm are also considered.

Key words: Regional economics, production analysis and firm location, technological change, publicly provided goods, business services

JEL classification: R0, R3, O3, H4, L8

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SOURCES OF INCREASING RETURNS AND REGIONAL INNOVATION IN THE UK

In recent years 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 increasing returns to economies and to firms have been particularly highlighted. The first of these is increasing returns to scale due to greater intermediation and industrial deepening in the economy. The second is increasing returns due to the externalities created by public R&D. A third source is increasing returns 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 increasing returns, the role of intermediation, the emergence of specialised markets, and consequently of "industrial deepening" are of particular interest in this paper. The existing secondary evidence on regional development in the UK strongly suggests that South East England has many features that may characterise an economy growing with a greater division of labour and specialised markets. Thus the more abstract arguments linking intermediation and innovation can also be related to issues of regional development and regional innovation in the UK.

We hypothesise that the development or non-development of intermediate markets due to an increasing division of labour in a regional economy has an important impact on innovative behaviour of firms in the region. Specialisation and increased intermediation, we argue, 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, or 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).[1] The other sources of increasing returns such as public R&D and firm specific dynamic economies of scale, we expect, will always stimulate innovative behaviour.

In our empirical analysis we find support for the above conjectures. Intermediation and non-price competition do affect innovative behaviour by firms in the South East, while neither of these variables is statistically significant in explaining the innovative behaviour of firms in the Industrial Heartland. Public R&D has a positive and statistically significant impact on firms' innovative behaviour in both regions: areas (counties) that spend more on university and government R&D as a proportion of GDP are also those where firms more frequently report product innovation. Firm-specific dynamic economies of scale are strongly associated with product innovation in both regions.

Our paper is organised in the following way. In Section 1, we draw 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). We added to this data set by incorporating data at the more geographically-detailed county level on relevant variables from secondary sources. The 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 issue 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

Adam Smith linked the enlargement of demand to increasing division of labour and specialisation in 1776. Among later economists both Young (1929) and Stigler (1951) recognised the importance of the scale of the market as the one factor which ultimately determined the emergence of new industries through specialised markets and vertical disintegration.

Rosenberg (1963) emphasised the value of specialised sub-sectors to patterns and rate 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. These external economies had a two-fold nature. First, the emergence of a machine tool market meant that producers had the opportunity to search for the kind of machinery they wanted without having to incur all the costs of learning how to make the machinery themselves. This greatly facilitated the entry of new firms in the system and reduced the cost of machinery. Second, improvements in one area of mechanical engineering technology were transmitted across the industrial sector through product improvements to several manufactured capital goods that shared a common technological base, thus raising the rate of technological innovation. Further, 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) observe similar benefits in the chemicals sector with the growth of Specialised Engineering Firms. Athreye (1998) notes the same kinds of externalities created for other firms in innovating activities through the growth of the software sector.

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. Among earlier economists, Babbage and later Marx developed the systematic implications of increasing division of labour within the firm and the increasing returns to scale that firms enjoyed as a consequence. More recently, transaction cost economics has shown that internalisation and vertical integration are advantaged when intermediate markets are "thin" or populated by small numbers. The locus of innovation in vertically integrated markets tends to be contained within firms, and as a consequence of imitative entry, within particular industrial sectors.

Specialisation and vertical disintegration are not frequently observed economic processes,[2] and the extent of specialisation will be uneven both industrially and geographically. We may thus expect the incidence of specialisation to vary between different regions.

The extent of intermediation or specialisation is very hard to measure empirically. Industrial classification systems tend to lump together products that are functional substitutes and do not discriminate between the stages of production. Without detailed and dis-aggregated input-output tables it is indeed hard to assess the extent of intermediation. However, 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. We use this measure to assess the extent of intermediation in the paper.

The UK economy 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.[3] 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.[4] This feature of the UK regional economy is useful as it allows us empirically to test for the influence of intermediation upon the behaviour of other firms.

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, also sometimes called the "Schumpeterian 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.

A pertinent question to ask at this stage is: "*What is the linkage between market structures, at a point of time, and the occurrence or non-occurrence of specialisation?"* We would 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 is imperfect (with easy entry and exit) or oligopolistic.[5] However, the lack of specialisation and the non-emergence of intermediate goods and services markets in any economy or sector imply missing markets in the production filiere. Because production often cannot be efficiently completed without those functions, firms are forced to internalise these activities. Equally, the existence of large firms may prevent smaller specialised suppliers from emerging. In general this should mean the existence of somewhat larger and more diversified firms coincides with the lack of intermediate markets. Market structures may also be less competitive, i.e. oligopolistic rather than characterised by imperfect competition - with the crucial difference between the two market structures being the relative ease of entry in imperfectly competitive market structures.

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. There are many indications of this. Higher rates of new firm formation have characterised the South East's economy for decades. 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. This is not a new trend. Keeble and Bryson (1996) found that in the 1980s, 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.

Two 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 by its firms. The former has been documented by various studies (Keeble, 1996, 1998: O'Farrell et al, 1992), a 1997 Cambridge CBR survey revealing a mean number of 'serious competitors' for South East SMEs (19.0) approximately double that (9.7) for their counterparts in the Industrial Heartland (Keeble, 1998). The South East firms also showed a greater external, and global, orientation with significantly higher shares of overseas competitors, and of exports as a percentage of turnover, compared with Industrial Heartland firms (see also O'Farrell et al, 1993).

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

Specialisation and market formation processes break down in the presence of goods and services that may be characterised as public goods. Both basic research and education are two such public goods, and economic theory suggests that we should expect the market mechanism to under-invest resources in the provision of these goods. Historically this has been the main reason for the 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. If successful, these expenditures can enable the firm to reap significant rents from their private R&D expenditures. Other firms may access this benefit only at a fee, such as through licensing.

While private R&D may depend upon the profitability and other calculations of a firm, and is again associated with bigger firm size, public R&D is largely a policy variable. Though recent policies in the UK appear to see the two types of R&D as substitutes, a case can be made for strong complementarity between public R&D and private R&D. Public R&D is an economic externality. More investment in it 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. While there is little difference between the two regions in terms of the volume of output

of university graduates and postgraduates,[6] expenditure on R&D performed within the South East's universities and other higher education institutions totalled £1,268 million, compared with only £581 million 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 (Office for National Statistics, 1997, table 13.11). 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

The foregoing review suggests that 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. Higher levels of R&D might potentially make a larger pool of basic science available for applied R&D in the firm. Additionally higher public R&D could have an impact on the availability of highly qualified staff thus enhancing the human capital of firms in the region.

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.

Our arguments implicitly 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. Treating regions as regional markets may be valid for our data-set, which comprises a sample of 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. Some details

about our sample of firms are provided in Appendix A.

Table 1a describes the product innovation measure that we use as the dependent variable in our analysis. 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.

In focussing here on product rather than process innovation, for which we have conducted separate but unpublished analyses, we are influenced by previous work on this data set by Wood (1997), who shows that process and product innovators are two distinct types of innovators with differing characteristics. Even more important, the regional development impact of these different types of innovation probably also differs significantly. Thus 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.

The independent variables proxy the kinds of factors that we summarised in Section 2. Thus, we measure *the effect of intermediation* in two ways. We use a location quotient (LOCQUO) variable that varies across the 24 counties included in our sample as a measure of the extent of intermediation. LOCQUO measures the share of national employment in a county in 'other business services', which includes management and business consultancy,[7] relative to the county's share of all national employment. This measure underestimates the full extent of intermediation inasmuch as it includes only producer services and not producer goods. Keeble *et. al.* (1991) have used it as an index of the provision of specialised services in earlier work.

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. This variable was defined as FIRMDENS94 and

measured as the ratio of the stock of firms in 1994 to the total area (in square kilometres) of a county. Using this variable along with the LOCQUO would have controlled for the effects of clustering and the effects of intermediation. Though we have not reported these results in the tables, we would like to note that there was a very high level of correlation between LOCQUO and FIRMDENS94 (r~0.8). This suggests that intermediation and clustering are at least statistically the same variable. However our measure of clustering is rather crude and does not take into account the industrial diversification of the concentration of firms.

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 a 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, 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 24 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. *Pre-innovation market structure* is measured by the number of serious competitors faced by a firm in 1990 (COMPS11). COMPS11 also measures the nature of competition facing a firm. Small values of this variable reflect imperfectly competitive environments, which may induce firms to be innovative. A further variable, FORCOMP, measures the share of foreign firms in COMPS11. This variable measures the intensity of foreign competition facing a firm. Foreign competition is likely to be based on firm specific advantages which over time may stimulate domestic innovative behaviour. The ability of a firm to undertake innovation is captured through three variables. SIZE1 measures the logarithm of a firm's turnover in 1990 and proxies the resources available to a firm for undertaking the strategies required for innovation. FINANCE1 is a dummy variable taking value 1 indicating that a firm sought external finance in 1990. PROF11 is the percentage of total employees in a firm that were professionals in 1990, and measures the human resources available to a firm. We tried to include the age of the firm as a proxy for cumulative learning within the firm but found that it was very highly correlated with SIZE1. Thus, SIZE1 measures both the firm's ability to spend on strategies that matter for innovation, and also its cumulative learning capacity.

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 may be expected to 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 11 groups, and industry-specific effects in explaining innovative behaviour are controlled for by the use of dummy variables for each industry group. We excluded the 11^{th} group of miscellaneous service sector firms. The counties and industry groups included are detailed in Tables 1b & 1c.

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 considered in the review of the literature, 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.[8] 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 = {COMPS11, FORCOMP, SIZE1, FINANCE1, PROF1, FINDEM, LOCQUO, PUBRD93} (3)

X = {COMPS11, FORCOMP, SIZE1, FINANCE1, PROF1, FINDEM, LOCQUO, PUBRD93, DGRP1-10} (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. In terms of descriptive statistics, Table 2 shows that most of the observations about differences in the regional environment noted in Section 1 are valid. PUBRD93 and LOCQUO have higher average values in the South East region. The value of FINDEM is only marginally different between the two regions. 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.

The right specification of variables that should constitute the vector X does seem to depend on the regional grouping. Thus we see in Table 3 that a specification including industry dummies is always 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.[9] In contrast, the presence of a large intermediate sector can confer *general* externalities to other firms, in turn stimulating innovation by them.

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. The results reported in Table 4 show that:

(i) In both regions, firm size, used here as an indicator both of firm resources and cumulative learning, is a positive and significant determinant of product innovation.

(ii) In both regions, greater foreign competition and higher county level public R&D spending are statistically significant explanatory

factors in determining product innovation.

(iii) However, there are also important differences in the factors that explain product innovation in the South East and the Industrial Heartland. The extent of intermediation and the nature of competition explain product innovation among South Eastern firms alone. In the Industrial Heartland, these factors are not determinants of innovative activity, while product innovation is markedly concentrated in the electronics and instrumentation sector.

We will discuss each of these findings in turn.

In both regions increasing firm size always increases the probability that a firm innovates. Since we have other variables in the statistical model that control for the intensity of competition, it is reasonable to 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.[10] The ability to raise finance was not an important factor. The employment of professionals was an important explanatory variable whose significance vanished when public spending on R&D was included as an explanatory factor. This suggests that firms in regions where there are higher levels of public spending on R&D are also firms that tend to employ more professional employees. When this correlation is controlled for the employment of professionals ceases to have any significant independent impact on the probability of innovative behaviour. 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.[11]

Comparison of the two regional analyses, however, also reveals interesting differences in the determinants of innovative behaviour in the two regions. 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 significantly associated with two different explanatory variables, namely, the nature of competition, and the extent of intermediation. Again this is in addition to the importance for product innovation of firm specific resources and learning proxied by SIZE1, county level public R&D and the extent of foreign competition faced by a firm.

In the South East, smaller numbers of serious competitors (in 1990) increased the probability of product innovation in 1995. Previous work on this data by Kitson and Wilkinson (1996) demonstrated that for all types of firms average numbers of competitors declined between 1990 and 1995. They argue that this represents the importance of niche markets for growth in the UK SME sector. We suggest a different interpretation of this finding linking smaller numbers of competitors and innovative behaviour. Bresnehan and Reiss (1991) show that it needs no more than 5 competitors for firms to behave as if they were price competitive firms. Thus, smaller numbers of competitors may only suggest 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.

The second specific influence identified by the analysis of South East firms is that in this region, greater relative local provision of (intermediate) business services (LOCQUO) significantly increases the probability of product innovation by SMEs. 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 of course 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.

4. Implications

Our research suggests that each of the three sources of externalities and increasing returns discussed in the endogenous growth literature have an impact on firms' innovative behaviour. 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. In contrast, these influences do not appear to operate in the Industrial Heartland, where industry-specific factors were important to explaining innovation. Finally, increasing foreign competition stimulates innovation in both regions.

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 (our 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. This increases the probability of observing product innovations in the region by more than 8%. Similarly a unit increase in LOCQUO increases the probability of product innovation 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.

The importance of all three sources of increasing returns to innovative behaviour in the South East gives credence to an endogenous growth story of cumulative causation through firm innovation, consequent growth and increasing employment. Particular industries are less important to an explanation of innovative behaviour in this region. The nature of competition and the development of intermediate markets are significant factors explaining innovation, and by implication growth. The smaller regional economies of the Industrial Heartland are handicapped in that they do not enjoy the benefits of one important source of increasing returns, namely the growth of intermediate markets. Moreover, while SME innovative behaviour in both regions appears to be positively influenced by local levels of public sector R&D, overall expenditure on university and government laboratory research in the Industrial Heartland is of course far lower than in the South East. So our finding of a significant relationship between public R&D and innovative behaviour in both regions also clearly implies a lower innovative capacity in the Industrial Heartland than in South East England.

We would like to emphasise two policy implications of our results.

The first arises from the clear finding that in both regions, increasing firm size and hence resources and cumulated learning capacity, is a significant determinant of innovation. This finding parallels that of other recent work (Cosh, Hughes and Wood 1996, Cosh and Wood 1998). But it does in turn suggest that a small-firm focussed policy of innovation as has been advocated if not followed by successive UK governments may be relatively inefficient in stimulating innovation, and that innovation policies should be focussed on larger rather than smaller SMEs in all regions of the UK.

Secondly, our findings also seriously question the validity of recent government policy that has restricted if not reduced funding of university and other public research in the belief that it is not efficient and is unimportant to innovative activity. We find strong evidence in both of our regions that public R&D increases the probability of private sector product innovation. 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. This is because advances in research in public institutions are usually in the public domain and can be exploited by firms, and because 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.

Notes

1. Scotland, North East England and Wales represent smaller manufacturing based regions, and are not included in the analysis. The grouping of the West Midlands, Northwest England, and Yorkshire and Humberside into a broad "Industrial Heartland" category is employed and justified in Keeble (1997).

2. 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 (Stigler 1951). The conjunction of the two factors happens uncommonly.

3. Labour Market Trends, August 1998.

4. 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, with manufacturing and other service sectors being much more important.

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

6. 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).

7. 'Other business services' (activity 8395 of the 1980 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).

8. We used LIMDEP software to estimate the model.

9. 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.

10. 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.

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

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 firm's 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 national employment in SIC 8395/ County's share of total national employment in all industries. SIC 8395 is other business (management and business consultancy) services	Keeble et. al.(1991)	+
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 firm's SIC field.		

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	

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.

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

Region	Results of testing specification (3) v/s (4)	L_{UR}	L_R	LR statistic (k=9)	P (χ^2)
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 : $-2 (L_R - L_{UR})$.
(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.

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.

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

Variable	Marginal effect	Mean of X
Constant	-0.787	
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.

References

Antonelli, C. (1998) *The microdynamics of technological change*, Routledge

Arora, A., Fosfuri, A. and Gambardella, A. (1998) Division of labour and international technology spillovers. Mimeo, Carnegie Mellon University, Pittsburgh, USA

Athreye, S. (1998) On markets in Knowledge. Journal of Management and Governance, 1(2): 231-253

Bresnahan, T. F. and Reiss, P. C. (1991) Entry and competition in concentrated markets. *Journal of Political Economy 99: 997-1009*

Bryson, J. R., Keeble, D. and Wood, P. (1997) The creation and growth of small business service firms in post-industrial Britain. *Small Business Economics, 9, 345-360*

Bullock, A., Duncan, J. and Wood, E. (1996) The survey method, sample attrition and the SME panel database, Appendix, pp. 94-101 in Cosh, A. and Hughes, A. (eds) *The changing state of British enterprise: Growth, innovation and competitive advantage in small and medium-sized firms 1986-95*, ESRC Centre for Business Research, University of Cambridge, Cambridge

Cosh, A. and Hughes, A. (eds) (1996) *The changing state of British enterprise: Growth, innovation and comparative advantage in small and medium sized firms, 1986-95*, ESRC Centre for Business Research, University of Cambridge, Cambridge

Cosh, A. and Wood, E. (1998) Innovation: scale, objectives and constraints, Chapter 4, pp. 38-48 in Cosh A. and Hughes A. (eds) *Enterprise Britain: Growth, Innovation and Public policy in the Small and Medium Sized Enterprise Sector 1994-97*, ESRC Centre for Business Research, University of Cambridge, Cambridge

Curran, J. and Blackburn, R. (1994) *Small firms and local economic networks*, Paul Chapman London

Dosi, G. (1988) Sources procedures and microeconomic effects of innovation, *Journal of Economic Literature*

DTI (Department of Trade and Industry) (1998) *Business start-ups and closures: VAT registrations and de-registrations in 1997*, Statistical Press Release p/98/645

Keeble, D. (1996) North-south and urban-rural variations in SME performance, innovation and business characteristics, Ch. 9, pp. 83-93 in Cosh A and Hughes A (eds) *The Changing State of British Enterprise: Growth, Innovation and Competitive Advantage in Small and Medium Sized Firms 1986-95*, ESRC Centre for Business Research, University of Cambridge, Cambridge

Keeble, D. (1997) Small firms, innovation and regional development in Britain in the 1990s. *Regional Studies, 31(3): 281-293*

Keeble, D. (1998) North-south and urban-rural variations in SME growth, innovation and networking in the 1990s, Ch. 10, pp. 99-113 in Cosh A and Hughes A (eds) *Enterprise Britain: Growth, Innovation and Public Policy in the Small and Medium Sized Enterprise Sector 1994-1997*, ESRC Centre for Business Research, University of Cambridge, Cambridge

Keeble, D. and Bryson, J. (1996) Small firm creation and growth, regional development and the North-South divide in Britain, *Environment and Planning A*, 28, 909-934

Keeble, D., Bryson, J. and Wood, P. (1992) Entrepreneurship and flexibility in business services: the rise of small management consultancy and market research firms in the UK. Chapter 4 in Caley, K, Chell, E., Chittenden, F., and Mason, C. (eds.) *Small enterprise development and practice in action,* Paul Chapman London

Keeble, D., Bryson, J. and Wood, P. (1991) Small firms, business services growth and regional development in the United Kingdom: some empirical findings. *Regional Studies, 25(5): 439-457*

Kitson, M. and Wilkinson, F. (1996) Markets and competition, in Cosh, A. D. and Hughes, A. (eds.) *The changing state of British enterprise*. ESRC Centre for Business Research, University of Cambridge

Nelson, R. and Winter, S. (1982) *An evolutionary theory of economic change*. Harvard University Press, Cambridge, Mass

O'Farrell, P. N., Hitchens, D. M. W. N. and Moffat, L. A. R. (1992) The competitiveness of business service firms: a matched comparison between Scotland and the South East of England, *Regional Studies*, 26, 6, 519-533

O'Farrell, P. N., Hitchens, D. M. and Moffat, L. A. R. (1993) The competitiveness of business services and regional development: evidence from Scotland and the South East of England, *Urban Studies,* 30, 10, 1629-1652

Office for National Statistics (1997) *Regional Trends*, The Stationery Office, London

Rosenberg, N. (1963) Technological change in the machine tool industry, 1840-1910. Reprinted in Rosenberg (ed.) (1976) *Perspectives on technology*, Cambridge University Press, Cambridge

Scazzieri, R. (1993*) A theory of production,* Clarendon Press, Oxford

Stigler, G. J. (1951) The division of labour is limited by the extent of the market. *The Journal of Political Economy,* 59 (3), 185-193

Vivarelli, M., Evangelista, R. and Pianta, M. (1996) Innovation and employment in Italian manufacturing industry. *Research Policy*, 25: 1013-1026

Wood, E. (1997) Innovator types and their determinants. In J. Mitchie and J. Grieve Smith (eds) *Innovation, co-operation and growth*, Oxford University Press, Oxford

Young, A. (1928) Increasing returns and economic progress. *Economic Journal* 38, 527-542

APPENDIX

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 conducted as well as an analysis of rates of attrition and non-response in the sample are contained in Bullock, Duncan and Wood (1996). In this section 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.

We analysed a sample that 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 Hereford and Worcester. The reasons for these exclusions are explained in Section 2.2 of the paper. This sample of firms was 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	430	212
% of total sample: 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, described in section 2.3, we treated missing values in a particular way. Thus, an observation was excluded from analysis if even one variable, of the 10 variables described in Table 1A, had a missing value. This way of treating missing values greatly reduced the total number of observations from 642 firms in all to 454 firms in all: 294 in the South East and 190 in the Industrial Heartland.

The dependent variable used in the empirical analysis (PROD3) was constructed using a firm's response to the following question included in the postal questionnaire. We quote from the questionnaire including the original emphasis and preface to the actual question:

"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 <u>both</u> products <u>and</u> processes please skip…."
(CBR (1995): Business Innovation Survey questionnaire)