Innovation, Networking and Proximity: Lessons from Small High Technology Firms in the UK

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The article explores how the innovative performance of small high-tech firms relates to their external networking activities, and whether geographical proximity in their network relations matters. Data from a small sample of electronics firms and software developers in South East England are used to construct indicators of innovativeness, which are correlated with variables capturing intensity of external interactions and proximity benefits. The regional science base is found to have played a key role in nurturing new high-tech ventures, but science parks had not contributed to this. Interaction with parties with complementary capabilities such as suppliers and service providers is also associated with high innovative performance. However, the findings do not support the current policy fashion of encouraging regional networks revolving around firms in similar business activities and close customer relations.

Science and technology policy Innovation policy SME Clusters Networks UK

Introduction

Small high technology firms have recently been the subject of much attention among researchers and policy makers in the UK. A particularly strong interest developed in dynamic companies operating in the field of newly emerging technologies with promising innovative potential, especially ICT, biotechnology and high-tech electronics. In the most recent Competitiveness White Paper on industry (DEPARTMENT OF TRADE AND INDUSTRY (DTI), 1998), they are identified as key agents of industrial regeneration which can help to close the productivity and innovation gaps between British industry and its main competitors.

One would hope that the design and implementation of the assistance infrastructure set up in the 1990s to nurture these firms was informed by insights from sound empirical research about the forces that drive small firms' innovative performance. Yet it seems that popular notions and rules of thumb about what works have been the main driving factors. A recent survey about research on R&D, technology and innovation in small business in the UK noted that: 'in many of the empirical studies . . . , the analytical treatment of innovation within the SME context is underwhelming, both theoretically and methodologically. These studies do not set out to measure comprehensively, and then to link innovative inputs to innovative outputs' (HOFFMAN *et al.*, 1998, p. 42).

This article attempts to make a modest contribution towards filling this gap and thereby to contribute to the current policy discussion, especially about the promotion of regional networks. It is based on interviews with 17 software and IT developers and 16 electronics firms in Oxfordshire and Berkshire, two counties with thriving regional concentrations of software and IT firms. The main locations were the Thames Valley and along the M4 corridor, as well as more rural parts. The interviews elicited detailed information about their innovative performance, the importance of various network relations, and geographical proximity advantages associated with these relations. Statistical correlations between these variables are examined, and the results are fleshed out and interpreted with the help of qualitative interview material. This small pilot survey cannot be used to draw firm conclusions about the driving forces of innovation in high-tech small firms in the South East as a whole, but it can generate key pointers to map out directions for further research, and issues to which policy designers might wish to pay particular attention.

Concepts, policy context and research questions are discussed in the next section. The variables are briefly introduced in the third section whilst the fourth section reports the main results from the analysis. A final section contains conclusions and a discussion of policy implications arising from the findings.

Concepts, policy context and questions

Firm-level technological advancement is often conceptualized in terms of a learning process which leads to various technological capabilities (DODGSON, 1991; GARVIN, 1993; HITT *et al.*, 2000). In this article we focus specifically on innovation capability. This is crucial in the present competitive environment characterized by fast change, because it contributes to dynamic competitive advantage.

Interaction with suppliers, customers, public agencies, industry associations, foundations and the like may provide important inputs for the accumulation of innovation capability (LUNDVALL, 1988, 1992). Firms interact to gather technological and market information, and to obtain other learning inputs such as training services, components, consulting services and R&D grants. Furthermore, many authors have suggested that the effectiveness of 'learning by interacting' would be boosted by regional clustering of the network actors, pointing towards the economic success of Silicon Valley, the Third Italy and regional clusters in Southern Germany (CAMAGNI, 1991; MAILLAT *et al.*, 1993; AUDRETSCH, 1998; COOKE *et al.*, 1997; COOKE and MORGAN, 1998; STORPER, 1993).

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The belief has taken hold that it might be possible to replicate this experience in the UK, too, through targeted interventions aimed at sparking new ideas through strong networking and collaborations – with competitors, suppliers, customers, universities and so on. Geographical proximity is the engine driving these linkages by facilitating face-to-face contact and fostering a sense of community, which encourages people to share ideas.

Two important policy instruments have a close bearing on the formation of small-firm regional networks and clusters. First, a dense network of regional Business Link (BL) centres provides single points of easy access to a range of business support services. Innovation and technology counsellors co-ordinate the use of local sources of innovation support and act as innovation management consultants. Several BLs have begun to facilitate local information exchange and networking through the formation of local business groups, provision of referral services that put like-minded enterprises in touch with each other, and help with establishment of research collaborations (DTI, 1997; HUGGINS, 1998). Second, creation of science parks tends to promote interaction between universities and business by exploiting advantages of geographical closeness. This instrument dates back some considerable time before the advent of the regional clustering strategy, but has now become an integral part of it, even though the evidence about its success so far has been mixed (WESTHEAD and COWLING, 1995; HOUSE OF LORDS, 1997; OAKEY and MUKHTAR, 1999).

The article seeks to shed light on the following questions:

1. Is intensive interaction linked to higher innovation capabilities in the sample firms, and if so, which specific network links are important?
2. Is geographical proximity in the network links beneficial for innovation?
3. What policy insights can be gained from the answers to questions 1 and 2?

Variables

Seven different indicators of innovative capabilities are used, namely: (1) at least one major product innovation (or major improvement of an existing product) completed during the three years preceding the interview;[1] (2) *idem* for process innovations; (3) *idem* for major organizational innovations; (4) substantial 'incremental' innovation during the past three years; (5) an 'innovativeness index' which combines the information about indicators 1 through 4, and also complexity and originality; (6) number of patents held; (7) quality accreditation status.

Indicators 1, 2, 3 and 7 are straightforward and correspond to measures commonly used in innovation surveys (OECD, 1992; PATEL and PAVITT, 1995; ARCHIBUGI and PIANTA, 1996). Indicator 4 reflects the notion that many improvements in small firms are made bit-by-bit. Indicator 5 is an unweighted average of innovation scores for major product, process, organizational and incremental innovation. In addition each of these four scores embodies an assessment of the degree of novelty embodied in the innovations, and of the extent to which their development required specialized scientific or advanced technological expertise (details in Appendix Table A1).[2] Quality accreditation status (ISO 9000 or QS 1000) captures the notion that firms with internationally recognized design procedures pursue innovation as a major formally organized activity.[3]

Intensity of interaction was measured mainly by means of Likert scores capturing frequency of contact with customers, suppliers, firms in similar lines of business, government support agencies, financial institutions, universities, science laboratories, service providers, public and private training institutions, and industry associations. Two additional variables try to capture actual knowledge or financial resource transfers, which would not be picked up adequately through frequency of interaction: whether or not a firm had received support from local government bodies such as BL and municipalities during the past three years; and whether or not technological licences had been obtained.[4] Proximity effects associated with external interactions were assessed by asking the respondents to indicate, for each network link, whether or not closeness (in the sense of less than one-hour travelling distance) conferred advantages for their company's performance.

Main findings

The findings are discussed with the help of Table 1, in which all those networking and proximity advantage variables that correlate statistically significantly with at least one of the innovation capability indicators have been listed. An important finding is that, the more strongly firms interact with research laboratories and universities, the more likely they are to have come up with at least one major recent product innovation. Moreover, the significance of the patents and innovativeness variables suggest that these innovations are relatively original and technically complex. Also, firms reporting proximity advantages in these contacts report more complex and/or original innovations, as shown by the significance of the innovativeness index correlations. Firms reporting proximity advantages from contacts with science laboratories also have more patents than others.

These laboratories are the National Atomic Energy Authority laboratories at Harwell and Culham, and the Rutherford Appleton laboratory of the University of Oxford. During the interviews it emerged that the

Table 1. Networking, proximity advantages and innovation capability: main findings

Innovation capability indicators	Frequency of interaction with			Resource transfers through	Advantages arising from geographical proximity to				
	Suppliers	Science laboratories	Universities	Receipt of local institutional suppport	Suppliers	Private service providers	Science laboratories	Univer-sities	Private training institutions
Major product innovations (y/n)	−0·275 (0·122)	0·365* (0·037)	0·353* (0·044)	0·126 (0·483)	0·343* (0·026)	0·087 (0·316)	0·210 (0·120)	0·400* (0·011)	0·373* (0·016)
Major process innovations (y/n)	0·000 (1·000)	0·153 (0·571)	0·035 (0·896)	0·111 (0·681)	−0·222 (0·204)	−0·041 (0·440)	0·182 (0·250)	0·372 (0·078)	−0·022 (0·468)
Major innovations in organization (y/n)	−0·062 (0·732)	0·226 (0·207)	0·114 (0·527)	0·302 (0·088)	0·241 (0·089)	0·132 (0·233)	0·131 (0·234)	0·087 (0·316)	0·166 (0·178)
Substantial incremental innovation (y/n)	0·437* (0·011)	0·136 (0·450)	0·145 (0·421)	0·109 (0·548)	0·230 (0·099)	0·296* (0·047)	−0·011 (0·476)	−0·065 (0·359)	−0·145 (0·210)
Patents (no.)	0·164 (0·360)	0·458** (0·007)	0·400* (0·021)	0·134 (0·456)	0·145 (0·211)	0·031 (0·432)	0·399* (0·011)	0·249 (0·081)	0·283 (0·055)
Innovativeness index	0·071 (0·695)	0·563** (0·001)	0·424* (0·014)	0·436* (0·011)	0·336* (0·028)	0·226 (0·103)	0·421** (0·007)	0·332* (0·029)	0·264 (0·069)
Accreditation index	−0·028 (0·876)	0·213 (0·234)	0·101 (0·575)	0·520** (0·002)	0·108 (0·275)	−0·045 (0·401)	−0·037 (0·419)	0·285 (0·054)	0·097 (0·295)

Notes: $n = 33$. Spearman correlation coefficients (p-values in parentheses).
**Significance at the 0·01 level (1-tailed).
*Significance at the 0·05 level (1-tailed).

links with these institutions had almost invariably come about through previous employment of respondents as scientists there. They had maintained their connections and continued to live in the same area. Most of the links with the universities had a similar origin. Thus, the correlations in Table 1 should not be interpreted as supporting evidence for science parks, in which geographical proximity between research agencies and enterprises is meant to forge contacts and exchange between them. Hardly any of the firms that were in active contact with research bodies were in fact located on an estate next to the institution that they were entertaining the contacts with.

The sample companies with links to the science base had developed the capability to capture specialized niches in the world's leading markets. They include a company producing CAD software for electromagnetic design in engineering and scientific fields, whose three founders worked in a science laboratory in Oxford on electromagnetic design; a firm designing mathematics software (FORTRAN and other products), whose founder (who holds a PhD in maths) worked in a university computing centre; and five firms designing high-precision electronic instruments for big corporations and/or for science and university laboratories. Their products include blue laser technology, cryogenic equipment, high-sensitivity gas sensors and nuclear magnetic resonance devices.

All founders with links to the science base had extensive work experience in a research environment, where they conceived the initial ideas that ultimately sparked off the establishment of their companies. The fact that a substantial amount of pre-competitive research took place in this environment, with access to laboratory equipment and a secure income, was undoubtedly vital to their subsequent success. Geographical closeness seemed to be essential for maintaining the frequent contacts required for effective interaction, especially for combining the running of one's own business with part-time employment at these institutions, access to laboratory facilities, informal exchange with staff, and so on.[5] Clearly, the regional science base had been a valuable source of internationally highly competitive spin-offs with high technological capabilities in the sample.

Another important finding from Table 1 is that interaction with a range of actors who provide inputs that are complementary to the firms' own activities appears to play a notable role in fostering innovation. These are suppliers, private service providers, training institutes and local support organizations. Interaction with suppliers contributes both to major and incremental innovation. In the case of the former, proximity rather than frequency matters, probably because radical innovations have many tacit elements, which can best be dealt with through face-to-face contact. In the case of incremental innovations, frequency rather than closeness matters. Probably, the sort of inputs that suppliers deliver to facilitate incremental innovation are not all that complex, so that substantial face-to-face communication is not required in order to absorb these inputs effectively. Private service providers (consultants, maintenance and repair services, and so on) are also associated with incremental innovation, but here proximity rather than frequency in the interaction matters. This probably suggests that private service providers play a creative role in firms' gradual upgrading processes, and that occasional face-to-face contact is invaluable for brainstorming and for sorting out specific bottlenecks that firms experience in the course of pursuing incremental improvements.

Several respondents reported that they maintained contacts with local training institutions to attract bright students on internships, with a view to future employment. They need to be able to tap into a labour pool when the need for recruitment arises. The labour market for software programmers was especially tight. This is consistent with the significant correlation between reported proximity advantages from private training institutions and firms' performance on major product innovation.

Recent support from governmental institutions (predominantly BLs) is significantly correlated with the scores on the innovativeness index and the accreditation index that measures the standard of a firm's quality procedures. The organizational innovation variable is also not far from being significant. The government's support thus appears to be associated at least partly with improved *management* of production and innovation processes, unlike scientific and private sector contacts. The BL centre at Oxford confirms that companies rarely need BL's help with solving actual engineering problems as such. Rather, they need assistance with directing their technological capabilities to better meet market needs. The significance of the accreditation variable probably reflects the fact that BL actively encourages companies to pursue ISO 9000 compliance. It also disburses subsidies for that purpose. A certain amount of reverse causality cannot be ruled out, however.

Remarkably, no other actors appear to have added much to the innovation performance of the sample firms. In particular, there is no significant innovation benefit associated with intensive networking with, and/or proximity to, customers. This runs counter to the established notion that intensive ongoing contact with customers is crucial for development of products that suit new market needs (VON HIPPEL, 1988; LUNDVALL, 1992). The distinct impression from the interviews was that the most innovative companies in the sample were those whose customers were located all over the world, especially in continental Europe, Japan and the US. Although they did indicate that ongoing interaction with these customers was essential to keep abreast of customer needs and new developments in their domain, neither high frequency nor physical proximity appeared to be particularly advantageous for successful innovation. Recent advances in ICT, and cost-reductions of long-distance communication may play a role here.

Neither is there evidence of benefits from frequent or geographically close interaction with like-minded companies, financial institutions, industry associations and government bodies. On the face of it, these findings provide only partial support for the UK government's area-based innovation strategy.

Conclusions and policy insights

In view of the small sample, the findings from this study can only serve as indications of possibly broader directions, but the fact that some clear patterns emerged from the data may suggest that they do have wider validity in the region in which the research took place. It is evident that external networking for innovation is highly multifaceted, both in its forms and its effects. Firms interact with some actors for major innovation, and with others for incremental innovation. In some contacts, frequency is apparently a key factor contributing to innovation performance, while in other instances the nature and the extent of knowledge, information, finance or other resources transferred through occasional face-to-face contact appear to be important. In yet other cases, both frequency and face-to-face aspects appear to matter, notably contacts with the science base. Thus, one reason why customers did not show up as an important source of innovative performance could be that neither proximity nor high frequency in these contacts were associated with innovation excellence in the sample firms. It should not be concluded that customers had been unimportant as a source of innovation and learning in the sample firms as such.

An important finding relates to the importance of scientific institutions in the region as sources of highly innovative science-based start-ups, and as contributors to ongoing innovative processes in these companies long after their establishment. The contribution of these institutions obviously does not lie in fostering technology-driven entrepreneurs in large numbers, but rather in their ability to nurture a limited number of highly successful firms that are capable of securing competitive advantage based on patentable innovations in leading overseas markets. These are the sort of companies that the UK government is especially interested in bolstering.

In the light of this finding, the current 'market-led' SME promotion strategy may have some shortcomings. Highly creative companies that develop patentable innovations cannot be created overnight, with only the help of short term public R&D support such as SMART or with backing from private venture capitalists, business angels or finance trusts. The innovations upon which such ventures are based carry high risks and have very long gestation periods. Scientific institutions were found to be effective as sources of innovative spin-offs not only because they offered the right kind of environment in which prospective entrepreneurs have access to, and were continually exposed to, state-of-the art knowledge, but also because they created a solution to the structural financial problems associated with launching a new technology-based business. Several businesses interviewed for this study would not have succeeded without initial support and encouragement from the institute from which they had spun off. Access to laboratory facilities, or subsidizing of staff costs through continued part-time employment in the first years were found to be particularly effective support mechanisms. Perhaps even more crucial was the fact that a large share of the initial development costs of the initial innovation were borne by these institutions, since substantial pre-competitive research had already been completed before the decision to branch out independently was actually taken. It is difficult to envisage that private financial sources could somehow substitute for this role.

In this context, the recent moves to commercialize science laboratories through privatization and/or through the redirection of their focus towards activities with greater commercial viability should give cause for concern. Increasingly, staff time is being diverted from fundamental research to activities that can yield short term commercial gains. In the short run this encourages spin-offs, but in the long run doubts have been expressed about the extent to which the UK's national science base would be able to continue to play the role of breeding ground for high-tech entrepreneurship in the future (LAWTON SMITH, 1997).

Another policy issue relates to the effectiveness of current policy focused on fostering innovation through small industry clusters. The analysis showed that *frequency* in external interactions with suppliers and scientific institutions is associated with higher innovative capabilities in the sample firms. Moreover, *proximity* of these actors seems to matter too. Other network relations also appear to carry innovation benefits associated with proximity, including links with service providers and private training institutions. Additionally, support from local government agencies, mainly Business Links, appears to be associated with higher innovative performance. On the other hand, there was no evidence that intensive networking with, and/or proximity to, firms in similar or the same lines of business and customers would add anything special to the firms innovative processes and performance.

Thus, an 'innovative milieu' in the context of South East England is likely to be a region in which small firm' innovative capabilities are fostered primarily through local contacts with business, support agencies and institutions that can provide inputs that are *complementary* to what the small firm itself possesses. However, it may prove harder to promote dynamism in clusters around a supposed 'community of interest' shared by small firms engaged in (semi-) competitive activities, or around a local customer-base. Our findings endorse the notion of the global–local interface, expounded in other writings on the subject (PORTER, 1990; SIMMIE, 1997). In an environment in which firms are increasingly exposed to global competition, effective area-based innovation policies for small high technology firms are likely to be those that strengthen local complementarities and thereby facilitate firms' strategies to capture specialized niches in leading international markets.

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Notes

1. 'Major innovation' is defined as an activity to which the firms' owners/managers attached strategic importance.
2. Grading was based on detailed information from respondents, but the results inevitably reflect subjective opinions of respondents and the interviewing team.
3. Quality accreditations were scored on a five-point scale (5 = accredited manufacturing and design procedures; 4 = accredited manufacturing, and working towards design accreditation; 3 = accredited manufacturing, but no efforts towards design accreditation; 2 = working towards manufacturing accreditation; 1 = no accreditations and no efforts to obtain them).
4. Receipt of grants from the DTI and the EU were also considered, but the direction of causality was too dubious to be of much value.
5. LAWTON SMITH *et al.*, 1999, find similar evidence from high-tech biotechnology companies in Oxfordshire.

Appendix

Table A1. *Classification used for innovativeness index*

	Degree of science intensity	
Degree of novelty	'Clever gimmick'	Science-intensive
Major innovations (products, processes, organization)		
Fundamentally new to the world	4	5
Similar innovations adopted in other industries	3	4
Similar innovations adopted in firm's own industry, but its innovations differ in identifiable ways from other companies' innovations	3	4
Same or very similar innovations adopted by competitors	2	3
No major innovations at all	0	
Incremental innovations		
Yes	1	3
No	0	

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