COLLECTIVE LEARNING PROCESSES AND INTER-FIRM NETWORKING IN INNOVATIVE HIGH-TECHNOLOGY REGIONS

ESRC Centre for Business Research, University of Cambridge
Working Paper No. 86

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March 1998

This Working Paper relates to the CBR Research Programme on Small and Medium-Sized Enterprises

Abstract

This study of 100 high-technology small and medium-sized enterprises in the Cambridge and Oxford regions investigates the nature and extent of regional collective learning processes and networking for technology development between local technology-based firms and other organisations, such as Cambridge and Oxford universities, as theorised by workers such as Camagni and Lorenz. It reveals evidence of a number of the elements hypothesised as necessary for such processes of regional collective learning. This is especially true of the role of entrepreneur spin-off activity and professional and scientific labour recruitment, with resultant transfer of embodied expertise and continuing inter-firm links. These processes appear to be particularly active in the case of Cambridge, with its larger volume and somewhat longer historical trajectory of development of technology-intensive enterprises. The study also however highlights the parallel importance in technology development of wider national and global networks, outside the local milieu, as argued by workers such as Camagni, particularly in relation to innovation inputs and formal research collaboration. National and global recruitment of expertise is also important. The extent to which these patterns mirror those of other European regions is currently under investigation by the European Commission-funded TSER network on collective learning, coordinated by the ESRC Centre for Business Research.

Acknowledgements

This research was funded by the Economic and Social Research Council as part of its core funding of the ESRC Centre for Business Research. The authors gratefully acknowledge this financial support, as well as valuable comments from Alan Hughes, Director of the CBR, and inputs from discussions with partners in the European Commission-funded TSER network on collective learning in regional clusters of high-technology SMEs, notably Ned Lorenz, Roberto Camagni and Asa Lindholm Dahlstrand.

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1. Introduction and Theoretical Framework

Recent theoretical research on the economic and technological development of dynamic European regions has drawn attention to the supposedly key role in such regions of "untraded inter-dependencies" between local firms and other organisations (Storper, 1995), involving informal inter-firm networking (Yeung, 1994) and processes of "collective learning" (Camagni, 1991; Lorenz, 1992; Lazaric and Lorenz, 1997; Lawson, 1997). These processes, which involve exchange and development of technological expertise and high rates of technological and product innovation, are seen as being based on relationships of trust and reciprocity, while the networks and processes themselves are viewed as influential in the recent evolution of dynamic regional clusters of innovative small and medium-sized enterprises (SMEs; see Keeble, 1996). One important source for this work are the ideas of the GREMI[1] European school of regional economic research associated with Aydalot (1986; Aydalot and Keeble, 1988), Camagni (1991) and their fellow workers. This group has developed the concept of "collective learning" to connote a broad notion of the capacity of a particular regional "innovative milieu" to generate or facilitate innovative behaviour by the firms which are members of that milieu. Indeed, for Camagni (1991, 130), collective learning is central to the development and definition of a successful milieu; "the local 'milieu' may be defined as a set of territorial relationships encompassing in a coherent way a production system, different economic and social actors, a specific culture and a representation system, and generating a *dynamic collective learning process*" (italics added). However, as Lawson (1997) points out, Camagni also and more directly defines the process of regional collective learning as being primarily concerned with regional mechanisms which reduce the uncertainty faced by firms in a rapidly-

changing technological environment, such as that associated with a "competence gap" arising from the firm's limited ability to process and understand available information; a key example of such uncertainty is "the existence of technical problems whose solutions are obscure" (Camagni, 1991, 126). Reducing or eliminating this "competence gap" demands the development by the firm of effective "transcoding functions" which "translate external information into a language which the firm may understand", functions which can merge both codified and tacit information into firm-specific knowledge, including R & D knowledge (Camagni, 1991, 127). For Camagni, a successful regional innovative milieu embodies "hidden, mainly tacit functions", in the form of "a collective learning process" operating "mainly through skilled labour mobility within the local labour market, customer-supplier technical and organisational interchange, imitation processes and reverse engineering, exhibition of successful 'climatisation' and application to local needs of general purpose technologies, informal 'cafeteria' effects, complementary information and specialised services provision".

Camagni's conceptualisation of regional collective learning thus focuses on links and networking between firms and via the regional labour market, accords it a central role in the development of a successful innovative milieu, and pinpoints a number of key mechanisms by which it may take place. A broadly related view is held by Lorenz[2] (Lorenz, 1996; Lazaric and Lorenz, 1997) as reviewed in Lawson (1997). Lorenz's starting point is however the literature on learning processes within the firm (for example March, 1991). This concerns the ways in which firms seek to overcome internal coordination problems by constructing shared knowledge in the form of commonly understood rules and accepted procedures. By extension, regional collective learning can be understood as the emergence of basic common knowledge and procedures across a set of geographically-proximate firms which facilitates co-operation and solutions to common problems. In this context, Lorenz identifies three areas in which firms need to develop shared knowledge. First, in

terms of preconditions for learning, there is the need to establish a common language for talking about technological and organisational problems. This is closely related to the need for common standards of honesty and information sharing as the basis for the adaptation of industrial partners to unanticipated contingencies not explicitly provided for in formal contracts. As Lorenz (1996) points out, "a clear understanding and mutual consensus over the rules provides a basis for the progressive build-up of trust, which is arguably indispensable for innovative collaboration, given the uncertainties which surround its terms and outcomes".

Secondly, "there is a need for a shared knowledge of a more strictly technological or engineering sort, which allows different firms to effectively collaborate in a technological project" (Lorenz, 1996). This knowledge is not simply (or most importantly) concerned with core research, but with the more down-stream phase of innovation, involving detailed product design, testing, re-design and production. This "in-house" knowledge is often difficult to transfer because it is not easily codified as "its transfer depends ultimately on the mobility of individuals or teams" with practical experience in the technology concerned. The third kind of shared knowledge is organisational, examples suggested by Lorenz being how to manage hierarchical relations, how to divide responsibilities among different occupations or services, or what procedures are needed to assure the consistency of collective decision-making.

Lorenz's approach, though from a different theoretical starting point, thus bears a number of similarities to Camagni's. There is the same stress on the need for firms to reduce uncertainties by sharing and collaborating, the same implicit emphasis on local inter-firm relations or networking, and the same recognition of the probable importance of such mechanisms or processes of regional collective learning as the movement of key research staff or entrepreneurs between firms; "mobile workers [are] the carriers of knowledge on the local labour market" (Lorenz, 1996). Equally, Camagni like Lorenz recognises the

importance of establishing common "tacit codes of conduct... and the formation of common 'representations' and widely shared 'beliefs' on products and technologies", an aspect of regional collective learning which Camagni sees as likely to be encouraged by "synergy effects stemming from a common cultural, psychological and often political background, sometimes enhanced by the effectiveness of some local 'collective agent' " (Camagni, 1991, 133-4). Camagni's longer theoretical discussion is however more explicit about the key role of geographical proximity in the development of collective learning, stressing as it does the role of locally-rooted (at least to some extent) human capital resources whose "presence accounts for much of the local collective learning process", the "presence of an intricate network of mainly informal contacts among local actors, building what Marshall called an 'industrial atmosphere'....., made up of personal face-to-face encounters, casual information flows, customer-supplier co-operation and the like" (Camagni, 1991, 133), and the local synergy effects associated with a common cultural background noted above.

The concept of regional collective learning as set out by Camagni and Lorenz clearly bears many similarities and connections to at least two other conceptual frameworks currently attracting research attention, namely those of "the learning region" (Asheim, 1996; Simmie, 1997; Morgan, 1997) and of "regional innovation systems" (Cooke, 1996; Cooke, Extebarria and Uranga, 1998). Whilst space rules out detailed discussion of the similarities and differences between these conceptual frameworks, it is important to stress that both the latter seem to place emphasis more on the role of "non-firm" institutions or organisations - governments, training organisations, development agencies, universities, etc. - in shaping regional innovative capacity, than perhaps on networking and the intensity of interaction between individual firms, with which this paper is primarily concerned. Thus Pratt (1997, 128) quoting Morgan (1997) suggests that "the learning region" is "a particular structured combination of institutions strategically focused on technological support, learning and economic

development", while there is also a marked stress throughout the innovation systems literature on institutions rather than firms, as with Freeman's (1987) definition of a national innovation system as "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies".[3] A further important point is that very few if any of the studies which advocate a "learning region" or "regional innovation system" framework appear to have made any attempt as yet to test these ideas against empirical reality, or to try to measure the extent and nature of actual learning processes operating within particular regions. In utilising a "regional collective learning" framework based on Camagni's and Lorenz' ideas, the present research reports original empirical findings which document the extent and nature of particular collective learning processes operating in the 1990s in two European regional clusters of innovative and technologically-dynamic SMEs.

2. The Cambridge and Oxford Regions: Context and Methodology

The focus of the research reported here is then on the role of collective learning processes in the recent growth of two dynamic regional clusters of innovative technology-intensive SMEs, namely those in the Cambridge and Oxford regions of the United Kingdom. Though differing somewhat in scale and historic development (Lawton Smith, Keeble, Lawson, Moore and Wilkinson, 1998), both of these have exhibited rapid growth of small and medium-sized technology-based firms since the 1970s (Keeble, 1989: Lawton Smith, 1990), are historically focused on major universities with a global reputation for research and scientific activity, and possess regional labour markets characterised by a marked bias towards research and professional workers. Both possess a diversity of technology-based sectors rather than being specialised on one particular sector, as documented by Lawton Smith for Oxford (1990, 25: 1997, 32) and illustrated for Cambridge by Figures 1 and 2. This diversity includes both high-technology manufacturing and services, the latter

representing the dominant growth component in the Cambridge case in the 1990s (Figures 3 and 4; data from Cambridgeshire County Council, 1996). Data on recent trends is unfortunately not available for the Oxford region, although Oxfordshire County Council and Oxford Trust records suggest that by 1996, the region contained at least 179 high-technology firms employing 16,278 employees, compared with 715 firms employing 24,024 employees in the Cambridge case.[4]

These two populations provided the sampling frame for a recent interview survey by the ESRC Centre for Business Research (hereafter called the CBR Survey) of 100 technology-intensive SMEs, 50 from each of the two regions. Stratified random sampling was used to produce a representative balance of such firms in each region between manufacturing and services, but with a stratification between larger and smaller (less than 100 employees) enterprises designed to ensure inclusion of a somewhat higher proportion of the former than their share in the population. Three-quarters of the firms sampled were nonetheless small businesses employing less than 100 workers, with 94% employing less than 500. The sample is intended to provide a representative picture of technology-intensive SMEs in the two regions, but with an emphasis on firms which have demonstrated an ability to grow.[5] While some differences do inevitably exist between the Cambridge and Oxford sub-samples, as in the regional contexts, the many similarities noted above arguably justify initial analysis of results for the whole sample, as a broad measure of the possible importance of collective learning processes and capacities in the two regions considered together, and with the benefit this gives of larger sample size.

3. Internationalisation and Local Embeddedness

The recent growth of these two European regional clusters of technology-intensive SMEs has of course to be understood in a wider and indeed global context of rapid technological change, the growth

of new knowledge-based and information intensive sectors, corporate restructuring and an increase in numbers of small and new firms, and increasing globalisation of firm activity (Amin and Goddard, 1986; Oakey and Rothwell, 1986; Keeble and Kelly, 1986; Aydalot and Keeble, 1988; Keeble, 1990; Castells and Hall, 1994; Amin and Thrift, 1994). The last of these has been shown by the present authors to be of great importance for many technology-intensive SMEs in the Cambridge and Oxford regions, which exhibit an exceptionally high level of international links and networks (Keeble, et al, 1997); on average, firms in the CBR Survey exported no less than 44% of their output of goods and services in 1995, while 27% of their collaborative research with other firms was with partners outside Britain altogether. These are exceptionally high levels of international activity, compared with most smaller firms in Britain (Storey, 1994, 153), and involved truly global. not just European, links. Globalisation here reflects the high degree of targeting by these SMEs of new technology-based market niches, demand for which is often confined to relatively few clients located in different global regions. Some 79% of firms surveyed in fact reported that they had been "set up to provide a specialised product or service for a particular market niche or set of customers".

The CBR study however also revealed that notwithstanding globalisation, Cambridge and Oxford technology-intensive SMEs also exhibit a significant degree of local networking, linkage and embeddedness. Indeed, it affords empirical evidence for the view that local embeddedness may actually be helpful if not necessary for successful internationalisation (Keeble, et al, 1997, section 7). Thus the most international and innovative firms were shown also generally to be more rather than less locally linked, particularly in terms of research collaboration. Equally, as Camagni (1991, 134-141) has argued, global networking is likely to be important for the competitive success of firms active in regional networking, if they are to remain innovative and technologically-dynamic in the long-term. These findings and arguments thus suggest that the two scales and levels of

networking relationships should not be seen as conflicting but as both necessary and mutually-beneficial for the growth of the individual firm and a regional collective learning capacity.

4. Collective Learning Pre-Conditions and Processes

One of the most important, but also most elusive and difficult to measure, aspects of regional collective learning capacity stressed by both Camagni and Lorenz is the need for pre-conditions for learning, in terms of common regional culturally-based rules of behaviour, language of engagement and collaboration, accepted but tacit codes of conduct between firms, which enable the development of trust, itself essential for innovative collaboration (see section 1). As Camagni notes (1991, 133), the development of these "cultural" pre-conditions may also be "enhanced by the effectiveness of some local 'collective agent' ". The existence to a significant degree of common tacit codes of behaviour between the research-intensive SMEs of the two regions can perhaps be inferred from the outcome of a high frequency of close inter-firm links documented later[6]. More generally, however, qualitative discussions with entrepreneurs and managers during the course of the CBR survey strongly suggested the existence of two key sources (or local "collective agents") of such regional codes of behaviour, namely Cambridge and Oxford Universities on the one hand, and key local "enterprise-generating" larger high-technology firms on the other.

Cambridge and Oxford Universities are characterised by generally liberal and positive academic attitudes towards research collaboration, sharing and the development of new knowledge[7] which appear to have spilled over into and helped shape, to a considerable degree, the wider culture of the local research-based business community, via university spin-offs, researcher recruitment and direct research collaboration (Keeble and Moore, 1997). Such attitudes and rules of research behaviour, with their positive valuation of research interaction, dissemination, debate and collaborative endeavour,

arguably provide a local cultural context which is particularly conducive to the development of innovative and cross-fertilising research within and between local firms. Segal Quince Wicksteed (1985, 69) even go so far as to suggest that Cambridge University's culture and policy may be exceptional in this regard; "it is perhaps in these respects that the Cambridge approach stands in sharpest contrast to those of most other British Universities; a central perception of the strategic value of industrial links and a commitment to its realisation, and to do so through a reliance on research excellence and on liberal ground rules governing its exploitation rather than by means of formal regulation and institutional devices". Their 1985 Cambridge Phenomenon study also argued that a high proportion of then operating Cambridge high-technology firms owed their existence to Cambridge University, either directly or indirectly by spin-off from firms themselves originally spinning-off from the University. This would support the 'culture of research collaboration' thesis suggested above.

The role of key "enterprise generating" larger local firms may also be significant in this development of regional cultures of trust and collaborative research. In the Cambridge region, a small group of large R & D consultancies (Cambridge Consultants, PA Technology, Scientific Generics, The Technology Partnership) appear to have played a very significant role in generating and fostering local research-intensive spin-offs, in a pro-active and positive fashion, while a somewhat similar role in the Oxford case has been played by Sir Martin Wood's Oxford Instruments Group, with its powerful impact on the regional growth of cryogenics firms (Lawton Smith et al, 1998). In both cases, positive encouragement of spin-off activity and continuing research links may have encouraged a local culture of trust and collaborative activity which has been highly beneficial to continuing technological innovation and small firm growth.

Much more easily measurable indicators of the possible development of collective learning capabilities in the two study regions relate to the

mechanisms or processes of collective learning discussed in section 1. Specifically, these focus on three key areas, namely the degree of local movement and spin-off of technological expertise in the form of entrepreneurs, the extent and frequency of inter-firm technological networking and interaction, and the importance of flows of key research and professional staff, as embodied technological and organisational expertise, between local firms.

5. Entrepreneurial Origins, Local Spin-Offs and Embodied Expertise

The importance for the development of regional collective learning of the spin-off of individual entrepreneurs, carrying with them embodied technological and perhaps managerial expertise, from existing local firms or institutions (such as universities) is perhaps insufficiently stressed in the theoretical literature reviewed in section 1. In a high-technology SME milieu characterised by vigorous processes of new firm creation, however, this is a major process whereby research ideas, technological innovations and expertise are diffused and shared within a region, rather than being confined and internalised within a single secretive firm. The CBR Survey reveals strong evidence of active processes of entrepreneurial spin-off of research-focused entrepreneurs, nearly all of whom choose to establish their new enterprises in the local region rather than move elsewhere. This can be documented both in terms of the origins of the firms surveyed (Tables 1 and 2) and their own subsequent role in spinning-off further new technology-based firms themselves (Table 3), in a cumulative and mushrooming process.

As Table 1 reveals, no less than 84% of the technology-intensive firms studied reported that they had been originally set-up either as entirely new independent start-ups or spin-offs from an existing firm or institution. The growth of technology-based firms in both regions has thus been characterised by vigorous processes of local entrepreneurship and new enterprise creation, rather than by

"colonisation" or branch plant establishment by external companies. Equally striking is the fact that 82% of the chief founders of these new start-ups and spin-offs were previously working within the local region, and most frequently for another local firm (50%), many of which were explicitly characterised by respondents as "research-based firms". Employment in a local university was the next most frequent origin (23%). Large government research laboratories, which have a major presence in the Oxford region (Lawton Smith, 1990), however have a very poor record of entrepreneurial spin-offs. With that exception, the data clearly show that entrepreneur spin-off from existing local firms, especially research-based firms, and local universities are by far the dominant processes in new enterprise creation in our sample. This finding carries with it the implication of considerable local diffusion of embodied research expertise and capacity for technological innovation as well as of cultures, values, and codes of conduct developed in the "incubating" organisation. This judgement is supported by Table 2, which reveals that 77% of founders claim to have possessed previous research experience, with 70% claiming actual research qualifications, when setting up their firm. However, only 58% and 23% claimed previous managerial experience or qualifications, respectively. This high degree of previous research expertise again reinforces the argument that entrepreneurial spin-off and start-up is an important process whereby technological expertise is diffused and a collective learning capability built up within a technology-based region such as Cambridge and Oxford.

A very similar picture emerges from Table 3, which reports the frequency of known cases of entrepreneurship by individuals leaving the surveyed high-technology firms to set up their own companies. Not only is this frequency high (46%), not least given the youthfulness of many of the enterprises surveyed, but nearly all the resultant spin-offs were set up locally within the Cambridge or Oxford milieu. In addition, nearly 70% (31 out of 46) retained formal or informal links with the "parent" or "incubating" company, with 57%

possessing informal links. These involved a wide variety of interactions, ranging from continuing personal contacts, swapping of ideas and helpful comments to more formal sub-contracting, share holding or joint venturing arrangements. The most frequent single type of continuing link was through sub-contracting, with 9 firms (20%) sub-contracting work from their previous employer. These empirical findings again reveal a high intensity of diffusion of embodied technological and research expertise via entrepreneurial spin-offs, together with a significant degree of continuing interaction and co-operation between "parent" and spin-off firms. This in our view is likely to reflect relations of trust and contribute to a regional collective learning capability.

Evaluation of the origins and processes of new enterprise formation in these two technology-based milieux thus provides strong evidence of the movement and diffusion of technological skills and expertise within the regional economies. It does however beg the important implicit question as to why entrepreneurs spinning off from local firms and universities have chosen to remain in these milieux, thereby adding to their collective learning capacities, rather than to establish their new technology-based business elsewhere. Simple "geographical inertia" is obviously a major factor here, no less than 61 firms (76% of new start-ups or spin-offs) reporting that a major reason for locating the business in the region was simply that the founder(s) already lived there. However, two types of evidence indicate that the possibility of the new firm being able to tap into the region's technological, research and collective learning capabilities was an important additional consideration for between a quarter and a half of the sample firms. Thus of the unprompted replies to the open question "why did the founder(s) choose to locate the firm in the Cambridge/Oxford region?", 20 or 25% referred to the value of links with other local firms, universities, or research staff as a significant influence. This was the second most important consideration, after existing residence. Secondly, as Table 4 reveals, while the most important regional advantages for the development of the whole group of technology-

intensive firms surveyed - and presumably the main reasons for entrepreneurs remaining in their region - centre on the region's residential attractiveness, international credibility, reputation and prestige, access to airports and availability of premises, the fifth, sixth and seventh ranked advantages (out of 19) are all to do with accessing the region's technological, research and innovative expertise. Just over half of all sample firms regarded "informal local access to innovative people, ideas and technologies" as an important advantage of their regional milieu, with just under half highlighting the quality and availability of the region's research staff. These findings thus reveal an awareness on the part of many SMEs in these regional clusters of the existence and benefits of access to regional technological expertise and a collective learning capacity.

6. Inter-Firm Networking, Links and Collaboration

The theoretical literature reviewed earlier explicitly or implicitly argues that regional collective learning is enabled by, and indeed requires, high levels of interaction and exchange of technological and other information between firms, institutions and individuals within the regional milieu. As Storper (1995) notes, however, the importance of inter-firm networking is not easily captured by local input-output flows of semi-finished products, even in traditional Marshallian "industrial districts" where such flows are especially visible (Lawson, 1997). Indeed, Storper (1995, 200) notes that high-technology regions are often characterised by relatively low intensities of such input-output, traded relations. He therefore argues that other informal and untraded links and interdependencies are of greater importance in explaining the clustering phenomenon. To what extent, then, do technology-intensive firms in the two study regions interact with one another, and what types of local links and networks may exist which contribute to the development of a collective learning capacity?

CBR survey results relevant to answering these questions are presented in Tables 5 and 6. The first of these, which relates solely to

contacts with other local firms rather than to universities or government research laboratories, reveals that three-fifths (61%) of local technology-based firms reported that they do currently possess "close links" with other firms in the regional milieu; and this figure rises to 76% for the Cambridge sub-sample. A high rate of Cambridge region interaction and linkages is true for both manufacturing (81%) and service (72%) high-technology enterprises. Oxford firms exhibit lower frequencies in both sectors (52% and 39%, respectively). This interesting difference may reflect the greater maturity and larger volume of firms in the Cambridge milieu and hence greater local density of interaction opportunities, together perhaps with the somewhat smaller size of Cambridge technology-based enterprises (Lawson et al., 1997). But in the Cambridge case at least, the evidence suggests that the region has developed a high level and density of inter-firm interaction, in line with theoretical expectations of an "information rich" milieu possessing an effective and vibrant collective learning capacity. Some of the links reported, in response to an open question, appear to involve close co-operation and a considerable degree of trust, as with local high-technology sub-contracting (18 firms or 30% of those with links), suppliers of inputs and components (22%), customers (17%), research collaborators (12%), specialised service providers (8%), and firms acting as technology consultants or owning shares in the company (7% each). Other close local formal and informal links cover a wide range of networking arrangements, such as "satellite firms which generate innovations", "share ideas and equipment", "share information about customers", "manufacturing alliance", "firms which manufacture products designed by us", "discussion of technical problems", "firms that develop our ideas", "joint venture", and so on. These detailed replies revealed the existence of numerous local links and networking arrangements, particularly within the larger and more mature Cambridge technology-based cluster.

This said, further findings from the survey provide an important qualification to the above argument. When asked to rate the perceived

importance to the firm - rather than simple existence - of different local links, most firms actually rated them as relatively unimportant, rather than important. The highest importance rating was for interaction with local suppliers or sub-contractors, with 65% reporting local links to be moderately, considerably or extremely important, followed by links with local firms providing services (54%), and with research collaborators and customers (32% in each case). Thus only one-third of these firms rated local research collaboration as important to them. This reflects the fact, revealed by detailed responses to another survey question, that only 22 firms or 31% of respondents to this question reported that 10% or more of their collaborative research activity in 1995 was with other firms in the local Cambridge or Oxford region, with only 16 firms (23%) reporting values of 20% or more. The bulk of collaborative research with other firms is in fact carried out with partners elsewhere in the UK, especially in South East England, and abroad (Keeble et al, 1997). While many firms are involved in national and global research networks, direct local inter-firm research collaboration appears to be a collective learning process of importance for only a minority of local enterprises. This could reflect concern over secrecy and intellectual property, or the specialised nature of many firms' technology niches and products and hence lack of local research collaboration opportunities. Alternatively, it could relate to Storper's argument (Storper 1995) noted above that the interdependencies which in his view are so important for innovation in high-technology regions such as Cambridge and Oxford are more likely to be untraded, as through spin-offs, than to be traded, as perhaps in the form of explicit research collaboration agreements between local partners.

A further indicator of the existence of local opportunities for inter-firm information and technology exchange is given in Table 7, which records the frequency of reported opportunities for informal mixing with managers and professionals from other firms in the local milieu. As various observers have noted (Segal Quince Wicksteed, 1985; Keeble, 1989), the relatively small size and compact urban structure

of the two regions studied undoubtedly facilitates informal mixing by entrepreneurs and professionals, a process encouraged by university and other technology transfer agencies (such as the Oxford Trust) and local business associations and clubs. Informal contact also follows from the high rate of entrepreneur spin-off (Section 5) and local staff mobility (Section 7). As a result, 82% of firms possessing close local links with other firms report occasional or frequent informal contact, with approximately 30% reporting frequent links. This finding perhaps provides some quantitative support for the quite frequent qualitative reference by respondents in interview discussions to the existence in the regions of a general "air of innovation", of informal innovation networks, from which local technology-based firms can benefit.

However, and as with the inter-firm research collaboration finding above, this judgment needs to be carefully qualified in the light of other survey evidence. First, when asked directly for the source(s) of the firm's "innovating activities" over the past three years, the vast majority of firms reported that by far the dominant or sole source was the firm itself. External sources of any kind were usually seen as secondary. Secondly, substantially higher (though small) proportions of firms rated external sources in the rest of the UK or abroad (Table 8) as important than rated external sources within the Cambridge or Oxford regions themselves. In all but one case, the most frequently cited geographical scale of innovation network was at the UK national level, with foreign sources of innovation inputs coming second. Within the UK, interview discussion often highlighted sources within the broader South East region of England, the acknowledged dominant focus of technology-based industry in the UK (Keeble, 1992). For innovation inputs from customers, as many as 61% of firms rated sources elsewhere in the UK as important, with 56% for foreign sources, compared with only 24% for local customer sources. Only in the case of university innovation inputs were local Cambridge or Oxford sources reported as important more frequently (24% of firms) than at least one of the other scale categories (21% foreign,

34% rest of UK). These results clearly indicate that wider innovation networks, at national and global scales, are appreciably more frequently rated as important than are local networks.

At first sight, this finding appears to contradict the thesis of the importance of regionally-based collective learning processes presented earlier. However, as Camagni (1991, 134-141) stresses, in a technologically-dynamic and highly uncertain world, local 'milieu' effects undoubtedly have their limits, and must be seen in conjunction with the parallel importance of wider inter-firm networks as an essential means of access to information on rapidly-changing technologies and market opportunities. This is particularly true "in those areas of production characterised by fast innovation and technological change" (Camagni, 1991, 137). Indeed, Camagni (1991, 139) argues explicitly that in such sectors, local firm involvement in wider national and global networks is absolutely essential for long-term regional growth, and that "the 'milieu' has to open up to external energy in order to avoid 'entropic death' and a decline in its own innovative capacity". For Camagni (1991, 139), regional collective learning or "'milieu' relationships and network relationships appear as complementary and mutually reinforcing 'operators', the former linking the firm to its contiguous environment through mainly informal, tacit (and often even overlooked and apparently unappreciated) relationships, the latter linking it explicitly to selected partners in its [wider] operational environment". The results of this study provide empirical support for this judgment of the importance both of milieu-based and tacit regional collective learning processes, as through spin-offs, and of wider national and global networks, as with external innovation inputs. The complementary nature of these two types of firm interaction was frequently highlighted in interview discussions, as for example by the many cases where global technological or client links were important in the development of innovative products, which in turn led individual researchers and entrepreneurs to spin out new firms from existing local companies,

with a corresponding diffusion of technological expertise within the local milieu.

7. Collective Learning and the Regional Research and Managerial Labour Markets

The last, and important, collective learning process to which the theoretical literature draws attention concerns the extent and role of "skilled labour mobility within the local labour market" (Camagni, 1991, 127), this "mobility of individuals or teams" (Lorenz, 1996) again involving the diffusion of embodied and tacit expertise and technological know-how. In the Cambridge and Oxford region context, this is likely to focus particularly on the role and local recruitment of scientists, engineers and other research staff, and of managers experienced in guiding technology-based start-ups. However, such highly-qualified and high-income workers are known to be exceptionally mobile geographically, usually operating within national if not international rather than local labour markets (Green and McKnight, 1996). In addition, opportunities for local recruitment are bound to be limited by the very small scale of business activity and employment (250 thousand) within each of the two study regions compared, for example, with neighbouring South East England (6,900 thousand).

The CBR Survey sought to measure the extent and importance for the growth of technology-based firms in the Cambridge and Oxford regions of such mobility, in two ways. First, firms were asked where the last three research and management staff to be recruited had previously been employed, in terms of the categories listed in Table 9. The table reveals that 24% of respondents had recruited at least one of their most recently-recruited research workers directly from Cambridge or Oxford University, while 28% had recruited such staff from other local firms or organisations. For management staff, respective proportions were 8% and 34%, local firms, not surprisingly, representing a much more important source of

management recruits than local universities. For research staff, the regional milieu thus provides the third and fourth most important sources of research expertise distinguished in the Table, after other UK firms and universities, but with appreciably higher shares than foreign universities and firms. In all, exactly one-third (33%) of all research staff recruitment reported by respondents came from within the regional milieu concerned. For management staff, the respective regional proportion was not far short of this, at 30%.

Bearing in mind the 'footlooseness' of highly-qualified staff and the small size of local labour markets, as noted above, these findings are noteworthy in demonstrating the existence of considerable localised flows of research and managerial staff within these technology-based regions, in addition to the spin-off and mobility of entrepreneurs and new firm founders discussed in Section 5. No doubt the residential attractiveness of the two areas noted earlier (Table 4) also contributes to the ability of local technology-based firms to recruit staff from other local firms and institutions. The benefits of local recruitment are also indicated by the fact that 60% of survey firms reported pursuing a policy of active recruitment of technical and scientific staff from within their regional milieu.

The second set of results, reported in Table 10, is equally interesting. These are responses to a direct question on whether local inter-firm links and networks exist because individuals - by implication high-level staff such as managers, researchers or other professionals - have moved between local firms, and whether such links have been of any importance in the firm's development. The results are striking. Just over half (53%) of all firms surveyed reported that such local links did exist, and two-thirds (66%) of these rated these links as moderately, fairly or very significant for the firm's development. For Cambridge region firms, the proportion rating these links as significant in this way was even higher, at 77%. These two findings again suggest that the movement of individuals between local technology-intensive firms in these two regions is relatively common, that it is important in

stimulating a significant degree of local inter-firm technological and business networking, and that such networks play a valuable role in the development of a sizeable minority (approximately one-third overall; Table 10) of local technology-intensive enterprises. Local networking through staff mobility is particularly important in the Cambridge case, a finding which may possibly be associated with the recent growth here of distinctive micro-clusters of small dynamic technology-based SMEs in such sectors as telecommunications, computer software and internet applications, and bio-technology (Keeble and Moore, 1997). Interview discussions with local firms suggested that there is a significant interchange of highly qualified staff within these clusters, with new local firms benefiting from a growing local pool of technological, research and professional expertise.

While national and even global labour market mobility is thus very important to technology-based firms in these regions, bringing into the region valuable external technological and managerial expertise, the CBR survey does reveal that even within the relatively small local labour markets involved, local inter-firm movement of skilled staff plays an important role in the intra-regional transmission of expertise and fostering of inter-firm links. Qualitative discussions with firms, banks and business advisers also suggest that this may be of growing importance and value to local firms, as the local pool of such staff has grown over the last decade. These results do thus provide qualified support for the stress in the collective learning literature on labour market processes in enhancing regional collective learning capacity.

8. Regional Collective Learning Processes and "Institutional Thickness"

As noted earlier, writers adopting both a "learning region" and "regional innovation system" approach to understanding the development of economically successful regions have placed considerable emphasis on the key role of local institutions "such as

research institutes, universities, technology transfer agencies, chambers of commerce, banks, government departments" as well as of individual firms and firm clusters (Cooke and Schienstock, 1996, 11). A similar view is held by Amin and Thrift (1994; 1995, 102) who stress the importance of regional "institutional thickness" in the form of an interlocking web of supportive organisations and institutions "including firms, financial institutions, local chambers of commerce, training agencies, trade associations, local authorities, development agencies, innovation centres, clerical bodies, unions, government agencies providing premises, land and infrastructure, business service organisations, marketing boards, and so on", with considerable synergies of interaction, collective representation, and common purpose. In these authors' view, such "local institutional thickness can have a decisive influence on economic development".... "as firms gravitate towards localities which offer the best institutional milieu to support their needs" (Amin and Thrift, 1995, 103). These very interesting ideas are clearly relevant to the notion of regional collective learning, and of collective benefits to firms from "ideas, research capability, information, skills, supply structures and services.....available through recognisable institutions" of the type listed above (Amin and Thrift, 1995, 103).

Earlier discussion has stressed the major if not defining role of Cambridge and Oxford Universities as focal institutions influencing the evolution and collective learning capacity of the two technology-based SME clusters examined here. This influence has acted in a variety of ways (see Lawton Smith et al, 1997), including in the Cambridge case a significant impact by specific College-funded business support agencies such as the St. John's Innovation Centre, a particularly successful technology-based firm incubator (Reid and Garnsey, 1996, 1997). However, what impact if any have other local institutions, of the kind listed above, had upon local technology-based SMEs, and to what extent have these two distinctive and successful technology-based regions developed a degree of "institutional

thickness" in terms of a plethora of interlocking and effective business support and service agencies?

Although limitations of space rule out in-depth analysis of this important question, Tables 11 and 12 do provide some valuable though preliminary empirical indicators of local institutional support networks, as actually experienced by local technology-intensive firms. The first of these focuses on the role of local government-funded or collectively-organized business support and training agencies, providing help or advice to local technology-based firms. The local Training and Enterprise Councils (TECs) are part of a national central-government funded system of skills training provision, while Enterprise Agencies are non-profit making organizations which exist to advise new start-ups and first-time entrepreneurs. The Oxford Trust is unique to the Oxford region, being a charitable trust established in 1985 by Sir Martin Wood of Oxford Instruments to promote local science- and technology-based enterprises (Lawton Smith et al, 1998). Though based on a small sample, Table 11a shows that this organization achieved the highest frequency of reported "use" (55%) of all five agencies listed, with TECs second (only 40% of all respondents) and Chambers of Commerce third (only 31%). In addition, the aggregate satisfaction ratings of Table 11b, undifferentiated by agency, indicate that only one-third of firms reporting receipt of help or advice rated this as of significant or great value (4 or 5). In general, therefore, and with the possible interesting exception of the Oxford Trust, these results do not really suggest that these two regional milieux are characterised by local business support agencies which are widely used and valued by local technology-based enterprises. In this respect, institutional thickness appears to be limited.

The picture with regard to the local provision of key business services by other firms (Table 12) is however more mixed. Here, the survey results reveal that there are three areas of use of external firm expertise and service provision in which local services and networks

within the Cambridge or Oxford milieu are both widely accessed and highly rated. These are accountancy services (85% external use, 80% local use for 50% or more of the firm's needs, and 70% rating local service of significant or high quality), legal services (77%, 77% and 69% respectively), and design and printing services (77%, 74% and 84% respectively). In addition, although venture capital was accessed by only 16% of firms, three out of every five of these obtained finance from local venture capital firms and rated this highly (67%). In contrast, low local usage and quality ratings are recorded for management consultancy, public relations, and marketing agencies, while although local use is considerable, respondents rated both local banks and personnel and recruitment agencies surprisingly poorly in terms of the quality of the service provided (only 46% and 45% rated local provision of significant or high quality, respectively). These results do support the view that the two regions have developed an effective supportive infrastructure of local accountancy, legal and design/printing firms, perhaps with specialist experience of the needs of small and medium-sized technology-based firms, and that a minority of such firms also benefit from the local availability of venture capital providers. Other "layers" of local private-sector institutional support within these milieux do not however emerge from this analysis so positively, with local banks in particular recording a relatively low quality rating by local high-technology enterprises. This is particularly noteworthy given the stress in earlier accounts of the development of the Cambridge Phenomenon, at least, on the influential role of local banks such as Barclays in "brokering" and encouraging new technology-based start-ups in the late 1970s and early 1980s (Segal Quince Wicksteed, 1985; Keeble, 1989). Overall then, this analysis does suggest that the Cambridge and Oxford milieux have developed some degree of institutional thickness in terms of the provision and effectiveness of particular local services, quite apart from the wider role of Cambridge and Oxford Universities, and the positive activities of specific local agencies such as the Oxford Trust and Cambridge's St. John's Innovation Centre.

9. Conclusions

The concept of regional collective learning focuses on the argument that regional clusters of small and medium-sized enterprises can, given favourable environmental, socio-economic and institutional conditions and sufficient historical evolution, develop a capacity for self-sustaining technological learning, innovation and the generation of new products, services and enterprises. The development of a regional capacity for collective learning involves both the establishment of pre-conditions for learning, in the form of culturally-based rules of behaviour, engagement and collaboration and accepted but tacit codes of conduct between individuals and firms which enable the development of trust, and active regional processes of inter-firm networking, interaction and exchange of expertise.

This study has attempted to apply these theoretical ideas to the case of the Cambridge and Oxford regions, both of which have experienced a significant growth of research- and technology-intensive firms over the past two decades within regional milieux characterised by major international universities surrounded by a penumbra of research institutions. It has argued that in both regions, preconditions for collective learning and the development of trust may have been provided by the focal role of the university and its liberal ethos of unfettered and collaborative research enquiry, operating particularly through academic spin-offs and graduate researcher recruitment. A further positive impact on preconditions for learning may have come from the role of larger local technology-based businesses, such as Oxford Instruments and the very successful group of large Cambridge R & D consultancies. This very important issue is currently under further investigation within the ESRC Centre for Business Research at Cambridge University.

The paper also presents a range of empirical measurements of the extent and perceived importance for local high-technology SME development of key processes of collective learning identified by the

theoretical literature. It reveals that local SME creation dominantly (82% of founders) involves research-focused entrepreneurs who were previously working for other local firms or in local universities, clearly implying a process of intra-regional diffusion of embodied technological expertise. In addition, nearly half of all surveyed firms reported that they had themselves incubated local technology-based spin-offs. Moreover, nearly 70% of these spin-offs retained formal or informal links with their local "parent", in the form of sub-contracting, share holding, joint venturing or more informal personal contacts and swapping of ideas. These findings clearly suggest a high intensity of diffusion within the regional milieu of technological and research expertise in the form of individual entrepreneurs and new firm founders, together with a level of continuing interaction, collaboration and cooperation which is likely to affect relations of trust and the existence of an effective regional collective learning capability.

This judgement is also supported by the empirical finding that three-fifths (61%) of all technology-intensive firms surveyed in these two milieux report "close links" with other local firms, a proportion which rises to 76% for the Cambridge sub-sample. This relatively high intensity of local inter-firm networking involves a range of interactions, including formal contacts such as sub-contracting, the purchasing of inputs and components, supplying local clients, research collaboration, manufacturing alliances and joint ventures, and close informal links such as the sharing of technological and customer information, the sharing of equipment, joint problem solving, and inter-firm collaborative development of new technologies and products. However, the survey also revealed that these links are viewed by only a minority of local firms as "important" to their activities and development, and that in terms specifically of collaborative research and innovation inputs, firms exhibit a markedly higher level of inter-firm networking outside their local milieu, with enterprises in the rest of the UK and abroad. Notwithstanding their local links, most local technology-based firms clearly operate within

national and global research and innovation networks. This apparent contradiction with collective learning arguments can however be resolved in terms of Camagni's thesis of the need for and complementary nature of both local 'mileu' and wider 'network' external relationships, both of which, he argues, are of great importance for successful innovation in a technologically-dynamic world.

A further important mechanism of regional collective learning investigated by this study is the movement of skilled workers, in the form of highly-qualified research and managerial staff, within the regional scientific and professional labour markets. Again, the theoretical literature argues that the movement of such individuals, with their embodied and tacit technological and organisational expertise, is likely to be very important in the development of a regional collective learning capability. In the present case, however, such movement is likely to be constrained in extent by the small size of the local labour markets involved and exceptional national and international mobility of this type of worker. Given this, the survey results are of some significance in revealing that one-third of all recent research staff recruited by local high-technology firms has been from other firms and organisations within the regional milieu, with a 30% figure for regionally-recruited managerial staff. Some 60% of firms also reported pursuing an active policy of local recruitment of technical and scientific staff. Moreover, over half (53%) of all surveyed firms reported the existence of local inter-firm links because of individuals - managers, researchers or other professionals - who had moved between firms, with two-thirds of these rating these links as important. Continuing inter-firm links and networks because of previous staff mobility thus appear to play a significant role in the development of a substantial minority (one-third) of local high-technology enterprises. Local networking of this kind is more important in Cambridge than in Oxford.

While these results thus indicate that local technology-based firms are actively involved in wider - and indeed global (Keeble et al, 1997) - labour market networks, recruiting highly-qualified research and managerial staff nationally and internationally, they reveal that the regional labour market nonetheless plays an important secondary role in such recruitment. The existence of significant local flows of embodied know-how and technological expertise, with resultant links which are viewed by firms as influential in their continuing development, is in line with the view that these regions, and especially the Cambridge region, are developing a capacity for regional collective learning and technological networking which encourages and sustains innovation and new enterprise development.

Finally, preliminary analysis of the issue of "institutional thickness" and the extent to which these regions have developed a multi-layered and interactive web of organizations and institutions supporting local high-technology SME growth and collective learning yields equivocal results. Leaving on one side the very important issue of the role of Cambridge and Oxford universities in this respect, survey results suggest that with the possible exception of the Oxford Trust, local government-funded or collectively-organized agencies appear to play a limited rather than major role in advising or helping local technology-based firms[8]. Certain local business services - accountancy, legal services, and design and printing services - are used widely and valued highly by local technology-based enterprises. But others, especially local banking and personnel and recruitment services, are rated more poorly in terms of quality of service provision. Overall, the survey results perhaps suggest that the Cambridge and Oxford milieux have developed some degree of institutional thickness in terms of the provision and effectiveness of particular local private sector services, although the role of other agencies and institutions requires further investigation.

In general, however, this study does reveal evidence of a number of the elements hypothesised as necessary for processes of regional

collective learning and collaborative technology development. This is especially true of the role of spin-off activity and professional and scientific labour recruitment, with resultant inter-firm links and networking. These processes appear to be particularly active in the case of Cambridge, with its larger volume and somewhat longer historical trajectory of development of technology-intensive enterprises. It is however also the case that the study highlights the parallel importance of wider national and global networks, outside the local milieu, as argued by workers such as Camagni, particularly in relation to innovation inputs and formal research collaboration. The extent to which these patterns mirror those of other European high-technology regions is currently under active investigation by the European Commission-funded research network on "Networks, Collective Learning and RTD (Research and Technology Development) in Regionally-Clustered High-Technology SMEs", co-ordinated by the Cambridge University ESRC Centre for Business Research, which is described in end-note 2 of this paper.

Notes

1. Groupe de Recherche Européen sur les Milieux Innovateurs. The Group was chaired by Philippe Aydalot until his untimely death in 1987, and subsequently by Roberto Camagni, with Dennis Maillat as General Secretary. The Group's publications include Aydalot (1986), Aydalot and Keeble (1988), Camagni (1991) and Ratti et al (1997).

2. Camagni and Lorenz's ideas and the concept of regional collective learning in the development of regionally-clustered technology-intensive SMEs are being explored by the European Research Network on "Networks, Collective Learning and RTD (Research and Technology Development) in Regionally-Clustered High-Technology SMEs", which is funded by DGXII of the European Commission under the Targeted Socio-Economic Research Initiative of the Fourth Framework Programme. This research network is co-ordinated by the ESRC Centre for Business Research of Cambridge University and comprises 11 teams in 8 EU countries. Members include Professor Edward Lorenz, Professor Roberto Camagni and the present authors. It has already produced three reports to the European Commission dealing with regional institutional and policy frameworks for high-technology SME development (Keeble and Lawson, 1996), the role of regional university and research institute linkages and spin-offs in the development of high-technology SME clusters (Keeble and Lawson, 1997a), and inter-firm networks, links and large firm impacts within these clusters (Keeble and Lawson, 1997b). Some further information about the network and its research programme is reported in Keeble (1996).

3. Note, however, that Cooke et al (1998) explicitly extend this definition to include "the network of public and private organisations and institutions" and stress that the most clearly

developed example of a regional system of innovation is one in which "firms and other organisations are systematically engaged in interactive learning through an institutional milieu characterised by embeddedness".

4. The definition of high-technology sectors was based on Butchart (1987) modified to exclude service activities such as British Telecom and to include only those known to be innovative. The Cambridge region is defined as the three local authorities of the City of Cambridge, South Cambridgeshire and East Cambridgeshire, together with the Royston Fringe, while the Oxford region covers Oxfordshire excluding the Banbury travel-to-work area in the north and a rural area to the south.

5. For further details on the survey and its methodology, see Lawson et al, 1997, and Keeble et al, 1997.

6. Direct inquiry into the existence of such codes is also currently underway in the Cambridge region in a follow-up study by the ESRC Centre for Business Research.

7. Though this has changed somewhat in the 1990s in the Oxford case: see Lawton Smith et al, 1998.

8. It should however be noted that Hull and Hjern's (1987, 130) study of local business support agency impacts on small firm growth in Germany identified a very substantial and exceptional impact in the Borken area, notwithstanding a frequency of agency contact for the three main organizations involved of only 39%, 36% and 36% of surveyed firms respectively.

TABLES

Table 1: Cambridge and Oxford High-Technology SMEs: Founder's Origins, Locally-Generated Entrepreneurship and New Firm Start-Ups

A. "Was your firm set up by another firm, as a spin-off from an existing firm/institution, or as a new independent start-up?"

Firm origin: set up	Number	%
by another firm	16	16
as a spin-off	29	29
as an independent start-up	55	55
Total	100	100

B. "For new start-ups and spin-offs only, where was the chief founder employed immediately previously?"

Location	Type of Firm or Organisation					
	Self employed/ Unemployed	University	Government Research Laboratory	Firm	Other Institution (Hospital, Local Government)	Total
Cambridge or Oxford regions	3 (4)	17 (23)	1 (1)	37 (50)	3 (4)	61 (82)
Rest of UK (9) or abroad (4)	1 (1)	3 (4)	0	9 (12)	0	13 (18)
Total	4 (5)	20 (27)	1 (1)	46 (62)	3 (4)	74 (100)

Note: % of total respondents (74) given in brackets.

Source: CBR Survey

Table 2: Local Entrepreneurship and Research and Managerial Expertise

"Did the founder possess managerial qualifications, managerial experience, research qualifications and/or research experience?"

	Qualifications		Experience	
	No.	%	No.	%
Managerial	19	23	48	58
Research	58	70	64	77
Total	83	100	83	100

Source: CBR Survey

Table 3: New Local Start-Ups by Former Employees and Inter-Firm Links

"Have any people who have left this company formed their own businesses?"

	Cambridge	Oxford	Total
	No. %	No. %	No. %
New business start-ups by former employees	24 (48)[1]	22 (44)	46 (46)
of which:			
located in local area	23 (96)[2]	19 (86)	42 (91)
of which:			
continuing links with 'parent' firm			
informal			26 (57)[2]
formal			23 (50)
both			18 (39)

[1] % of all firms surveyed

[2] % of new business start-ups by former employees

Source: CBR Survey

Table 4: Region-Specific Advantages for Firm Development in the Cambridge and Oxford Regions

"How important have the following been for your firm's development?"

	% of firms reporting moderately, considerably or extremely important
Attractractive local living environment for staff and directors	80
Credibility, reputation and prestige of a Cambridge/Oxford address	66
Access to international airports	55
Availability of appropriate premises	54
Informal local access to innovative people, ideas, technologies	51
Quality of local research staff	48
Local availability of research staff	48

Note:results relate to the seven most important (out of 19) advantages in terms of the number of firms rating the advantage 3, 4 or 5 on a scale from 1 indicating completely unimportant to 5 indicating extremely important

Source: CBR Survey

Table 5: Local Inter-Firm Networking by Technology-Intensive SMEs in the Cambridge and Oxford Regions

"Do you have any *close* links with other firms in the Cambridge/Oxford region?"

	High-technology manufacturing		High-technology services		Total	
	No.	%	No.	%	No.	%
Cambridge region	17	34	21	42	38	76
Oxford region	14	28	9	18	23	46
Total sample	31	31	30	30	61	61
Number of firms in survey	48		52		100	
of which: Cambridge	21		29		50	
Oxford	27		23		50	

Note: % is of total respondents in each row
Source: CBR Survey

Table 6: The Importance of Local Inter-Firm Links to Cambridge and Oxford Technology-Intensive SMEs

"How important are *local* links with:"

	No.[1]	% of firms with local links
Suppliers or subcontractors	48	65
Firms providing services	40	54
Research collaborators	24	32
Customers	24	32
Firms in your line of business	17	23

[1] Firms rating the local link moderately, considerably or extremely important (3, 4 or 5) on a scale from 1 indicating completely unimportant to 5 indicating extremely important

Source: CBR Survey

Table 7: Opportunities for Informal Contact with Managers or Professionals from Other Local Firms

"How often do you have an opportunity to mix informally with managers or professionals from other local companies?"

Frequency	Cambridge		Oxford		Total	
	No.	%	No.	%	No.	%
Never	8	21	3	13	11	18
Occasionally	19	50	14	61	33	54
Frequently	11	29	6	26	17	28

Note:percentages are of total firms with local inter-firm links

Source: CBR Survey

Table 8: External Sources of Innovations in Products or Services over the Last Three Years

"Please rate the importance of the following as sources of your innovating activities"

	% of total respondents[1]		
	Source in Cambridge/Oxford region	Source in Rest of UK	Source Outside UK
Suppliers of standardised materials or components	8	17	16
Suppliers of customised materials or components	9	22	18
Clients or customers	24	61	56
Competitors in your line of business	7	22	35
Consultancy firms	6	8	3
Universities/higher education institutions	24	34	21

[1] % rating source as moderately, considerably or extremely important (3, 4 or 5 on a scale from 1 completely unimportant to 5 extremely important)

Source: CBR Survey

Table 9: Research and Managerial Staff Recruitment and Mobility within the Cambridge and Oxford Regions

Firms reporting recruitment of at least one of their last three research/management staff from:

	Research staff		Management staff	
	No.	% [1]	No.	% [1]
Cambridge/Oxford University	17	24	5	8
Other Cambridge/Oxford firms or organisations	20	28	21	34
Other UK universities	28	39	6	10
Other UK firms/organisations	31	44	38	62
Overseas universities	10	14	2	3
Overseas firms/organisations	6	8	13	21

[1] Percentages are of total respondents to this question (71 for research staff, 61 for management staff)

Source: CBR Survey

Table 10: The Regional Research, Professional and Managerial Labour Markets and Local Inter-Firm Networking

"Do any links exist between your firm and any other local firms because of *people* who have moved between these firms?"

	Cambridge		Oxford		Total	
	No.	%	No.	%	No.	%
Firms reporting links	23	48	29	58	52	53
Firms reporting that these links were moderately, considerably or very significant for their development	17	77	14	56	31	66

Note:
row 1 is % of all firms
row 2 is % of firms with links due to staff movement (excluding 7 missing responses): rating on scale of 1 not significant to 5 very significant.

Source: CBR Survey

Table 11: Business Support Agencies and Technology-Intensive SMEs in the Cambridge and Oxford Regions

11A "Have you received help or advice from any local agencies (government-sponsored or otherwise) over the last five years?"

	Cambridge		Oxford		Total	
	No.	% respondents	No.	% respondents	No.	% respondents
Training and Enterprise Council	16	32	23	49	39	40
District or City Council	6	12	12	26	18	19
Chamber of Commerce	15	30	15	32	30	31
Enterprise Agency	4	8	5	11	9	9
Oxford Trust	-	-	26	55	-	-

11B "How useful was this help/advice?"

	No.	% respondents
No help sought	19	21
Of no value at all	10	11
Of slight value	13	14
Of moderate value	18	20
Of significant value	18	20
Of great value	12	13

Note:responses to 11B were ranked from 1 of no value at all to 5 of great value.

Source: CBR Survey

Table 12: Institutional Support and the Provision and Quality of Local Services in The Cambridge and Oxford Milieux

"In which of the following areas have you used external firms or services during the last five years? For those ticked, to what extent have you used firms from the Cambridge/Oxford region as opposed to firms located elsewhere? How do you rate the quality of the service or advice provided?"

	Use external firm to provide service?		% responding 'yes' using local firms for 50% or more of their service needs	% of respondents using local firms rating quality of local service provided
	Yes	% firms		4 or 5[1]
Accountancy	79	85	80	70
Banking	76	82	76	46
Venture capital	15	16	62	67
Legal services	72	77	77	69
Management consultants	18	19	31	20
Public relations	20	22	33	33
Personnel and recruitment	51	55	72	45
Advertising	49	53	41	40
Market research	12	13	20	50
Marketing	13	14	33	33
Computer services	35	38	48	61
Design/printing services	72	77	74	84

[1] on a scale from 1 indicating poor quality to 5 indicating high quality

Source: CBR Survey

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