Do clusters really matter for innovation practices in Information Technology? Questioning the significance of technological knowledge spillovers

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Abstract

A widespread assumption in economic geography and the economics of innovation is that firms located in clusters benefit from territorial learning and knowledge spillovers. However, it remains unclear to what extent these benefits actually occur. This paper aims to address this issue and examines to what extent research and development (R&D) workers in the Cambridge Information Technology (IT) Cluster benefit from being located in the Cluster. The study shows why many do not believe that their work benefits from being located in the Cluster. The results suggest that academics as well as policy makers need to be more careful with the assumption of technological knowledge spillovers in innovative clusters. The significant advantages of the Cambridge IT Cluster seem to be of a different nature; in particular they concern labour market advantages and benefits from the global 'brand' of Cambridge.

Keywords: clusters, knowledge spillovers, territorial learning, agglomeration economies

JEL classifications: D83, O18, R11

1. Introduction

It is widely accepted that acquiring external knowledge is crucial for the success of firms, particularly in the creative and high-technology industries (Pittaway et al., 2004). In the literature on regional learning and innovation it is often argued that firms located in innovative clusters benefit from other co-located organisations that create local knowledge spillovers (e.g. Audretsch and Feldman, 2003). Within this context it has been often stressed that informal knowledge networks are crucial for regional competitiveness (e.g. Keeble, 2000; Saxenian, 1996). Furthermore, the more recent debate about local 'buzz' (Bathelt et al., 2004; Storper and Venables, 2004) has emphasised knowledge advantages that can happen without any concrete interactions. However, it is surprising that despite the vast amount of literature on this topic, there is still very little empirical evidence on the mechanisms of local knowledge spillovers. Many assumptions in the literature actually remain untested as highlighted, for instance, by Breschi and Lissoni (2001a) or Döring and Schnellenbach (2006). Whilst a few recent empirical contributions have suggested that the knowledge advantages of clusters might not be that clear-cut (Giuliani, 2007; Moodysson, 2008), more empirical research is needed to clarify the role of clusters for knowledge flows.

The aim of this paper is to critically engage with the assumed innovation benefits of successful clusters by focusing on research and development (R&D) workers—including Technology Managers and Managing Directors in micro businesses—in one of Europe's most prominent high-technology clusters, the Cambridge Information Technology (IT) Cluster. This paper investigates whether R&D workers experience knowledge spillovers and, fundamentally, whether and how the Cluster matters for their work. The results challenge some of the widespread beliefs in the literature. They show that technological knowledge spillovers within the Cluster seem highly limited, and many R&D workers do not believe that their work benefits

from the Cluster. The significant advantages of the Cluster seem to be of a different nature; in particular they concern labour market advantages and the global 'brand' of Cambridge.

This paper proceeds as follows. Section 2 will critically discuss the existing literature on knowledge spillovers in economic clusters, and it will highlight open questions. In section 3 the research design and methodology of the case study will be presented. Section 4 will address the question whether the Cambridge IT Cluster really matters for innovation practices of R&D workers. It will be shown that for many this is not the case and the reasons for this will be examined. Section 5 will explore in which respects the Cluster is beneficial. Section 6 will conclude.

2. Innovation advantages in economic clusters: technological knowledge spillovers and knowledge networks

Since Marshall's (1920/1890) seminal work, local externalities have been used as explanations of regional growth (e.g. Kelly and Hageman, 1999; Krugman, 1991; Porter, 1998). In this context, next to labour pooling advantages and the availability of related materials and other inputs, knowledge spillovers have been emphasised as an important agglomeration force. It is a popular idea that firms located in clusters benefit from local knowledge spillovers: knowledge created by a local agent can be accessed and used by other agents without market interaction and financial compensation for the producer of the knowledge.[1] In particular, in much of the literature on this topic, this concerns technological knowledge generated through

[1] This definition does not regard unintentionality of knowledge flows as a necessary condition because knowledge can be intentionally transferred to other organisations informally. Also, this definition does not include cases of so-called rent externalities where less compensation is given than the market value of the knowledge (Caniels and Romijn, 2005, 499).

research and development (Wolfe and Gertler, 2004, 1076).[2] It has been often argued that knowledge flows freely within co-located organisations as a local public good (Breschi and Lissoni, 2001a). This is often regarded as a source of regional economic growth and as a causal reason for the emergence of agglomerations (Döring and Schnellenbach, 2006).

Most *territorial innovation models*, including concepts such as innovative milieu, industrial districts, clusters, regional innovation systems, and the learning region (see Moulaert and Sekia, 2003), propose that territorial learning and local (technological) knowledge spillovers are an important agglomeration and innovation force. Most approaches concentrate on local socio-cultural pre-conditions for knowledge to diffuse effectively within co-located actors (e.g. Camagni, 1991; Capello and Faggian, 2005; Lawson and Lorenz, 1999; Storper, 1997). Within this context, it has often been claimed that the nature of tacit knowledge, knowledge which is highly contextual and difficult or even impossible to codify (Gertler, 2003), is decisive (Breschi and Lissoni, 2001b). Because it requires direct face-to-face interactions, regular co-presence and a shared local social context, the transfer of such tacit knowledge is argued to be highly localised (Feldman, 1999; Maskell and Malmberg, 1999). Face-to-face is often argued to be a critical medium for knowledge exchange (Morgan, 2004; Storper and Venables, 2004).

Although increasingly multi-scalar knowledge sourcing and 'global pipelines' have been highlighted, current debates still often involve similar ideas on local knowledge flows: Taking up the idea of Marshall's 'industrial atmosphere', the neologisms local 'buzz' (Bathelt et al., 2004; Storper and Venables, 2004) and 'noise' (Grabher, 2002) have been introduced recently. A key characteristic of these

[2] In this article, I differentiate between technological knowledge spillovers, used interchangeably with technological spillovers, and knowledge spillovers, which refer to a broader class of knowledge (including business knowledge).

concepts is that actors in clusters “are automatically exposed to news reports, gossip, rumours and recommendations about technologies, markets and strategies by just being in the cluster” (Bathelt, 2005b, 206).

Furthermore, there have been more empirically oriented approaches of ‘new economics of innovation’ (Audretsch and Feldman, 2003; Feldman, 1999) which have emphasised the importance of local technological knowledge spillovers. Here, knowledge production functions (Audretsch and Feldman, 1996) or patent citations (Jaffe et al., 1993) have been used and proposed as indirect indicators of technological spillovers.

However, these assumptions usually have not been developed on the basis of rigorous empirical work on the processes of learning and knowledge spillovers. Usually without investigating specific mechanisms, firms located in clusters are assumed to benefit from hypothesised knowledge spillovers as critically remarked by Malmberg and Maskell (2002, 434). Also, ironically the meaning and functioning of ‘tacit knowledge’ usually remains tacit (Martin and Sunley, 2003, 17).

The recent focus in economic geography on ‘local buzz’ does not clarify this aspect but rather reinforces the shortcomings. No definition of buzz unambiguously states which social processes are included or excluded in ‘local buzz’ phenomena, face-to-face interactions and buzz are conflated (Asheim et al., 2007), and it still remains unclear whether and how knowledge quasi-automatically travels among local actors (Moodysson, 2008). Thus, the actual processes of territorial learning usually remain unexplored (Benner, 2003, 1810; Oinas, 1999; Staber, 2009). A major reason for this is that the focus on inter-firm knowledge activities tends to neglect personal, and often informal, relationships of individuals; this is the level where the mechanisms of learning actually take place (Malmberg and Power, 2005, 421). With a few exceptions (in particular Benner, 2003; Dahl and Pedersen, 2004; Grabher and Ibert, 2006; Henry and Pinch, 2000; Ibrahim et al., 2009; Kesidou et

al., 2009; Lissoni, 2001; Østergaard, forthcoming; Saxenian, 1996) the literature has not looked closely at cross-firm knowledge links beyond the firm-level and formal linkages. A notable exception in this respect is the survey by Ibrahim et al. (2009), which suggests that inventors in US telecommunication clusters benefit more from local sources of knowledge and knowledge spillovers than inventors not located in clusters. However, the low absolute ratings of knowledge spillovers in their survey, the low response rate and potential sector-specificity produces uncertainty about the prevalence of local knowledge spillovers. Moreover, Kesidou et al. (2009) studied the role of various local sources of knowledge in the Uruguay software cluster; although their respondents rated market-based knowledge flows much higher than non-market knowledge spillovers, they suggest that local knowledge spillovers might still have a significant role for innovation.

Furthermore, as an attempt to look into the processes of knowledge flows, one of the key themes is that networks matter (Keeble, 2000). The dominant picture is that

> "a key feature of successful high-technology clusters is related to the high level of embeddedness of local firms in a very thick network of knowledge sharing, which is supported by close social interactions and by institutions building trust and encouraging informal relations among actors" (Breschi and Malerba, 2001, 819-20).

Empirical studies that do not find extensive knowledge networks in clusters, tend to argue that this is an undesirable situation which is causally responsible for the lack of success of clusters (e.g. Bathelt, 2005a). Often, for instance, in Porter's (1998) work on economic clusters, the role of social networks for clusters is emphasised but the specific mechanisms are not rigorously theorised and empirically investigated (Martin and Sunley, 2003, 16-7). As highlighted by Sunley (2008), this lack of empirical testing of relational accounts can be problematic.

Among the important positive exceptions is the study by Dahl and Pedersen (2004, 2005) which reveals that engineers in the wireless communication cluster

around Aalborg have frequent contacts with each other, which often leads to the receipt of useful work-related knowledge. However, their paper does not examine the value of the transmitted knowledge. Moreover, the contribution by Moodysson (2008) shows that in the Swedish Medicon Valley life science region carefully selected, potentially global, informal networks are important for problem-solving activities but unstructured local buzz seems largely absent. However, the exact role of local clusters and technological spillovers for knowledge workers remain underexplored.

Furthermore, although the elaborate methodological approaches in economics of innovation have thrown some light on the geographical foundations of knowledge production and innovation, they are even more silent about processes of knowledge flows. Because they use indirect indicators, the knowledge production function approach and the patent citation approach are not able to investigate the concrete mechanisms of local technological spillovers (Breschi and Lissoni, 2001a; Döring and Schnellenbach, 2006; Henderson, 2007). Even the most fine-grained recent economic studies on technological spillovers such as Zucker et al. (1998) use crude proxies such as co-authorship to represent more complex and diverse social relationships and processes.

It is important to note that recent literature has emphasised that not only local but knowledge linkages at multiple spatial scales are important (e.g. Amin and Cohendet, 2004; Bathelt et al., 2004; Bunnell and Coe, 2001; MacKinnon et al., 2002). However, the multi-scalar perspective does not imply that local knowledge networks and spillovers are insignificant as, for instance, the ‘local buzz and global pipelines’ (Bathelt et al., 2004) metaphor illustrates. The view tends to be that

> “[l]ocal and global innovation networks thus appear to be of simultaneous – and probably complementary – importance for the competitive success and growth of regionally-clustered technology-based SMEs” (Keeble, 2000, 218).

Overall, knowledge spillovers all to often remain a 'black box' and more empirical research is needed to clarify these issues (Breschi and Lissoni, 2001a; Döring and Schnellenbach, 2006).

This paper aims to address the voids discussed above by being one of the first papers that systematically examines R&D workers and their experiences of an innovative cluster. It addresses the following research questions: (i) To what extent and how does being located in the cluster matter for R&D workers. (ii) Specifically, to what extent do R&D workers benefit from local knowledge spillovers and knowledge networks within an innovative cluster?

3. Case study and research design/methodology

3.1. Research design and sampling

In this paper the term 'cluster' refers to a geographical agglomeration of firms operating in related industries; to what extent in reality relationships and knowledge interactions occur is an empirical question but not part of the definition.[3] Within the Cambridge IT (Information Technology) Cluster, high-technology firms of the sub-sectors hardware and software were randomly selected.[4] In each firm R&D workers were chosen as the embedded unit of analysis.

Cambridge is used as a case study because it is widely regarded as one of the most innovative and successful high-technology region in the UK and the EU (Simmie et al., 2006). The existing literature tends to suggest that in such successful clusters vibrant knowledge flows are going on. Therefore, Cambridge represents a

[3] For a similar approach and a useful discussion of different theoretical concepts see Giuliani (2005).

[4] In the remainder of this paper, "the Cluster" is used interchangeably with "the Cambridge IT Cluster".

prime example where the theoretical assumptions of local knowledge spillovers and inter-firm knowledge flows can be scrutinised.[5]

The IT sector is used as an empirical focus because it constitutes the dominant sector of the 'Cambridge phenomenon' in terms of the number of innovation-based businesses (LibraryHouse, 2004). Within IT, this study looks at the dominant product-based sub-sectors hardware and software (excluding purely service-based companies).

The focus on R&D workers in various job positions—from junior developers, Chief Technology Officers to Managing Directors in micro firms—enables a direct investigation of the knowledge sourcing experiences. Asking managers only would lead to partial and potentially incorrect views because they do not necessarily know what employees are really doing, and their views are likely to be biased towards the official ideal strategy of the firm (see e.g. Dahl and Pedersen, 2005, 76).

The list of the firms in the target population was constructed by merging two existing databases from the research and consultancy companies 'Library House Ltd.' and 'Cambridge Investment Research Ltd.'. Those companies maintained a list of innovation-based firms in the Greater Cambridge Region.

The target population (sampling frame) at firm-level consists of 220 firms, 156 in software and 68 in hardware, in the Greater Cambridge Region. The sample is constituted by first taking a random sample of 100 firms (70 in software, 30 in hardware; that is, the proportions of the sub-sectors in the sample mirror the target population). Within those I asked the firms to select R&D workers according to the

[5] Saxenian remarked in the late 1980s that the tenants of the Cambridge Science Park complain that there is hardly any information sharing or co-operation among firms (Saxenian, 1989, 468-9). However, after a vibrant development in the last decades and more recent studies about Cambridge, nowadays the dominant belief is that local interaction and knowledge flows between firms are indeed a key ingredient of high-tech agglomerations such as Cambridge (see e.g. Garnsey and Heffernan, 2005; Keeble, 2000; Keeble et al., 1999).

following criteria (if applicable): the Managing Director if s/he is actively involved in research or development; the Director of Research or Development or Chief Technology Officer; one 'key' engineer/developer who is regarded as most important for the firm; one senior engineer/developer (e.g. project leader); one mid-level engineer/developer; one junior engineer/developer with less than two years of work experience in the industry.

It has to be emphasised that getting access to the firm was incredibly difficult. After 11 months (January-November 2008), data from 105 individuals in 46 firms were collected.

Taking a multi-method approach, I arranged face-to-face meetings with the R&D workers and went with them through structured questionnaires and conducted semi-structured interviews.[6] Overall, the meetings lasted from 20 to 120 minutes (mean 45 minutes). The recorded interview material was fully transcribed. Using ATLAS.ti software, the quotes were systematically coded, and those codes were categorised into meta-concepts. The results presented in this paper (in particular Figures 1 and 3) are based on this multi-step coding process.

3.2. Key characteristics of the sample

Out of 100 firms in the sample, 46 participated, which represents a response rate of 46% of the firms. 25 firms (54%) are in software, and 21 firms (46%) in hardware, which means that hardware is over-represented in the data (recall that around 70% of the firms in the target population are in software and around 30% in hardware). At the individual level, 58 respondents (55%) are in software, and 47 (45%) in hardware, which again shows that that hardware is over-represented.

[6] To reduce biases as much as possible, assurance was given to the interviewees that their accounts would not be divulged to anybody, particularly not to their boss.

Because there are no detailed data of the population available, it was not possible to check for any additional response biases. However, let us explore several characteristics of the sample.

In contrast to Silicon Valley, Cambridge IT companies tend to be small with only very few exceptions. The average *firm size* in terms of the number of employees (full-time head count) is 35 for the Cambridge sites (median 20) and 81 for all locations world-wide (median 30). On average there are 17 R&D workers in each firm site in Cambridge (median 9).

Since IT is a broad field, let us explore some of the specific characteristics of the Cambridge IT industry. First, let us look at which *knowledge base* is a source of competitiveness. Table 1 outlines which type of knowledge is regarded the main source of competitiveness by the respondents.

Table 1. *Type of knowledge which is rated most highly for contributing to the competitiveness of the firm. "Cutting-edge knowledge can be an important source of competitiveness for firms. With regard to the product you are working on: to what extent does your firm hold cutting-edge knowledge in the following areas that contributes to its competitiveness?" (% of respondents, N=105).*[7]

	Technology	**Market-needs**	**Marketing**	**Management**	**All four rated equally**	**Technology AND market-needs**	**All other combinations**	**Total**
Software	37.9	24.1	3.4	0.0	8.6	17.2	8.6	100.0%
Hardware	55.3	10.6	2.1	2.1	6.4	17.0	6.4	100.0%
Total	45.7	18.1	2.9	1.0	7.6	17.1	7.6	100.0%

In the literature the knowledge base of the software industry has been characterised as being centred on incremental change using widely available technologies rather than radically new scientific knowledge (Steinmueller, 2004, 229). Although several software companies in the sample operate exactly in this mode, the Cambridge software industry seems to be special in containing many

[7] 7-point Likert scale from "1=very much" to 7="not at all" and alternatively "Don't know". The types of knowledge are: "*Technological* knowledge", "Specific knowledge about *market needs* gained from *feedback from customers or suppliers",* "General knowledge in *marketing",* "Knowledge in *management* (e.g. how to organize projects effectively and efficiently)".

companies that apply cutting-edge technology (e.g. new mathematical algorithms) to develop products (37.9%).[8] For hardware companies, as one might expect of this sector, cutting-edge technology is more important than in software: more than half of the R&D workers (55.3%) are in technology-driven companies and only 10.6% in market-driven ones.

In terms of the *job position* in the sample there are 14 Managing Directors, 33 Directors of Research/Development or Chief Technology Officers, 34 senior engineers/developers, 16 mid-level engineers/developers, 6 junior engineers/developers and 2 in other positions. That is, people in senior positions are over-represented in the sample.[9]

On average the respondents worked for 3.0 (median: 2) firms before their current employment, and they lived at 1.8 (median: 2) places outside of the Greater Cambridge region before.

It is characteristic for the *male-dominated* industry that only 6 respondents (5.7%) were female, although I have explicitly tried to ask for female participants in each firm. In terms of *nationality*, British citizens are very dominant with 89.5% being British citizens and an additional 3% sharing a British citizenship with another one. This shows that the labour market is not really internationalised but operates strongly within the national boundary. It is remarkable that only 4.8% are of a non-white *ethnic group*. The average *age* of the respondent is 38.8 years (median: 38) with the vast majority being between 30 and 50 years (11.7% were younger than 30 years, and 6.8% were older than 50 years). Not surprisingly, the respondents are

[8] Also, recall that the sample does not include purely service-based companies.

[9] Two possible reasons for the selection bias are first, that people in junior positions might not feel as confident to speak with 'outsiders' as R&D workers in senior positions. Second, it might be that firm representatives who selected the interviewees believed that experienced senior R&D workers make a better 'impression' for the company.

highly educated with 26.5% having Ph.D. degrees, 31.4% Master's degrees and 35.3% Bachelor's degrees as their highest degrees.

4. Does the Cambridge IT Cluster really matter?

This section investigates to what extent the R&D workers benefit from being located in the innovative Cluster.

4.1. Is the Cluster beneficial for R&D workers?

The R&D workers were presented with the following question: "To what extent is it beneficial for your work in your current firm to have many innovative firms/research institutions located in the Cambridge region?". They could rate if from "1 = very much" to "7 = not at all". Surprisingly the most frequent answer is "7" (see Table 2), which very strongly indicates that for their work the Cluster is not beneficial at all.

Table 2. *"To what extent is it beneficial for your work in your current firm to have many innovative firms/research institutions located in the Cambridge region?" ["1 = very much" to "7 = not at all"] (% of respondents, N=104).*

	Total	**R&D Managers or Managing Directors**	**Engineers or developers**
1 = very much	13.5	16.9	8.9
2	15.4	21.7	12.5
3	13.5	13.0	12.5
4	8.7	10.9	7.1
5	15.4	17.4	14.3
6	15.4	2.2	25.0
7 = not at all	18.3	15.2	19.6
Mean:	4.1	3.5	4.6[10]
Median:	4	3	5

Overall, it seems remarkable that 49.1% explicitly state that it is not beneficial

[10] The difference of the mean between R&D managers/managing directors and engineers/developers is statistically significant at the 1% level (independent samples t-test).

for their work (“5” to “7”) and 8.7% are undecided. Whilst 42.2% think that the Cluster is beneficial (answers “1” to “3”), more than a third of those concern reasons that do not represent knowledge benefits but other advantages which will be discussed in section 5. That is, overall, nearly two-thirds of the respondents do not see a *knowledge* benefit for their work.

These results suggest that in an innovative technology cluster local knowledge spillovers and territorial learning might not be as widespread as the literature tends to suggests. Instead this supports a more critical view that knowledge networks can be selective (Giuliani, 2007; Morrison and Rabellotti, 2009; Østergaard, 2009), and more fundamentally, even in an innovative technology cluster the sourcing of knowledge from the Cluster environment can be very limited. Furthermore, Table 2 also illustrates that R&D Managers and Managing Directors benefit more from the Cluster (median: ‘3’) than ‘pure’ engineers or developers (median: ‘5’).[11]

This begs the question of why many believe that they do not benefit. In the following section we will explore this issue.

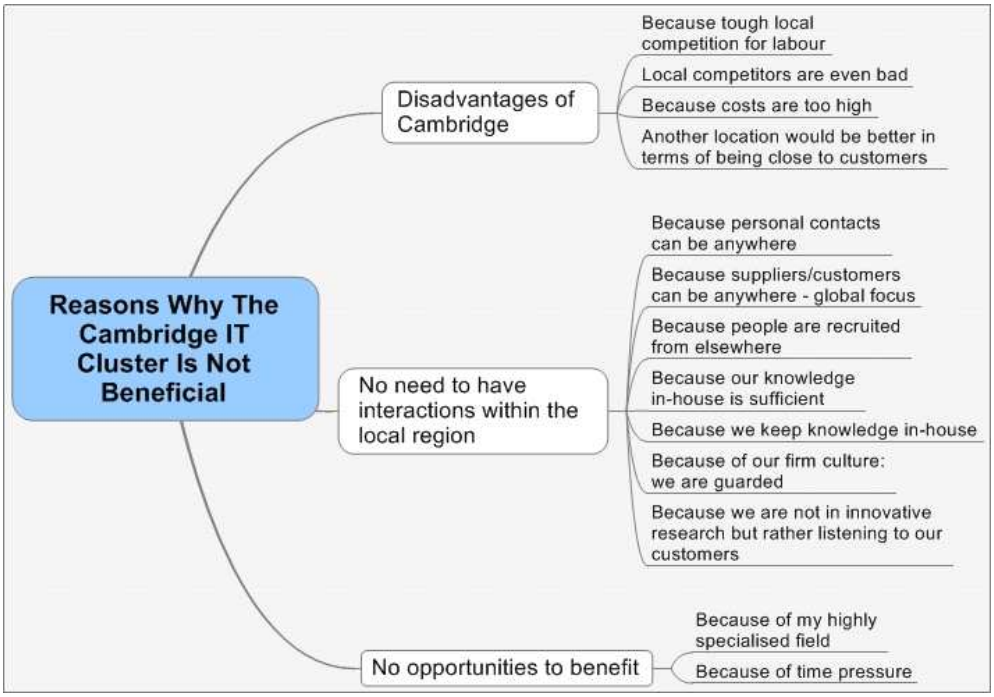
4.2. Why the Cambridge IT Cluster is not beneficial for R&D workers

The following discussion is based on the analysis of extensive interview material; the respondents had the opportunity to qualify why they think that the Cambridge IT Cluster is not beneficial for their work. Their responses fall into these

[11] Whilst it is beyond the scope of this article to discuss detailed regression analyses, it is important to note that the job position is the most important variable in explaining the variation of the responses. In contrast, the knowledge base of the firm, as presented in Table 1, does not make any difference. Furthermore, there are no statistically significant differences between the responses from the R&D workers in hardware versus software.

groups (see Figure 1).[12]

Figure 1. *The reasons why R&D workers think that the Cambridge IT Cluster is not beneficial for their work*



The first group of responses highlights *disadvantages* of the Cluster. All of these were stated by people in managerial positions.[13] Several interviewees emphasised that although there is an extensive pool of highly-skilled labour available in the Cluster, local competition between the employers for bright minds is intense, which can be a disadvantage. This was particularly mentioned by small companies, which lack financial stability and kudos. This warns us that labour pooling cannot be regarded as advantageous for all companies. Other reasons mentioned are that the costs (for office space and labour) are too high, and that other locations would be closer to the customers.

[12] Every single response, even when only mentioned once, was categorised into these types. The frequency of the responses is mentioned approximately in the text. The same applies for Figure 2 below.

[13] Because of the broader responsibilities of the senior-managerial R&D workers, several of their responses in the remainder of this paper concern 'the firm' as a whole. However, note that the units of analysis are the R&D workers and inferences to the firm-level are based on their individual experiences.

Secondly, the most frequently mentioned reason is that there is simply *no need to have interactions* within the local region. The most important arguments mentioned are that personal contacts and suppliers and customers can be anywhere because of the global focus of the company. Also, one respondent emphasised that they recruit people from elsewhere and are therefore not dependent on Cambridge. Moreover, several respondents highlighted that their internal knowledge base is sufficient for being successful and nowadays they can access a lot of useful knowledge via the Internet; consequently, there is no need to source knowledge from the local region. Also, a few respondents stressed that strategically their firm is quite guarded, aims to keep their expertise in-house and does not want to have any knowledge interactions with other Cambridge companies.

Another reason put forward by one firm is that the business model is based on feedback from customers rather than on research (that is, a synthetic rather than an analytic knowledge base according to Asheim et al., 2007); therefore, the research intensive Cambridge environment is not relevant.

A third group of responses underlines that there are *no opportunities to benefit* from the Cluster. The most frequent argument is that the technological field is so highly specific and specialised that there is nobody within the Cluster who could be helpful in terms of either an official business relationship or as a source of knowledge as the following quote illustrates:

> "It [the Cambridge Cluster] doesn't seem to be beneficial in this particular organisation. […] The sort of development work we do is not really the sort of thing that other companies in the area are doing, or has been recently researched by the University." (Applications Group Manager, small hardware company, spin-off of a Cambridge technology consultancy)

Finally, another reason mentioned a few times is that time pressure both in the work place and in private life severely limits the opportunities for professional

socialising and learning from other Cluster companies. Consequently even local inter-firm mobility often does not result in inter-personal knowledge flows:

> "People in this organisation have worked in probably every high-tech software company in this region. […] But I don't know to what extent people maintain their contacts with previous people. […] I would suspect that it is probably less than you might believe because you are so busy generally, and work takes up a lot of time. And family life and all as well, and it's quite difficult to keep that personal thing going." (Senior Developer, large software company)

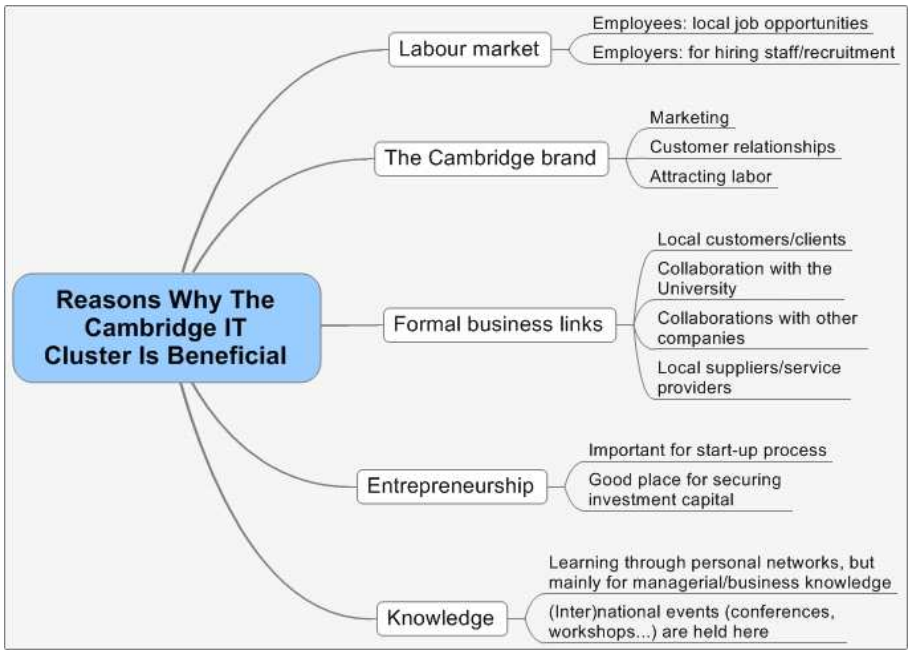
5. Why the Cluster matters

The discussion so far is just one part of the picture. In this section we discuss benefits of the Cluster from the R&D workers' perspective.

5.1. Advantages of the Cambridge IT Cluster

Based on the analysis of the qualitative interviews, Figure 2 provides an overview of the benefits of being located in the Cluster.

Figure 2. *Reasons why the Cambridge IT Cluster is beneficial for R&D workers.*



Labour market advantages. Importantly, the most frequently mentioned benefit is not directly related to the working practices in the current job. Rather, it concerns broader labour market advantages. On the one hand, employees like to work in the Cambridge region for the following reason:

> "One of the attractions of Cambridge for me was that if one job didn't work out, there would be lots of others to choose from. So, that was important for me on a personal level and in terms of career in general." (Application Group Manager, medium-sized hardware company)

That is, the fact that there are many potential employers in the region is a critical issue for many R&D workers in terms of career perspectives and private dimensions ('managing' a family and not having to move house). Interestingly, many of the interviewees believe that this is the only advantage of the Cluster:

> "But for my job there is not really any other specific advantage of being in Cambridge. (mid-level developer, medium-sized software company)

On the other hand, employers and people involved in recruitment value the Cluster because of the opportunities to attract bright minds, both in terms of recruiting people from other local companies and from elsewhere. Again, many interviewees emphasised that this is the only benefit.

Critically, while personal networks are often not important for sourcing R&D related knowledge, they can be important for recruitment; subsequently, technological expertise is not acquired via personal communication but through hiring embodied knowledge:[14]

> "I would say Cambridge is pretty beneficial, but not for knowledge contacts. Rather, if we need some skills that we don't have, we might look to recruit people. And recruiting people within Cambridge is a great way of recruiting. a) there is a

[14] In this article embodied knowledge refers to all aspects of an individual's human capital and also includes embrained knowledge or encultured knowledge according to the terminology of Blackler (1995).

large source of people available, and b) because many of us here are from Cambridge. We probably have a quite large local knowledge about who might be available and might be interested. And it's a great way of finding the right people quickly and readily. So, that sort of networking is very useful at certain times when we are growing teams." (Senior developer, large software company)

In other words, skilled labour mobility can be an important 'collective learning' process (Audretsch and Keilbach, 2005; Eriksson and Lindgren, 2009) as has been also shown for Cambridge by Keeble et al. (1999) as well as by Lawton Smith and Waters (2005; 2008). However, although there is some local inter-firm mobility in Cambridge[15], the vast majority of all recruited managers and R&D workers come from outside of Cambridge (Keeble et al., 1999, 326). That is, the flows of embodied expertise operate on multiple spatial scales and collective learning cannot be seen as a local phenomenon. Furthermore, whether inter-firm labour mobility can be regarded as a form of knowledge spillover is a contested issue (Breschi and Lissoni, 2001a, 992-4). For instance, if the individuals take certain embodied knowledge with them, knowledge is merely shifted from one place to another and does not lead to a club good or public good. Also, hiring embodied knowledge is not free—as the traditional spillover notion would suggest[16]—but the employers have to pay for it (often a premium for 'star' R&D workers).[17]

[15] The average individual job tenure in Cambridgeshire for scientists and engineers in the study by Lawton Smith and Waters (2005) is 5.78 years; they argue that the rate of turnover is below some of the national metrics and surprisingly slow.

[16] It is a contested terminological issue whether rent (or pecuniary) externalities through the official (labour) market should be called knowledge spillovers or not; see Breschi and Lissoni (2001a) versus Caniels and Romijn (2005).

[17] As the recent study by Maliranta et al. (2009) suggests, labour mobility of R&D workers only increases productivity and profitability when they are hired to non R&D occupations, which was interpreted as indirect evidence that mobility between R&D labs do not seem to be a channel for knowledge spillovers.

The Cambridge brand. Another frequently mentioned reason why being located in the Cluster is advantageous is of a more subtle nature: individuals and firms benefit from being related to Cambridge as a global 'brand' indicating excellence in science and technology:[18]

> "I'm not sure about other firms or research institutions being beneficial. I think it's the name Cambridge […]. If you're working in Cambridge, people assume that, I don't know what the word is really, there seems to be a kind of respect because you work in the Cambridge area. I definitely realised this. […] So it is purely Cambridge as an address." (Engineer in a small hardware company)

Many R&D workers think that the Cluster does not impact on their current work, but the company enjoys benefits in terms of marketing and getting orders from customers:

> "For my own work not at all beneficial. It doesn't make any difference at all. But I guess we get quite a bit of work because we are in Cambridge, a kudos thing. But not for me personally." (Developer in a small software company)

For instance, the image of Cambridge makes it easier to attract international customers to visit the company for creating or maintaining business links. Also, it facilitates recruiting R&D workers from abroad.

Formal business links. The results confirm that in clusters there are rather limited official transactions going on between firms (Malmberg and Maskell, 2002, 437). Only a rather small subset of companies in the sample benefit from local horizontal or vertical business relations.

[18] The brand of Cambridge is not only constituted by its world-famous university but also by its agglomeration of high-technology companies (with global media coverage such as in the Economist, 2001).

First and foremost, several specialist technology companies have local clients/customers. These supply highly specific products for high-tech sectors such as inkjet or scientific software for research institutions. Here regular face-to-face contacts are often regarded as convenient and useful for effective discussions.

Second, people in only six companies mentioned that collaboration with the University of Cambridge is important for official research collaborations. That is, whilst the University was influential for the emergence of the Cluster (Garnsey and Heffernan, 2005), official collaborations seem to be limited in present days.

Third, a few companies mentioned beneficial collaborations (e.g. sharing of equipment) with other companies, in particular in display technology and in inkjet, where there is a consortium of local firms (Garnsey and Heffernan, 2005, 1136-8).

Fourth, a few interviewees stated that it is convenient, but not critical, to have local suppliers or service providers.

Also other forms of non-formal business-related relationships are highly selective according to the interviews. In contrast to Giuliani (2007) who finds that business networks are more pervasive than knowledge networks, I could not find evidence of widespread business relationships in the Cambridge IT Cluster. However, it needs to be emphasised that these results are based on R&D workers, who might not have an overview about all kinds of business relationships.

Entrepreneurship. Several respondents, usually R&D workers who founded their own company, emphasised that Cambridge is a great place to set up a business because of infrastructure, institutional support and venture capital opportunities as discussed by Garnsey and Heffernan (2005). Interestingly, a few R&D workers highlighted that although Cambridge was important for the start-up phase, it is not important anymore later on, in particular in terms of knowledge flows.

Knowledge activities. Only few R&D workers mentioned getting access to

knowledge through personal networks as an advantage of the Cluster. Importantly, nearly all is related to business/management knowledge and not to technological knowledge. That is, access to knowledge through personal networks within the Cluster seems to be more important for entrepreneurs or people in senior management positions. Within this context, personal contacts can help for hiring embodied knowledge (see the labour market advantages above). Also help and advice on general management issues can be important:

> "For instance, the CEO of one of those companies rang me three or four weeks ago, he got the opportunity to quote for a very big job, and his concern was, is this job too big for his company's size, it could easily suck in all of his resource and kill him, on the other hand. So he was asking my advice off the record. […] Of course, we actually had that conversation on the phone, so it could have been on the other end of the country, but I think he chose to call me because we had established a personal relationship because it was easy to do so because we see one another, well not regularly, but enough times." (Product Manager, large hardware company)

In this example co-location enabled regular face-to-face contacts, which enabled trust and led to asking for advice on confidential management issues. Whilst this example confirms the widespread views on the advantages of spatial proximity for knowledge sharing, it hardly applies to *technological* knowledge flows: only two interviewees explicitly mentioned that the Cluster is beneficial to discuss specific technological issues with local personal contacts; this helps to explain why job position makes a difference in Table 2. Furthermore, only one person reported that a local 'networking' institution—in this case 'Refresh Cambridge', a community of web designers and developers—was a source of knowledge. Finally, a couple of people stated that it is convenient that conferences or meetings of national professional societies often happen to be in Cambridge, which is an indirect effect of the Cluster.

It should be highlighted that the above results are from the R&D workers'

perspective and might therefore neglect or downplay other potential advantages of the Cluster for other job positions or the firms as a whole (such as access to finance or access to specialist suppliers or intermediary institutions).

5.2. Knowledge spillovers out of sight?

As already discussed, some of the literature suggests that regional learning and local knowledge spillovers might happen 'quasi-automatically' without any tangible interaction (Bathelt et al., 2004; Malmberg and Maskell, 2002). Staber (2009) suggests that imitation without any close interaction can lead to learning in clusters, in particular, concerning strategic business issues. One could argue that the R&D workers might not be aware of such subtle and perhaps 'tacit' knowledge flows. Therefore, one might maintain, we cannot trust the responses of the interviewees.

One could argue that the R&D workers might be competent in reflecting on their working practices. Because 'knowledge work' is their core activity, reflecting on various sources of knowledge is vital for their professional success. Furthermore, many respondents had lived in other places, including more peripheral regions.[19] Contrastive comparisons of different regions might increase the chances that the workers become consciously aware of place-specific contexts and otherwise 'hidden' mechanisms. The following respondent who worked at Silicon Valley before illustrates this:

> "Over there [in Silicon Valley] they talk about everything. So you know in detail about other companies. That's a U.S., Silicon Valley thing. People are just staying in companies a year or two, and you keep your friends. That encourages you to pass information a lot more freely that over here. Here it's different; people stay in

[19] Recall that on average the respondents worked for 3.0 (median: 2) firms before their current employment, and they lived at 1.8 (median: 2) places outside of the Greater Cambridge region before.

> their jobs longer, and there is a bit more loyalty to the company rather than to the social contacts. […] One of the differences were the sales guys over there you know a lot better. And they know everything that's going on in other companies. They talk, they go out for dinner, and they tell what's going on all the time. But it's not that culture here. They don't come here, there is less information." (Principal engineer, medium-sized hardware company)

A few other respondents reported similar experiences. This suggests that the labour market in Cambridge is less dynamic[20], increases loyalty to the employer and consequently leads to less knowledge flows. Furthermore, the cultural norms of sales representatives seem to be different and seem to affect knowledge interactions. This illustrates that institutional and cultural differences in different regions can affect knowledge interactions and spillovers.

However, opinions of interviewees generally might not necessarily reflect real-world processes. Certain processes might happen without any noticeable effort while living in Cambridge so that the respondents are not aware of it.[21] More detailed empirical work on mechanisms of potentially 'hidden' mechanisms is needed to clarify this issue.

6. Conclusions

While the literature tends to assume that firms located in innovative clusters benefit from access to knowledge networks and technological knowledge spillovers, the results in this paper question this. Nearly two-thirds of the R&D workers in IT companies *do not see a real knowledge benefit* for their work in their current company from being located in one of the most prominent and successful IT clusters in Europe. The most frequent argument why the Cluster is not beneficial is that there

[20] Recall that R&D workers do not tend to change their employer frequently (cf. footnote 15).

[21] However, one might question whether really valuable types of knowledge are transferred.

is simply no need to interact with other local companies or research institutions. In particular, many R&D workers believe that alternative sources of knowledge such as internal resources or the Internet are sufficient, or preferable, to be successful. This supports studies such as Freel (2003) which suggest that internal resources and competencies of firms are often sufficient for innovation. A further reason why the Cluster is not beneficial is that there are no opportunities to interact and learn. Similar to Moodysson's (2008) results in the life-sciences, this is especially the case for highly specific technological fields. The results suggests that—somewhat analogously to the insights of Moodysson (2008) for life-sciences—quasi-automatic, non-deliberate local buzz as understood by Bathelt et al. (2004) hardly seems to take place.

Moreover, the paper also shows *why the Cluster does matter*. For only a few companies local client or supplier relationships, collaborations with the University of Cambridge or other companies are important or convenient. In fact, the most frequently mentioned advantage of the Cluster is of a more subtle nature, which has been underrepresented in the recent literature on innovative clusters: R&D workers like to move and stay in the Cambridge IT Cluster because they believe it offers opportunities of always finding an appropriate job without having to move house. This represents a significant benefit to employers for attracting local and global highly-skilled labour. That is, local labour market pooling and local labour mobility do not only lead to well-known externalities (e.g. Eriksson and Lindgren, 2009) but also to non-local effects: the attraction of global talent.

An additional widely mentioned indirect benefit of the Cluster is the global image or 'brand' of Cambridge as a place of excellence in science and technology. This helps companies in terms of marketing, customer relationships and attracting labour. In terms of access to knowledge through personal networks only very few R&D workers see a benefit from the Cluster; this mainly concerns business knowledge of senior managers who appear to benefit more from the Cluster than

'pure' engineers/developers.

We have addressed the argument that more subtle forms of knowledge flows might take place without the interviewees being aware of them, which deserves further empirical investigation. Overall, the empirical results suggest that the role of knowledge networks and technological spillovers in innovative clusters is overrated.

Finally, I should also emphasise the *limitations* of this study and questions for *future research*.

First, it is possible that the situation is different for other job roles, for instance, for managers that are not involved in research or development. Indeed, my results suggest that that job functions matter and that clusters might be more important for senior managers (for sourcing business knowledge) than for engineers/developers (for sourcing technological knowledge).

Second, the potential sector-specificity of the findings in this paper needs to be highlighted. The networking behaviour of engineers/developers in IT might be very distinct. As Grabher and Ibert (2006) have shown, in contrast to creative professionals in advertising, people in software do not tend to practice vibrant, career-oriented networking in the 'sociality' mode. Also, we have to be aware that the study excluded purely service-based companies including technology consultancies which do not offer their own products. As argued by Lawson (2003) such technical consultancies can play a role for the dissemination of technical expertise within the Cluster.[22]

Third, there might be variation in national or regional culture. For instance, the contexts in Uruguay (Kesidou et al., 2009) or Silicon Valley (Saxenian, 1996) might facilitate knowledge spillovers more than in other successful clusters. As discussed in section 5.2., a few respondents who worked in Silicon Valley before noticed

[22] However, only one of the respondents in my sample mentioned to benefit from technical consultancies.

differences regarding knowledge interactions. This suggests that regional differences in terms of labour mobility, loyalty towards the employer and cultural norms of sales representatives make a difference. Comparative research with case studies in different national and regional contexts could examine these questions in detail.

Fourth, this study is an in-depth analysis at a specific point in time but does not investigate potential evolutionary processes and why the Cambridge IT Cluster formed historically. The role of agglomeration economies can change throughout the industry life cycle (Neffke et al., 2009; Potter and Watts, forthcoming). For instance, in the historical emergence of the IT industry in Cambridge, a few key people associated with the University of Cambridge and their personal networks shaped the serial entrepreneurship as documented by Myint et al. (2005). Personal knowledge networks and technological spillovers might have been more important in earlier stages than in present days.

Despite these limitations, this study suggests that *innovation policies* should be careful with the assumption that spatial clustering quasi-automatically leads to knowledge spillovers and networks. For many R&D workers, knowledge relationships with other Cluster organisations seem irrelevant, since alternative sources of knowledge are regarded as sufficient to be successful. In these cases cluster policies that focus on local networking might be inappropriate (see also Romijn and Albaladejo, 2002). Instead, the results suggest that a focus on labour market initiatives to attract and retain a critical mass of R&D workers and related territorial brand management can be more successful.

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References

Amin, A., Cohendet, P. (2004) *Architectures of knowledge: firms, capabilities, and communities*. Oxford: Oxford University Press.

Asheim, B. T., Coenen, L., Vang, J. (2007) Face-to-face, buzz, and knowledge bases: sociospatial implications for learning, innovation, and innovation policy, *Environment and Planning C: Government and Policy*, 25: 655-70.

Audretsch, D. B., Feldman, M. P. (1996) R&D spillovers and the geography of innovation and production, *American Economic Review*, 86: 630-40.

Audretsch, D. B., Feldman, M. P. (2003) Knowledge spillovers and the geography of innovation, in Henderson, J. V., Thisse, J.-F. (eds), *Handbook of urban and regional economics*, Amsterdam: North Holland Publishing.

Audretsch, D. B., Keilbach, M. (2005) The mobility of economic agents as conduits of knowledge spillovers in Fornahl, D., Zellner, C., Audretsch, D. B. (eds), *The role of labour mobility and informal networks for knowledge transfer*, pp. 8-25. New York: Springer.

Bathelt, H. (2005a) Cluster relations in the media industry: exploring the 'distanced neighbour' paradox in Leipzig, *Regional Studies*, 39: 105-27.

Bathelt, H. (2005b) Geographies of production: growth regimes in spatial perspective 2 - knowledge creation and growth in clusters, *Progress in Human Geography*, 29: 204-16.

Bathelt, H., Malmberg, A., Maskell, P. (2004) Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation, *Progress in Human Geography*, 28: 31-56.

Benner, C. (2003) Learning communities in a learning region: the soft infrastructure of cross-firm learning networks in Silicon Valley, *Environment and Planning A*, 35: 1809-30.

Blackler, F. (1995) Knowledge, knowledge work and organizations: an overview and interpretation, *Organization Science*, 16: 1021-46.

Breschi, S., Lissoni, F. (2001a) Knowledge spillovers and local innovation systems: a critical survey, *Industrial and Corporate Change*, 10: 975-1005.

Breschi, S., Lissoni, F. (2001b) Localised knowledge spillovers vs. innovative milieux: knowledge "tacitness" reconsidered, *Papers in Regional Science*, 80: 255-73.

Breschi, S., Malerba, F. (2001) The geography of innovation and economic clustering, *Industrial and Corporate Change*, 10: 817-33.

Bunnell, T. G., Coe, N. M. (2001) Spaces and scales of innovation, *Progress in Human Geography*, 25: 569-89.

Camagni, R. (1991) Introduction: from the local 'milieu' to innovation through cooperation networks, in Camagni, R. (ed.), *Innovation networks: spatial perspectives*, London: Belhaven-Pinter.

Caniels, M. C. J., Romijn, H. A. (2005) What drives innovativeness in industrial clusters? Transcending the debate, Cambridge Journal of Economics, 29: 497-515.

Capello, R., Faggian, A. (2005) Collective learning and relational capital in local innovation processes, *Regional Studies*, 39: 75-87.

Dahl, M. S., Pedersen, C. O. R. (2004) Knowledge flows through informal contacts in industrial clusters: myth or reality?, *Research Policy*, 33: 1673-86.

Dahl, M. S., Pedersen, C. O. R. (2005) Social networks in the R&D process: the case of the wireless communication industry around Aalborg, Denmark, *Journal of Engineering and Technology Management*, 22: 75-92.

Döring, T., Schnellenbach, J. (2006) What do we know about geographical knowledge spillovers and regional growth? A survey of the literature, *Regional Studies*, 40: 375-95.

The Economist (2001) Cambridge's high-tech cluster, 12th April 2001.

Eriksson, R., Lindgren, U. (2009) Localized mobility clusters: impacts of labour market externalities on firm performance, *Journal of Economic Geography*, 9: 33-53.

Feldman, M. P. (1999) The new economics of innovation, spillovers and agglomeration: a review of empirical studies, *Economics of Innovation and New Technology*, 8: 5-25.

Freel, M. S. (2003) Sectoral patterns of small firm innovation, networking and proximity, *Research Policy*, 32: 751-70.

Garnsey, E., Heffernan, P. (2005) High-technology clustering through spin-out and attraction: the Cambridge case, *Regional Studies*, 39: 1127-44.

Gertler, M. S. (2003) Tacit knowledge and the economic geography of context, or the undefinable tacitness of being (there), *Journal of Economic Geography*, 3: 75-99.

Giuliani, E. (2005) Cluster absorptive capacity - Why do some clusters forge ahead and others lag behind?, *European Urban and Regional Studies*, 12: 269-88.

Giuliani, E. (2007) The selective nature of knowledge networks in clusters: evidence from the wine industry, *Journal of Economic Geography*, 7: 139-68.

Grabher, G. (2002) The project ecology of advertising: tasks, talents and teams, *Regional Studies*, 36: 245-62.

Grabher, G., Ibert, O. (2006) Bad company? The ambiguity of personal knowledge networks, *Journal of Economic Geography*, 6: 251-71.

Henderson, J. V. (2007) Understanding knowledge spillovers, *Regional Science and Urban Economics*, 37: 497-508.

Henry, N., Pinch, S. (2000) Spatialising knowledge: placing the knowledge community of Motor Sport Valley, *Geoforum*, 31: 191-208.

Ibrahim, S. E., Fallah, M. H., Reilly, R. R. (2009) Localized sources of knowledge and the effect of knowledge spillovers: an empirical study of inventors in the telecommunications industry, *Journal of Economic Geography*, 9: 405-31.

Jaffe, A. B., Trajtenberg, M., Henderson, R. (1993) Geographic localization of knowledge spillovers as evidenced by patent citations, *Quarterly Journal of Economics*, 108: 577-98.

Keeble, D. (2000) Collective learning processes in European high-technology milieux, in Keeble, D., Wilkinson, F. (eds), *High-technology clusters, networking and collective learning in Europe*, pp. 199-229. Aldershot: Ashgate.

Keeble, D., Lawson, C., Moore, B., Wilkinson, F. (1999) Collective learning processes, networking and 'institutional thickness' in the Cambridge region, *Regional Studies*, 33: 319-32.

Kelly, M., Hageman, A. (1999) Marshallian externalities in innovation, *Journal of Economic Growth*, 4: 39-54.

Kesidou, E., Caniels, M. C. J., Romijn, H. A. (2009) Local knowledge spillovers and development: an exploration of the software cluster in Uruguay, *Industry and Innovation*, 16: 247-72.

Krugman, P. (1991) *Geography and Trade*. Cambridge, MA: MIT Press.

Lawson, C. (2003) Technical consultancies and regional competences, in Dannreuther, C., Dolfsma, W. (eds), *Globalisation, social capital and inequality: contested concepts, contested experiences*, pp. 75-92. Cheltenham: Edward Elgar.

Lawson, C., Lorenz, E. (1999) Collective learning, tacit knowledge and regional

innovative capacity, *Regional Studies*, 33: 305-17.

Lawton Smith, H., Waters, R. (2005) Employment mobility in high-technology agglomerations: the cases of Oxfordshire and Cambridgeshire, *Area*, 37: 189-98.

LibraryHouse (2004) *Flight to quality. The Cambridge Cluster Report 2004*, The Library House, Cambridge.

Lissoni, F. (2001) Knowledge codification and the geography of innovation: the case of Brescia mechanical cluster, *Research Policy*, 30: 1479-500.

MacKinnon, D., Cumbers, A., Chapman, K. (2002) Learning, innovation and regional development: a critical appraisal of recent debates, *Progress in Human Geography*, 26: 293-311.

Maliranta, M., Mohnen, P., Rouvinen, P. (2009) Is inter-firm labor mobility a channel of knowledge spillovers? Evidence from a linked employer–employee panel, *Industrial and Corporate Change*, doi:10.1093/icc/dtp031

Malmberg, A., Maskell, P. (2002) The elusive concept of localization economies: towards a knowledge-based theory of spatial clustering, *Environment and Planning A*, 34: 429-49.

Malmberg, A., Power, D. (2005) (How) do (firms in) clusters create knowledge?, *Industry and Innovation*, 12: 409-31.

Marshall, A. (1920/1890) *Principles of economics. 8th Edition*. London: Macmillan.

Martin, R., Sunley, P. (2003) Deconstructing clusters: chaotic concept or policy panacea?, *Journal of Economic Geography*, 3: 5-35.

Maskell, P., Malmberg, A. (1999) Localised learning and industrial competitiveness, *Cambridge Journal of Economics*, 23: 167-85.

Moodysson, J. (2008) Principles and practices of knowledge creation: on the organization of "buzz" and "pipelines" in life science communities, *Economic Geography*, 84: 449-69.

Morgan, K. (2004) The exaggerated death of geography, *Geography*, 89: 32-49.

Morrison, A., Rabellotti, R. (2009) Knowledge and information networks in an

Italian wine cluster, *European Planning Studies*, 17: 983-1006.

Moulaert, F., Sekia, F. (2003) Territorial innovation models: a critical survey, *Regional Studies*, 37: 289-302.

Myint, Y. M., Vyakarnam, S., New, M. J. (2005) The effect of social capital in new venture creation: the Cambridge high-technology cluster, *Strategic Change*, 14.

Neffke, F., Svensson Henning, M., Boschma, R. A., Lundquist, K.-J., Olander, L.-O. (2009) The dynamics of agglomeration externalities along the life cycle of industries, *Regional Studies*, forthcoming.

Oinas, P. (1999) Activity-specificity in organizational learning: implications for analysing the role of proximity, *GeoJournal*, 49: 363-72.

Østergaard, C. R. (2009) Knowledge flows through social networks in a cluster: comparing university and industry links, *Structural Change and Economic Dynamics*, 20: 196-210.

Østergaard, C. R. (forthcoming) Knowledge flows through social networks in a cluster: interfirm versus university-industry contacts, *Structural Change and Economic Dynamics*.

Pittaway, L., Robertson, M., Munir, K., Denyer, D., Neely, A. (2004) Networking and innovation: a systematic review of the evidence, *International Journal of Management Reviews*, 5-6: 137-68.

Porter, M. E. (1998) *On competition*. Boston, MA: Harvard Business School Press.

Potter, A., Watts, H. D. (forthcoming) Evolutionary agglomeration theory: increasing returns, diminishing returns, and the industry life cycle, *Journal of Economic Geography*, doi:10.1093/jeg/lbq004.

Romijn, H., Albaladejo, M. (2002) Determinants of innovation capability in small electronics and software firms in southeast England, *Research Policy*, 31: 1053-67.

Saxenian, A. (1989) The Cheshire cats grin - innovation, regional-development and the Cambridge case, *Economy and Society*, 18: 448-77.

Saxenian, A. L. (1996) *Regional advantage: culture and competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.

Simmie, J., Carpenter, J., Chadwick, A., Martin, R., Wood, P. (2006) *State of the English cities. The competitive economic performance of English cities*. London: Department for Communities and Local Government.

Staber, U. (2009) Collective learning in clusters: mechanisms and biases, *Entrepreneurship & Regional Development*, 21: 553-73.

Steinmueller, W. E. (2004) The European software sectoral system of innovation, in Malerba, F. (ed.), *Sectoral systems of innovation. Concepts, issues and analyses of six major sectors in Europe*, pp. 193-242. Cambridge: Cambridge University Press.

Storper, M. (1997) *The regional world: territorial development in a global economy*. London: Guilford Press.

Storper, M., Venables, A. J. (2004) Buzz: face-to-face contact and the urban economy, *Journal of Economic Geography*, 4: 351-70.

Sunley, P. (2008) Relational economic geography: a partial understanding or a new paradigm?, *Economic Geography*, 84: 1-26.

Waters, R., Lawton Smith, H. (2008) Social networks in high-technology local economies - The cases of Oxfordshire and Cambridgeshire, *European Urban and Regional Studies*, 15: 21-37.

Wolfe, D. A., Gertler, M. S. (2004) Clusters from the inside and out: local dynamics and global linkages, *Urban Studies*, 41: 1071-93.

Zucker, L. G., Darby, M. R., Armstrong, J. (1998) Geographically localized knowledge: spillovers or markets?, *Economic Inquiry*, 36: 65-86.