

CONTEXTUALISING THE ROLE OF EXTRA-FIRM PERSONAL NETWORKS AS A SOURCE OF WORK-RELATED KNOWLEDGE

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ABSTRACT

This paper systematically examines the role of extra-firm personal knowledge networks vis-à-vis alternative sources of work-related knowledge. A guiding question is whether there is a difference between job positions. The study is based on a survey and interviews with 105 R&D workers in 46 IT companies in the Greater Cambridge Region. The results show that alternative sources of knowledge are considerably more important than external personal networks. Importantly, the results highlight that for technical engineers/developers, external personal knowledge networks are significantly less important than for senior managers. Furthermore, the most frequent type of knowledge that is uniquely available through personal networks concerns business knowledge of senior managers rather than technical knowledge. Overall, the results suggest that academic theory and R&D management/policy on personal knowledge networks needs to be more sophisticated and would benefit from differentiating between job positions.

Keywords:

Personal networks, knowledge networks, knowledge sourcing, R&D, inter-organisational networks

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1. INTRODUCTION

The acquisition of knowledge has been identified as a key topic for understanding innovative firms and R&D management. Importantly, technological fields have become increasingly dynamic and complex in recent times. This implies that an individual R&D worker faces challenges in terms of sourcing the kind of knowledge required for his/her work. Knowledge-based theories of the firm (e.g. Galunic & Rodan, 1998; Kogut & Zander, 1992) and theories of transactive memory (e.g. Akgun et al., 2005; Hollingshead & Brandon, 2003) have emphasised that specialised knowledge is distributed across different individuals. For solving certain R&D problems, a firm needs to integrate distributed knowledge. This requires communication across individuals and working groups (Berends et al., 2006; Tushman, 1978), and it has often been argued that there increasingly is a need to source knowledge outside of ones own organisation. Accordingly, the increasingly distributed nature of networked R&D makes external sourcing of knowledge important (Howells, 2008; Howells et al., 2003; Huggins, 2010; Leonard-Barton, 1995).

However, the literature has often uncritically accepted the importance of extra-firm personal knowledge networks. This involves the risk of ‘empirically immune’ celebrations of relational theories (Sunley, 2008); that is, the risk that research is merely reinforcing theoretical assumptions rather than contributing new insights on the basis of critical analysis. More critical empirical research is needed to understand the exact significance of extra-firm personal knowledge networks and to contextualise them vis-à-vis alternative sources of knowledge. Specifically, the literature has ignored the question whether the importance of personal knowledge networks varies according to job positions.

This paper aims to address this issue by systematically examining the relative significance of extra-firm personal knowledge networks—often only called personal networks in this paper—for R&D workers in SMEs in the Cambridge IT (information technology) Cluster. The results are based on a survey and interviews with 105 R&D workers—including technology managers and managing directors in micro businesses—in 46 hardware and software companies in the Greater Cambridge Region. The paper aims to investigate the role of personal networks vis-à-vis alternative sources of knowledge for (i) problem solving and (ii) keeping up-to-date with the latest developments, and it aims to explore which kinds of knowledge are uniquely available through personal networks. A guiding question for the analysis is whether there is a difference between job positions, in particular between senior-managerial versus ‘purely’ technical positions.

The results lead to a more nuanced picture by highlighting that for many R&D workers the role of extra-firm personal networks is limited because alternative sources of knowledge—in particular internal colleagues and the internet—are much more important. More specifically, the paper shows that the job position is critical: for non-managerial engineers/developers, personal networks are significantly less important than for senior R&D managers. This is reinforced by the finding that the most frequent type of knowledge which can be sourced uniquely through personal networks concerns business knowledge rather than technological knowledge. Overall, the results suggest that rather than uncritically celebrating the importance of personal knowledge networks, academic theory and R&D management/policy needs to be more sophisticated and would benefit from differentiating between job positions.

The remainder of the paper is structured as follows. First, the existing literature is critically discussed and gaps are highlighted in section 2. Section 3 outlines the methodology of the study. Afterwards, section 4 examines the general importance of personal knowledge networks for the R&D workers. Section 5 investigates the role of personal networks vis-à-vis alternative sources of knowledge for problem solving and keeping up-to-date with the latest developments. Finally, the paper examines which types of knowledge are uniquely available through personal networks (section 6). Section 7 concludes.

2. SOURCING KNOWLEDGE: PERSONAL NETWORKS AND BEYOND

Nearly all recent territorial innovation models have highlighted that networks between firms and organisations are critical for innovation and regional economic development (Boggs & Rantisi, 2003, 109; Grabher, 2006, 164). Furthermore, inspired by the work of Lundvall (1992), the general literature on innovation has highlighted the vital role of interactive learning across organisations (Pittaway et al., 2004). For instance, in the software industry, it has been widely argued that knowledge networks, alliances and partnerships are essential (Grabher, 2004; Jordan & Segelod, 2006; Segelod & Jordan, 2004; Trippel et al., 2009, 445). In the light of these thoughts, ‘open innovation’ has been proposed as a strategy to deliberately allow inflows and outflows of knowledge across company boundaries to enhance innovation capability (Asakawa et al., 2010; Chesbrough, 2003; Mortara et al., 2010). It has been often argued that firms without external knowledge linkages face severe disadvantages in terms of innovativeness and commercial success (Enkel et al., 2009).

Knowledge networks can represent formal arrangements such as official alliances, subcontracting, co-operative agreements, joint ventures, R&D collaboration or licensing (see e.g. Krätke, 2010; Lane & Probert, 2007; Powell et al., 1996). Furthermore, many of the conceptual approaches in the literature on learning and innovation have also stressed the importance of informal inter-firm networks beyond and next to officially planned collaborations. Individuals often know each other and interact beyond official business duties, which can lead to knowledge flows and learning. As a result, the activities of employees are often invisible to executives and managers. As illustrated, for instance, by Allen et al. (2007), gaining an understanding of informal organisation of R&D staff is critical for knowledge management. Several studies have shown that informal personal networks are often an invisible, but powerful, intangible infrastructure (e.g. Allen, 1977; Cross & Parker, 2004; Krackhardt & Hanson, 1993). The seminal work by Allen (1977, 145) has also highlighted the role of gatekeepers: they are key people who are exposed to sources of knowledge outside of their organisation and to whom others within the organisation frequently turn for knowledge. More generally, the acquisition of resources through personal networks has been emphasised by the discourse on social capital (Chen et al., 2008; Lin, 2002), which can also encompass inter-firm relationships beyond organisational boundaries.

In the innovation literature, the critical role of informal personal knowledge relations, which can even take place among rivals, has been emphasised (e. g. Carter, 1989; Von Hippel, 1987). Also in the entrepreneurship literature, the importance of internal and external personal networks has been highlighted (Chen & Wang, 2008; Collinson & Gregson, 2003). External relationships can help entrepreneurs to source complementary knowledge as illustrated, for instance, by Macpherson et al. (2004).

Furthermore, in the literature on regional economic development, it has been argued that informal contacts across companies, often driven by inter-firm mobility, can lead to important inter-organisational knowledge linkages (e.g. Keeble, 2000; Saxenian, 1996). Moreover, the collective, and often informal, aspect of knowledge production in regional economies has been emphasised – often with reference to the notions of communities of practice and epistemic communities (Amin & Cohendet, 2004; Benner, 2003; Brown & Duguid, 2000; Håkanson, 2005).

However, there seems to be the general danger in the above-mentioned literature that relational research is merely confirmatory and empirically immune: “there is little dialogue between theory and data, little real possibility of falsification but, rather, a continual mirroring and reinforcement of ideas” (Sunley, 2008, 18). The risk is that research only looks for examples of personal knowledge networks that can be found somewhere without contextualising how widespread or important these examples are. In particular, to avoid this danger, it seems essential to investigate the role of personal networks vis-à-vis alternative sources of knowledge.

In the innovation literature, a few studies have already warned us that the heavy focus on inter-firm networks might be exaggerated by highlighting that intra-firm knowledge sources and market relations can often be sufficient for innovation, not only for large firms but also for SMEs (e.g. Freel, 2003; Huggins & Johnston, 2009; Romijn & Albaladejo, 2002; Vega-Jurado et al., 2009; Weterings & Boschma, 2009). Although these statistical analyses are important contributions, there are two rather fundamental limitations. First, external knowledge networks are crudely measured. Second, these studies examine the relevance of knowledge networks on the firm-level and not at the individual level. Yet, the personal level is where the mechanisms of learning and knowledge flows actually tend to take place (Liebeskind et al., 1996; Oliver & Liebeskind, 1997-98), even if they are embedded in formal networks. Consequently, the above-mentioned studies are limited and cannot reveal the knowledge sourcing practices in detail.

Also Oakey (2007) argues that successful R&D tends to be located in focused groups within firms, whereas external knowledge relationships in local clusters tend to be limited because of confidentiality and competition. Yet, more research is needed to systematically empirically investigate the role of personal knowledge networks relative to alternative sources.

The relative significance of various sources of knowledge for innovation practices is an underexplored topic (Trippel et al., 2009, 444). An important exception is the study by Trippel et al. (2009), which examines a variety of formal and informal knowledge. In particular, they demonstrate that in the Vienna software industry informal networks and what they call spillovers (reading literature and patent specifications, monitoring competitors, recruiting specialists, and participating in trade fairs and conferences) are most important. However, this study still leaves certain questions unanswered: first, their research does not examine for which types of work (e.g. management, technical problem solving or exploration) those sources are used. Second, external sources are not contrasted with internal sources (in particular asking colleagues within the firm). Third, the composition of their respondents in terms of job positions remains intransparent; their focus on surveying ‘firms’/‘key personnel’ seems to be on higher managerial job positions, which leaves out the experience of ‘normal’ engineers. This to ignorance towards potential differences between job positions reflects the general weakness of the existing literature. In particular, whether knowledge sourcing is different for R&D

workers in senior-managerial positions compared to ‘purely technical’ workers remains unexplored. This study addresses these three shortcomings.

This paper addresses the above-mentioned issues by examining the following research questions: (i) what is the significance of personal networks vis-à-vis alternative sources of knowledge for individual R&D workers, and (ii), does the importance of personal networks vary for different job positions?

3. METHODOLOGY

Cambridge was the focus because the study aimed to understand the knowledge sourcing practices in a prominent high-technology region. 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 list of the firms in the target population was constructed by merging two existing databases on innovation-based firms from the research and consultancy companies ‘Library House Ltd.’ and ‘Cambridge Investment Research Ltd.’. The target population (sampling frame) at firm-level consists of 220 firms, 156 in software and 68 in hardware. 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 the firms were asked to select R&D workers according to the 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.

Getting access to the firms was challenging. After 11 months, data from 105 individuals in 46 firms were collected. Taking a multi-method approach, face-to-face meetings with the R&D workers were arranged and structured questionnaires as well as semi-structured interviews were used. The interviewees were briefed about the meaning of the terms ‘personal networks’ or ‘personal relationships’ for the purpose of this study; in particular it was emphasised that it is about personal relationships which can be purely private or professional as long as it involves personal acquaintance and the work-related knowledge interaction goes beyond official duties.

The recorded interview material was fully transcribed. Using ATLAS.ti software, the quotes were systematically coded, and those codes were categorised into meta-concepts.

Let us examine some 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.

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).

Table 1 outlines the job position of the respondents in the sample, which shows that people in senior (engineering/development or managerial) positions are over-represented in the sample.

Table 1. Job positions of the respondents (N = 105)

	N	%
R&D Managers	47	44.8%
Managing Directors	14	13.3%
Directors of R&D or Chief Technology Officers	33	31.4%
‘Pure’ engineers/developers	58	55.2%
Senior engineers/developers	34	32.4%
Mid-level engineers/developers	17	16.2%
Junior engineers/developers	7	6.7%

4. ASSESSING THE GENERAL IMPORTANCE OF PERSONAL KNOWLEDGE NETWORKS

To understand the overall importance of personal networks and to avoid the danger of celebrating their importance in an uncritical manner, the interviewees had to assess the following statement: “For people who have a job like mine and want to be successful in it, it is very important to have personal relationships with professional colleagues in other firms or research institutions”. Although this question seems rather leading towards the popular view that networks are beneficial, 40.8% did not explicitly agree with this statement if one includes the undecided category (see Table 2).

Table 2. Importance of personal knowledge networks. *“For people who have a job like mine and want to be successful in it, it is very important to have personal relationships with professional colleagues in other firms or research institutions” (N = 103)*

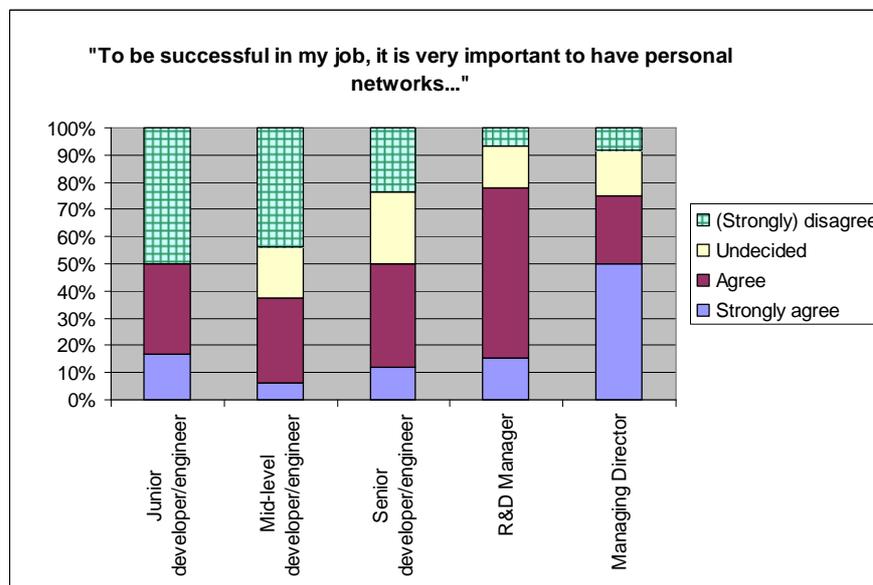
	Total	R&D Managers or Managing Directors	Engineers or developers
Strongly agree	17.5%	24.4%	10.7%
Agree	41.7%	51.1%	35.5%
Undecided	18.4%	15.6%	21.4%
Disagree	21.4%	6.7%	32.1%
Strongly disagree	1.0%	2.2%	0.0%

That is, although the most frequent answer is ‘agree’ (41.7%), many do not regard personal contacts to professional colleagues outside of their company as important for their current job: 22.4% disagree or strongly disagree, and 18.4% are

undecided. The most frequently mentioned reason for being undecided is that personal networks might help but they are not sure whether this is really critical to be successful in the job. Furthermore, 12 respondents self-critically remarked that personal networks would be important but they do not have any. The most frequent qualitative response to this question, mainly mentioned by engineers/developers, was that personal networks are very helpful for getting jobs but not necessarily essential for acquiring work-related knowledge.

Furthermore, the table also illustrates that for senior managerial people personal knowledge networks are significantly more important than for ‘pure’ technical workers: only 24.5% of the R&D Managers/Managing Directors—compared to 53.5% of the engineers/developers—were undecided, disagreed or strongly disagreed. Looking at this issue in more detail, Figure 1 illustrates that there is a clear picture: the higher the job position, the more important are extra-firm personal networks.

Figure 1. Importance of personal networks by job category (N = 103)



The analysis of the interview material suggests that there are two main reasons for this. First and most importantly, the nature of the job of ‘pure’ developers/engineers versus people in managerial positions (R&D managers or Managing Directors) seems to be significantly different: senior managers need to talk to other people outside of the company much more frequently; hence, it follows that senior managers are more likely to benefit from personal relationships with people outside of their company. Second, people in senior managerial positions need to assess the market environment and potential people they could recruit. These types of knowledge are often uniquely available through personal networks. The technical knowledge ‘pure’ developers/engineers need for their work tends to be available through other sources such as the internet or local colleagues. That is, the nature of the job position shapes which kind of knowledge one needs, which subsequently shapes the importance of personal networks.

Moreover, to gain an understanding of concrete examples of personal knowledge networks, the respondents were asked to think of up to four most important personal contacts outside of the firm for work-related knowledge in the past year. It seems

remarkable that 16.5% could not think of a single personal contact, and more than 75.7% could not think of four contacts. This represents complementary evidence for, and reinforces the results about, the limited importance of personal networks.

Overall, these results highlight that the role of extra-firm personal networks for gaining work-related knowledge is varying. In particular, there is a clear pattern that the higher the job position, the more important are personal knowledge networks.

5. THE IMPORTANCE OF PERSONAL NETWORKS VIS-À-VIS ALTERNATIVE SOURCES OF WORK-RELATED KNOWLEDGE

Let us look into this issue in greater detail by evaluating the relative importance of personal knowledge networks in contrast with other sources. The interviewees were asked to describe their knowledge sourcing practices for problem-solving and keeping up-to-date with new technological developments. In particular, the role of colleagues within the firm in the respective site, other colleagues within the firm but in other sites, the internet (including online discussion forums), documents within the firm, professional publications, personal contacts from other firms or research institutions, chatting with strangers at events, and institutionalised customer/supplier relationships were discussed.

Table 3. Sources of knowledge for problem solving. “When you faced a problem in your work and you did not know a solution, how important were the following sources of knowledge (e.g. information, know-how) for you in the past year?” (1 = Very important, 7 = Not important at all, N = 104)

	R&D Managers (mean)	‘Pure’ engineers/ developers (mean)
Colleagues within your firm in this site	2.05	1.43
Other information on the Internet (e.g. blogs)	3.09	2.66
Documents within your firm (e.g. intranet, other documentation)	3.87	3.50
Professional publications (e.g. magazines, journals, books)	4.00	3.70
Online discussion forums or email discussion lists	4.13	3.8
Other colleagues within your firm but in sites located somewhere else	3.29	4.65
Personal contacts from other firms or research institutions	3.86	4.78
Other: institutionalised suppliers (mentioned two times in open answer category)	2.00	3.00

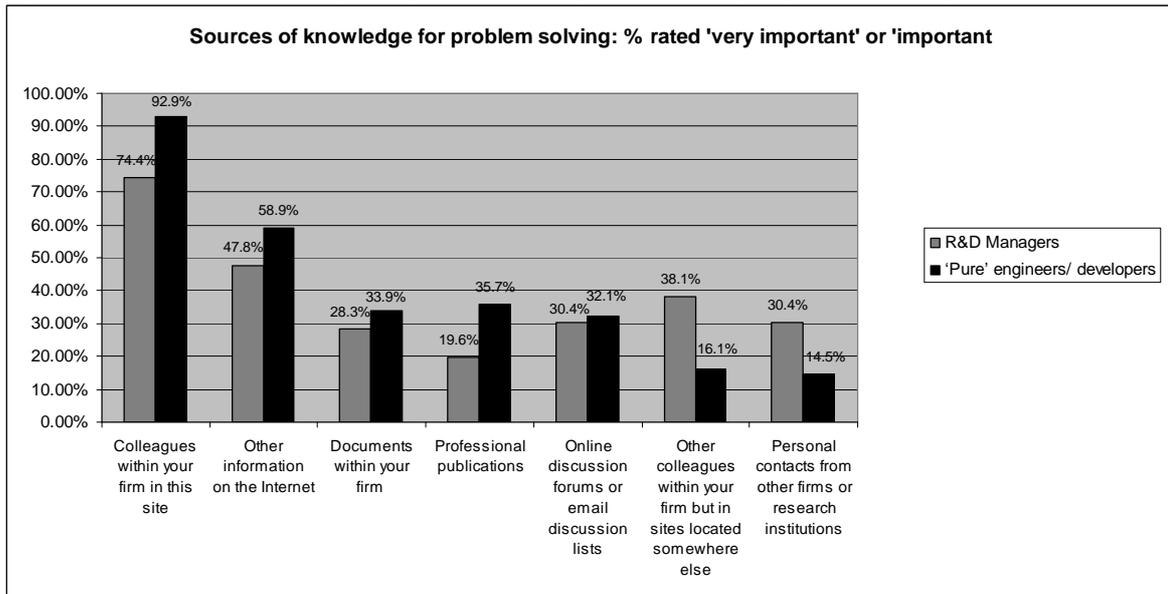
The data in Table 3 illustrate the importance of various sources of knowledge for problem-solving on a scale from “1” (very important) to “7” (not important at all). Colleagues within the firm in the respective site are the most highly ranked source of knowledge (mean: 2.05 for R&D managers and 1.43 for ‘pure’ engineers/developers). Also the internet and, in two cases, institutionalised supplier relationships² are very

² Two respondents mentioned institutionalised supplier relationships in the open answer category. This refers to knowledge relationships to suppliers which are governed by an official market-relationship rather than by inter-personal relationships; that is, people are able to contact a supplier without having to know a specific person at the respective company.

important. Interestingly, personal contacts outside of the company are the least important source.

Figure 2 illustrates those sources of knowledge ranked as ‘very important’ or ‘important’. First, this highlights again that personal networks are the least important source of knowledge, and second, it shows that job position matters: whereas 30.4% of the R&D managers rated personal networks as (very) important, this is only the case for 14.5% of the engineers/developers. For engineers/developers colleagues, the Internet, documents or professional publications are significantly more important than for R&D Managers.

Figure 2. Sources of knowledge for problem solving: % rated ‘very important’ or ‘important’



Generally, a frequently mentioned approach for sourcing knowledge is a combination of colleagues and the internet:

“Usually the first step is just google to see what there is. And if the problem is anything related to our work, there will be someone in this building who will be an expert on it, so the first step is somebody here. [...] Much of the stuff I do is experience based and people here know. And other people move to this company and that’s how knowledge gets passed” (principal engineer, medium-sized hardware company).

This quote also underscores the importance of experience-based learning and labour mobility; people from other firms bring in their experience-based, embodied knowledge and can subsequently act as a local source of expertise within the company. The results are in line with the arguments by Whelan et al. (2010) that the internet has become important for modern gatekeeping activities linking external and internal communication.

It should also be noted that several respondents commented that on the basis of their experience, they tend to solve problems on their own:

“The main benefit for me comes from reading technical periodicals, documentations and also my past experience and background training you have as an engineer, and using that knowledge to project forward” (R&D manager, small hardware company).

That is, one should not ignore the role of individual human capital as a ‘source’ of knowledge.

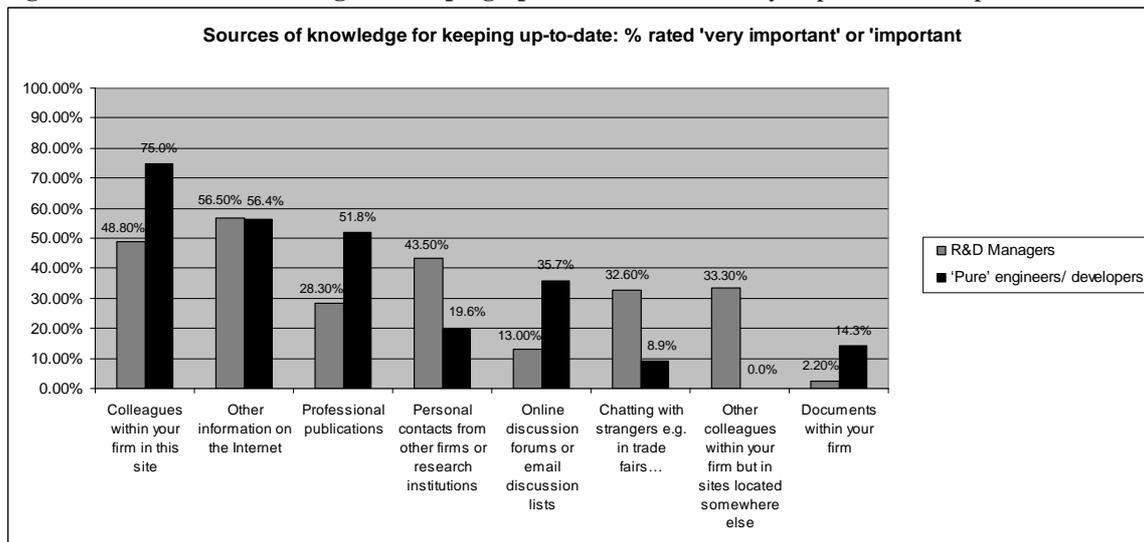
Furthermore, next to problem-solving, keeping up-to-date with new technological developments is another important knowledge activity.

Table 4. Sources of knowledge for keeping up-to-date with new technological developments.

“Keeping up-to-date with the latest work-related technological developments (new potential solutions, tools, techniques) can be crucial and can be a challenge. How important are the following sources of knowledge (e.g. information, know-how) for you to be informed about and assess the importance of the latest technological developments?” 1 = Very important 7 = Not important at all (N = 104)”

	R&D Managers (mean)	‘Pure’ engineers/ developers (mean)
Colleagues within your firm in this site	2.95	2.00
Other information on the Internet (e.g. blogs)	2.61	2.67
Professional publications (e.g. magazines, journals, books)	3.61	3.21
Personal contacts from other firms or research institutions	3.43	4.30
Online discussion forums or email discussion lists	4.35	3.82
Chatting with strangers e.g. in trade fairs/conferences/seminars/workshops	3.91	4.98
Other colleagues within your firm but in sites located somewhere else	3.62	5.53
Documents within your firm (e.g. intranet, other documentation)	5.39	4.66
Other: institutionalised customer/supplier relationships (mentioned two times in open answer category)	2.00	1.00

Figure 3. Sources of knowledge for keeping up-to-date: % rated ‘very important’ or ‘important’



As Table 4 shows, relative to other sources of knowledge, personal contacts from other firms or research institutions are slightly more important with average ratings of 3.43 and 4.30 respectively. However, also here colleagues within the site, the internet and, for three respondents, institutionalised customer/supplier relationships are by far the most important sources. Several of the respondents explicitly stated that extra-firm personal contacts are not a prerequisite for being successful in their job.

Figure 3 again illustrates that in terms of (very) important sources of knowledge, personal networks are significantly more important for R&D Managers than for engineers/developers (43.5% versus 19.6%).

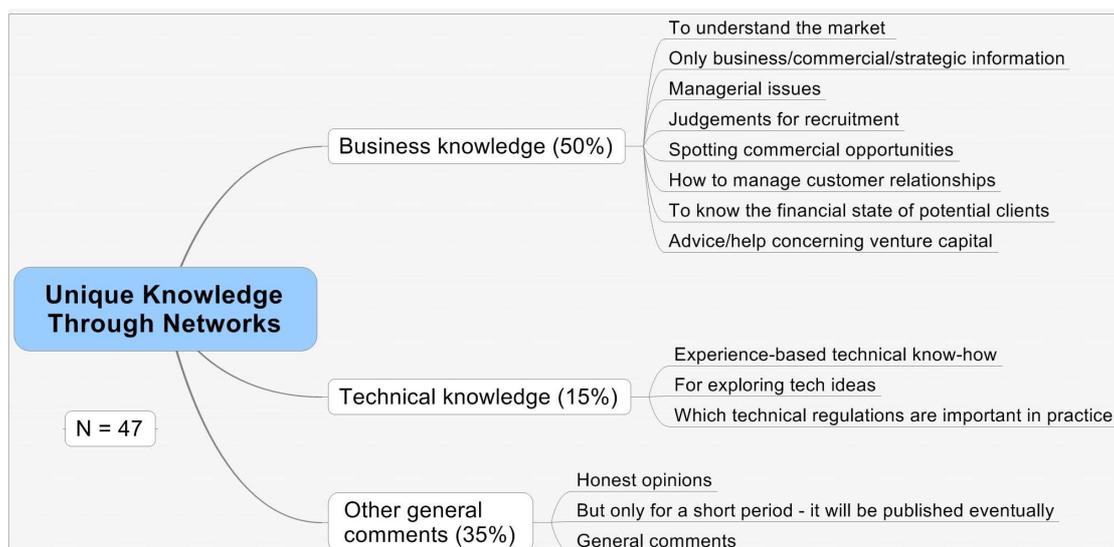
Previous studies have emphasised the importance of knowledge relationships with customers for software companies (Isaksen, 2004; Kesidou et al., 2009; Segelod & Jordan, 2004; Trippel et al., 2009). In this study ‘personal contacts’ can include customer relationships insofar they involve personal acquaintance and interaction that goes beyond official formal requirements, and indeed for several respondents this was the case.³ But apart from that, customer relationships were not mentioned.⁴ That is, in contrast to the above-mentioned literature which states that generally customers are an important source of knowledge, the results clarify that for problem solving and keeping up-to-date this is not the case.

6. UNIQUE SOURCES OF KNOWLEDGE THROUGH PERSONAL NETWORKS

Having provided an overview of the importance of personal networks vis-à-vis alternative sources, let us now be even more specific about their exact role. The interviewees were asked whether there are any types of work-related knowledge that can *only* be accessed through personal networks (and not through any other medium).

Interestingly, more than half of the respondents emphasised that they do not think that there is any knowledge of this type. In several cases, the respondents put forward reasons why personal networks can be helpful, but they highlighted that they could also access this type of knowledge through other sources. Figure 4 shows the types of work-related knowledge which one can only access through personal networks.

Figure 4. Unique knowledge acquired through personal networks



³ Overall, 12% of the most important knowledge contacts are customers/clients.

⁴ During the pilot study and in the actual study, the respondents had the possibility to mention any other source in an open category.

Importantly, the most frequent class of knowledge—mentioned by nearly 50% of the respondents and primarily senior managers—is *business knowledge*. A typical response is the following:

“I think business information is what we talk about, because the technical information is, I think, becoming increasingly available on the internet” (head of development, micro-sized software company).

The most frequent response is that networks are helpful for senior managers in terms of *understanding the market*:

“For instance, gossip. [...] Through chit-chat you can find out about other companies, what people are doing, where they are moving from and to, you really can’t get that kind of information very easily any other way. So, this helps you build a picture of the market as it really is. [...] So you can find out in a few minutes chatting what products perhaps people are interested in developing, whether they are moving into another market, whether they are addressing this successfully” (managing director, small software company).

This is a theme that has been emphasised by various authors in the literature on regional learning and innovation (Bathelt et al., 2004; Malmberg & Maskell, 2002); yet, importantly, it only concerns business knowledge.

Furthermore, many people in managerial positions find networks useful for *managerial issues* of senior managers:

“I think there is a lot you can learn from other people’s experiences with people. And because my job now is so dealing with people rather than then technology side, I find that very useful. And I think I would struggle to find that written down. [...] Just the experiences they’ve had, and I’ve had and the reaction on what I have been through, it’s been very interesting” (programme manager, medium-sized hardware company).

Also in terms of recruitment personal networks can be essential for judging other people. Related to this, two respondents mentioned the spotting of commercial opportunities:

“A further class of problems is where there are commercial opportunities where again it’s probable that a personal contact is, who is able to bring another perspective, because they know more about the industry than you do. [...] Here personal contacts is the only plausible way forward” (product manager, medium-sized hardware company).

Furthermore, one respondent learned *how to manage customer relationships*, and one managing director emphasised that *getting to know the financial state of potential clients* is useful.

Finally, one respondent emphasised that personal networks were essential for *advice/help concerning venture capital*.

The second broad category of knowledge uniquely acquired through personal networks is *technical knowledge*, which, interestingly, has mainly been stated by respondents working in hardware. However, in contrast to business/commercial knowledge, this type is only mentioned by few respondents (about 15%).

The most frequently stated reported sub-type is *experience-based technical know-how*, mentioned only by hardware engineers as the following quote illustrates:

“In electronics there is a lot of rules of thumb and there is stuff, you know, you do a college course or a university course and you might be qualified, but it’s not the same as the knowledge that people get from actually doing it for real.” (senior engineer, small hardware company).

Interestingly, all of these cases concern physical materials. This suggests that accessing uncodified technical know-how largely concerns material objects rather than ‘immaterial’ intellectual problems.

However, one has to bear in mind that much of the learning of experience-based knowledge happens through learning from colleagues within the firm rather than extra-firm personal networks.

Furthermore, a few interviewees mentioned *exploring technical ideas*, in particular on cutting-edge technologies, as unique types of knowledge only available through networks:

“For the work we do there aren’t that many people, not all of it is currently held in the public domain. We are cutting-edge on a number of things, which means that it is sometimes handy to be able to talk to people in similar sort of fields, because they may not have published the work yet, or they may have published only some of it. And it would be useful to bounce ideas off them, which we do” (senior engineer, medium-sized hardware company).

Moreover, one person remarked that assessing which codified technical regulations are actually important in practice is a non-trivial issue which can only be resolved through personal networks.

Third, about 35% of the respondents made *other general comments* on the usefulness of personal networks.

First, several people emphasised that personal relations with people you trust (regarding competence) can be critical for getting *honest opinions* (both in terms of technical and business knowledge):

“You can usually get quite a frank and sincere answer from that group of people, whereas if you were reading a, you know, trade magazine or something you are not quite sure whether this is a truly independent opinion or otherwise. Yeah, I think, it’s a test, whether it’s just marketing. Trusting people” (director of engineering, medium-sized hardware company).

That is, personal networks help to differentiate between ‘strategic’ marketing and independent opinions.

Furthermore, several R&D workers emphasised that personal networks are useful as unique sources of knowledge but *only for a short period*, because *it will be published eventually*. However, respondents from only very few companies stated that this is the case. Many people from companies that are also technologically cutting-edge, did not state that this is the case for them.

Among those who stressed that personal networks offer no unique source of knowledge, several respondents emphasised that networks nevertheless help to have *knowledge filtered and acquired more quickly*. That is, even if there is a great quantity of information available in the public domain, it is non-trivial to filter out the important bits. Here personal relationships with people you trust and have been in a similar situation can increase the speed of filtering in order to find out which information is good for the respective particular problem:

“Most of it is available through publications or online. But it can be much faster to speak to someone and to work it all out. And that’s often because if someone has been through a particular problem before, knows ‘Ah!, that’s the problem, and this way you need to do it!’ Or ‘This is what you need to read!’ Whereas if you try to assemble all the information yourself from various sources, journals and other books and publications, it can take a lot longer and you can reinvent the wheel” (mid-level developer, micro-sized software company).

According to the resource-based view in strategic management (Barney, 1991; Barney, 2007), value and rareness of resources within the firm are positively related to competitive advantage, which positively affects firm performance. The empirical results highlight an important qualification of the resource-based view: filtering public knowledge, although it is not rare, can still represent critical value.

7. CONCLUDING REMARKS

This paper has sought to critically investigate the widespread view that extra-firm personal knowledge networks are critical for R&D. Whilst a few studies have indicated that the significance of external networks might be exaggerated in the literature (e.g. Freel, 2003; Huggins & Johnston, 2009; Romijn & Albaladejo, 2002; Vega-Jurado et al., 2009; Weterings & Boschma, 2009), this paper systematically examines the importance of extra-firm personal networks vis-à-vis alternative sources of knowledge from individual R&D workers' points of view. Specifically, this paper addresses the underexplored topic whether different job positions in R&D make a difference.

The significance of personal knowledge networks has been investigated in three steps:

First, the paper has analysed the general importance of personal networks, which reveals a polarised picture and showed that senior-managerial R&D workers (R&D managers or managing directors) find personal knowledge networks significantly more important than purely technical engineers/developers.

Second, we have seen that alternative sources, in particular colleagues within the same site and the internet, are much more important sources of work-related knowledge than personal networks. This is the case for keeping-up-to-date with the latest developments but even more so for problem solving. These results highlight the critical significance of intra-firm knowledge networks among colleagues, and it shows that for extra-firm learning the internet, rather than personal networks, tend to be vital. Furthermore, the results suggest that, in contrast to previous literature which has stressed that customer relationships are a most important external source of knowledge for software companies (Segelod & Jordan, 2004; Trippel et al., 2009), for problem solving and keeping up-to-date with new technology, customer relationships are only of very limited importance. Importantly, again the results highlight the significance of job roles: for purely technical R&D workers, personal knowledge networks are significantly less important than for senior-managerial R&D workers.

Third, the paper has examined kinds of knowledge which are available uniquely through personal networks. The results show that the most frequent type concerns business knowledge rather than technological knowledge, which reinforces the findings that for managerial job positions personal networks are more important. Furthermore, personal networks can be a critical help for filtering out the pieces of publicly available knowledge R&D workers need for a specific problem. This enriches the resource-based view (Barney, 2007), which has not appreciated such subtle dimensions of useful public knowledge.

Overall, the results suggest that rather than assuming that extra-firm personal knowledge networks are generally important for R&D, we need to develop a more nuanced understanding. For many R&D workers, personal networks seem irrelevant or of limited importance. In these cases policies that focus on facilitating networking might

be inappropriate (see also Romijn & Albaladejo, 2002). In particular, the results highlight that R&D management and policies such as 'open innovation' should consider the significance of job positions. Since in particular for non-managerial engineers/developers, personal knowledge contacts outside of their organisation often seem of very limited significance, it seems most fruitful to concentrate fostering external personal knowledge contacts on senior-managerial job functions.

Finally, it should be mentioned that because the results are based on SMEs in the IT sector within one innovative region, there is a need for further research to explore whether similar patterns hold in other sectors and regions. The networking behaviour of engineers/developers in IT might be distinct. As Grabher and Ibert (2006) have argued, creative professionals in advertising are more active 'networkers' than people in software. Also, it remains unclear whether service-based firms show different patterns than technology-based firms. Furthermore, there might be national differences in networking behaviour as suggested by Dodd and Patra (2002).

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