The Search for External Knowledge

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Abstract: The purpose of this paper is to examine the process by which firms search for external knowledge, with a view to better understanding how to represent and manage this central function of the knowledge exchange process; the identification and acquisition of external knowledge being a fundamental activity for organisations seeking to replenish their internal knowledge stocks. However, previous research on search activity does not distinguish between internal and external search actions. Therefore, conceptual and empirical understandings about external search activity are very scarce. This paper seeks to address this gap by investigating the external search activity of three Irish based manufacturing firms. The comparative case method is used to develop a framework of external knowledge search. Findings regarding external knowledge search activity are identified across six key areas; drivers of external search, problem definition and external search, external search actions, external search paths, external knowledge sources and external search frequency. This paper's theoretical contributions and empirical findings increase our understanding about the external knowledge search process and in turn aid managerial decision making centered on harnessing the value of external knowledge and resource allocation to boundary spanning activity.

Keywords: external knowledge: knowledge search: external knowledge search: knowledge acquisition: open innovation: exploitation: exploration

1. Introduction

In 2000, Procter and Gamble initiated their 'connect and develop' strategy aimed at boosting innovative output and supplementing a lagging 'invent it ourselves' model. This open innovation strategy has since resulted in multiple successful developments including Olay Regenerist and Oral B pulsonic toothbrushes. The 'connect and develop' model is centred on 'systematic searching for proven technologies ... (can be)…improved, scaled up and marketed, either on our own or in partnership with other companies' (Huston and Sakkab, 2006: 62). Connect and develop is just one example of how organisations are focused on harnessing the innovative power of external knowledge. While the concept of open innovation has been studied extensively, the mechanism by which external knowledge is searched for and acquired by the firm remains relatively unexplored. This paper examines the external knowledge search process through a cross case comparison analysis of three exploratory case studies within the Irish High Technology sector.

External knowledge is important to firm innovation processes for two reasons, firstly the integration of external knowledge allows firms to create new knowledge and thus close internal knowledge gaps and external competitive gaps (Zack, 2005). Secondly, the use of external knowledge avoids the risk of an over-reliance on internal knowledge, thus avoiding learning traps. The benefits derived from the sourcing and assimilation of external knowledge centre on the development of absorptive capacity (Cohen and Levinthal, 1990), architectural competency (Henderson and Cockburn, 1994) and dynamic capability (Zahra and George 2002). To this end, many organisations enable and facilitate boundary spanning activities, such as, external partnering activity; boundary spanning networks, informal boundary spanning communities and individual level interpersonal networks. Sourcing and acquiring external knowledge in therefore a primary concern of business organisations. Organisations source external knowledge through external search activity.

In addition, internal and external knowledge pools exhibit very different characteristics, for instance, external knowledge pools often display increased levels of variance, which in turn can increase the variance of search outcomes (Lichtenthaler et al, 2010). Compared to internal knowledge sources, searching in external domains often means that searchers have limited prior experience and limited control (Mezias and Glynn, 1993), this is further reflected in higher levels of uncertainty (Koput, 1997). However, despite the differing characteristics of internal and external knowledge pools, most researchers have chosen not to distinguish between internal and external search. As proposed by Katila (2002: 1006), 'researchers know a lot about a firm's ability to search internally over time', less however is known about external search activities.

While direct research is limited, inferences on external search activity can be drawn from related areas. We do know that organisations make choices about search activity, in that, some organisations favour external knowledge sources over internally generated knowledge (Menon and Pfeffer, 2003), while others exhibit a 'not invented here syndrome', and rely predominantly on internal knowledge sources (Allen, 1986). A process requiring complementary recombinatory problem solving efforts by the firm is also linked to external search (Cassiman and Veugelers, 2006). In addition, Lane and Lubatkin (1998) argue that skills different to those required to process internal knowledge, characterise the firm's ability to acquire, integrate and exploit knowledge sourced from the external search space. Lastly, the traditional conceptualisation of search activity as existing on a technological trajectory operationalised as varying degrees of exploitation (local search) and exploration (distant search), is assumed to apply to external search activity also (March, 1991).

This paper contributes to both the knowledge search and innovation literatures by extending our understanding of the external knowledge search process. Despite continued contentions that the success of innovative performance is dependent on externally sourced knowledge and know-how (Keeble et al, 1999); studies detailing the external search process as part of organisational knowledge acquisition processes are limited.

Based on the rich exploratory data, we develop a framework of the external search process and compare it to classic conceptions of search. The primary point of departure between these two conceptions is the investigation of external search process as a distinct activity, with distinct characteristics.

2. Data and methods

Our goal in gathering the exploratory data was to delve into the process by which external knowledge is searched for. As a result we identified firms in industries which we believed would have a large representation of external search activity. Data was gathered from three multinational organisations, operating in Ireland. The case firms operate in the Medical Device, Consumer Healthcare and Biotechnology sectors respectively. For each firm we identified a formal group with whom the study would be conducted. In the Medical Device firm we identified the advanced process development group (hereafter APD group), who were responsible for research and development onsite. In the Consumer Healthcare firm we identified the knowledge management group. The knowledge management group had responsibility for the advancement of knowledge management onsite and packaging development. Lastly, in the Biotechnology firm, we identified the technology transfer group, during the course of this study; the technology transfer group was engaged in the inward transfer of a new drug manufacturing process.

These three cases are important as they each represent a different contextual environment for external knowledge search, thus ensuring that the potential derived understandings on external search are maximised. The use of a qualitative case study approach to investigate organisational search, represents a departure from previous search literature, which to date is dominated by investigation through quantitative techniques such as computer simulation, structured patent analysis and survey data (e.g. Levinthal and March, 1981; Mezias and Glynn, 1993; Makadok and Walker, 1996; Katila, 2002). The implementation of a qualitative approach allows a deeper understanding of *how* external knowledge search happens.

The case investigation was conducted over an 18 month period, using the between method triangulation of in-depth interviews, non-participant observation and documentation analysis. The comparison method proved particularly efficient in this instance, since it enabled the comparison of different three exploratory cases from different perspectives. Data collection, reduction and display were aided by the use of the qualitative data analysis programme QSR NVivo.

3. A Framework of external knowledge search

3.1 The classic model of search

Classic management research on search, built on evolutionary economics and behavioral theory, argues that search is a costly and at least partly planned and routinised process through which organisations attempt to solve problems, discover opportunities in an ambiguous world and drive adaptation. Organisation search is motivated in response to problems, such as, a need to improve upon current technologies (Nelson and Winter, 1982), learn and develop new skills (Makadok and Walker, 1996) and adapt to environmental change (Cyert

and March, 1963). Searching without a problem, is only tolerated in times of success (Levinthal and March, 1981). Search often takes place in complex and dynamic environments (March and Olsen, 1976); thus searching organisations often have incomplete information about the search environment and the best solutions, these uncertainties drive indecisiveness about where and how to search. This means that the effectiveness of search actions can be highly context-dependent. Search is costly (Cyert and March, 1963), especially if the target is ambiguous; however, investment in search is a key determinant of a successful outcome for organisations (Levinthal and March, 1981). These time and monetary costs constrain searchers in the location of optimal solutions, and therefore they exhibit satisficing behaviour. Search is goal directed (March and Simon, 1958), with search frequency and propensity often responding to changes in perceived success or failure. Search is also regarded as path-dependent, in that, new searches begin where previous searches ended, over time leading to the establishment of search rules and routines (Nelson and Winter, 1982). As described by Cyert and March (1963), search often begins as local and only becomes more distant if the initial search actions fails to generate a 'satisficing' outcome. Search is a central agent of organisational change (Sastry, 1997), as by driving problem-solving, search also drives adaptation. In this view, search strategies follow organisational change activities, characterised as simplistic or complex (Miller et al., 1996). Searching organisations are also members of searching communities, and therefore the outcomes of searching are dependent on not only the firms' own activity, but the search activity of others (March, 1996).

Organisations can develop capabilities in the area of search, based in part on its path dependent nature. Eisenhardt and Martin (2000) liken search actions to a dynamic capability due to the role knowledge search plays in keeping organisations abreast of changes in the environment. Added to this Kogut and Zander (1992) propose that knowledge search actions on the part of organisations represent a combinative capability, in that search represents a way in which organisations can capture and integrate knowledge resources with the aim of creating new resources. Within evolutionary models the process of search is viewed as resulting in organisational adaptation and learning, since adaptation commonly occurs in response to environmental change and learning implies the development of new skills, achieving these outcomes through search behaviour can decrease the risk of organisational failure. In this way, goal oriented search should provide a selection advantage (Levinthal, 1990).

A common strand of search theory is that search is characterised by the technological direction of search effort, i.e. the type of knowledge the firm is searching for relative to their own knowledge base. The technological direction of search distinguishes between a) increasing specialisation on what the organisation already knows vs. b) searching what is new to the organisation. Many researchers have treated these two constructs as opposite ends of a single continuum, indeed a hallmark of management literature is the tradeoff between the flexibility and efficiency of organisations (March, 1991). Within early management theorising, Cyert and March (1963) make the distinction between problemistic search i.e. search that is focused on improving and/or refining current practices, and innovative search, i.e. search that is focused on changing the practices used by the organisation. Levinthal and March (1981) later refer to this as the focusing of search activity within refinement or innovative pools of knowledge, March (1991) adopts this construct under the terms exploitation, referring to refinement and exploration, referring to innovation. An addition to the technological focus of search activity is the degree to which a searcher focuses on exploitation and exploration, i.e. search depth and scope (Katila and Ahuja, 2002).

Search models routinely depict the search process as both linear and sequential and investigate search activity solely at the firm level (e.g. Levinthal and March, 1981; Mezias and Glynn, 1993; Makadok and Walker, 1996). Following the majority of investigation in the area, the processes involved in exploitation, receive more attention. Conversely, investigations into the processes involved in exploration, are limited, this is due in part to the proliferation of Campbell's (1960) early observation that exploratory search is often 'blind' from a process perspective, whereby, the search unit must engage in recombination and trial and error to improve radically upon current technologies. Later models have attempted to address this and represent a more complex search process, particularly in relation to non-local search activity (e.g. Koput, 1997; Katila and Ahuja, 2002; Mahdi, 2003), representing search as a more dynamic process.

Search modeling begins with Levinthal and March (1981) who regard organisations as experiential learning systems, thus emphasising the local and path-dependent nature of search. Levinthal and March's (1981) decision rules have in turn been adopted by Mezias and Glynn (1993). Although, Levinthal and March (1981: 327) warn that their model 'is obviously incomplete…it assumes…a very simple conception of search', it

remains one of the most comprehensive models of organisation search. Makadok and Walker (1996) model search activity within the sphere of evolutionary economics, thus the selection advantages attributed to search take precedence over detailing the search activity itself. These and other models also assume an organisation's search activity to be goal-directed, by persisting in areas of previous success and impacted upon by the perceived variance of search opportunities. Theoretical and empirical investigations into the external search process are lacking however.

3.2 The external search process

Figure 1 illustrates our framework of the external search process. The external search process is distinct from the classic conceptions of search presented in the previous section in multiple ways. Examples include the emergent nature of external search at individual level, the evidence of micro level drivers of external search, the addition of a social search dimension as evidenced by the search mechanisms used by searching units and the ongoing nature of the search for external knowledge. The majority of external search actions evidenced in our case analyses followed a similar series of steps as outlined in Figure 1.

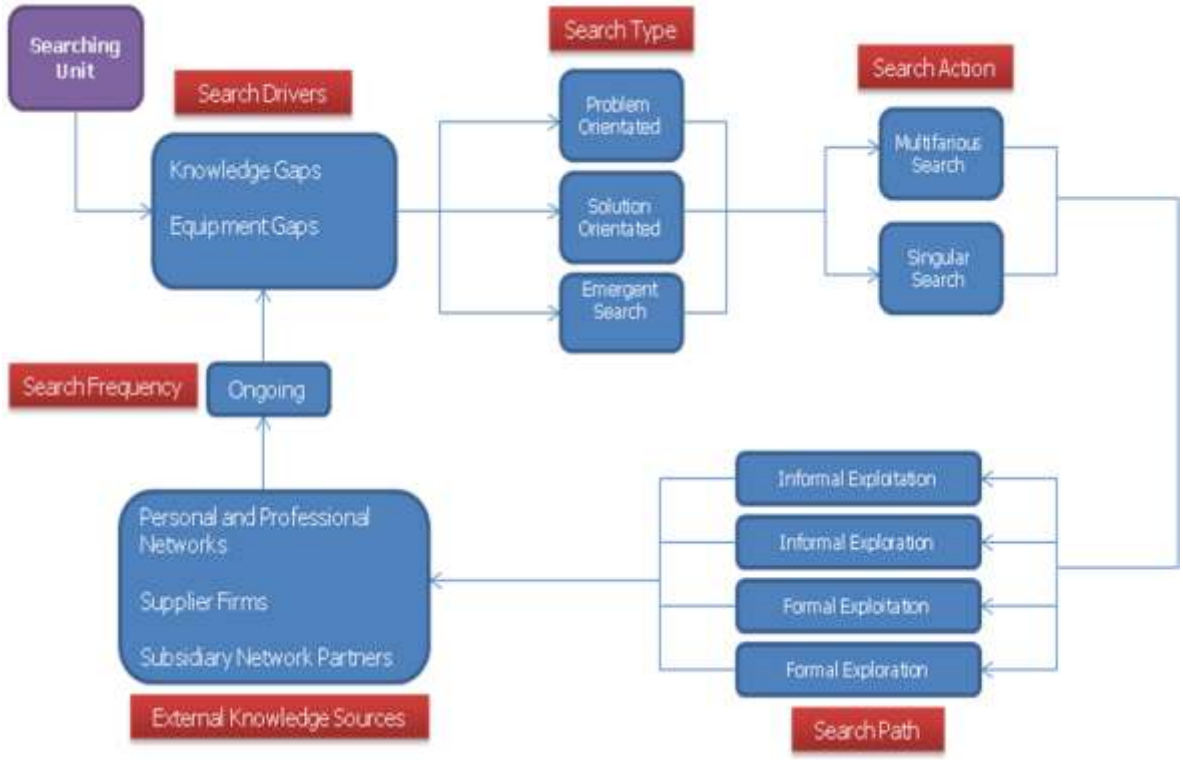

Figure 1: A framework of external knowledge search

Drivers of External Search

Traditional search literature cites search as motivated by the need to solve problems, central of which is the need to meet or exceed performance goals (e.g. Mezias and Glynn, 1993). Evidence from this study, however, classifies specific micro-issues that drive the external search activity of searching units. Firstly, searching units are motivated to search externally to close knowledge gaps. Previously, Zack (2005) determined that locating external knowledge is a key way in which firms can fill internal knowledge gaps and external competitive gaps. The drive to fill knowledge gaps was evidenced throughout the firm at both personal and firm level. Mechanisms evidenced in this regard at the firm level included hiring from competitor firms, as reflected by McEvily and Chakravarthy (2002), merger and acquisition activity, market intelligence activity and the formation of partnerships and collaborative relationships with outside bodies. At the personal level, as evidenced in recent studies in personal knowledge management (Wright, 2005), knowledge processes play an important role in filling these gaps at the more micro levels of the firm also. In addition to enhancing personal knowledge stocks, the acquisition and dissemination of external knowledge can also improve one's status internally. As reported by Menon and Pfeffer (2003) compared to heavily scrutinised internal knowledge, external knowledge appears to be more special and unique and therefore more valuable.

Secondly, searching units in this study were motivated to search externally to close internal equipment gaps. As the head of the technology transfer team commented, 'there were equipment gaps, that were essential to fill, something that could only be done externally'. The decision to search for equipment externally highlights the cost efficiencies that can be garnered through external searching (Powell et al., 1996). In all cases the cost of developing the necessary equipment internally would have far outweighed the cost of external search and partnering. Of course, the focus on the need to fill equipment gaps is most likely a direct result of this studies focus on manufacturing firms.

External Search and Problem Definition

First, the degree of problem definition prior to the search action influences the external search action. Two categories of external search were identified, emergent search and reactionary search; reactionary search can be further subdivided into problem-orientated and solution-orientated external search. Acknowledging degrees of problem definition in external search allows for the representation of search actions stemming from problems that are well defined and finite at the start of the process (problem-orientated), to evolving problem definition, happening throughout the process (solution-orientated).

When a problem is well defined prior to the search action, multiple levels of the firm engage in problem-oriented external search. For instance, in the Consumer Healthcare firm a concerted effort was made to ensure problems were well defined by searching individuals and groups prior to partnering or searching externally. The predominance of problem-oriented external search at the Consumer Healthcare firm, may reflect the fact that early stage research and development work does not take place on site, as reflected upon by the Supply Chain Manager, 'there is usually a well defined need'.

When a problem is not well defined, prior to searching externally individuals and groups engage in solution-orientated external search. We found that the absence of a well defined search problem meant that searching units searched a wider number of possibilities, across a wider area of technological disciplines, allowing them, as one technologist put it, to 'make sense of everything you think you need to know'.

Emergent external search is search enacted by the individual level with no prior problem definition. Individual searchers simply wanted to expand their personal knowledge relating to particular topics that held a special interest for them. While these knowledge areas were not related to the work occurring onsite at the time of search action, they later became central to each firm's strategy. For instance, in the medical device firm one member of the APD group had a personal interest in laser technology, this was manifested in conference attendance and subscriptions to publications, this occurred prior to lasers becoming central to the firm's manufacturing strategy, at which point the Individual in question became a central driver of laser technology onsite. These findings on emergent external search reflect findings on the early stages of community of practice development, whereby, individuals satisfy their own technological and professional interests through external scanning (Wenger et al, 2002). However, traditional concepts of search would consider, emergent search inefficient or irresponsible.

The External Search Action

March (1994) alludes to branches of search actions, when he cites goals as representing search branch points along which multiple firm-level search heuristics can be enacted. In relation to external search actions, however, our findings demonstrate that problems as opposed to goals represent the search branch points and define the search action. Comparative evidence across all three case firms highlights that external search is enacted in one of two ways; multifarious external search and singular external search.

In multifarious external search actions searching units search among a number of external knowledge sources simultaneously. The decision to engage in multifarious search is driven by, preference, i.e. searchers and groups simply prefer to use a multifarious search strategy or, necessity, i.e. problems that are very open and not well defined often mean that a multifarious approach has to be used as knowledge on the location of suitable solutions is limited. For instance, the members of the APD group regarded a multifarious search action as reflecting search policy within the group, whereby the aim of the group, as highlighted by the head engineer, was to 'pursue different options, at the same time'. Multifarious external search actions were

enabled by the proliferation of boundary spanning technologies on offer, including, patent and journal databases, the internet and knowledge management and social networking tools.

In a singular external search action, searching units focus their search effort on one source of external knowledge during the search action, often this makes singular search suited to problem-oriented search, as the well defined nature of problems makes the prior identification of solutions and therefore knowledge sources more straightforward. Singular search actions are enabled by the many formal boundary spanning arrangements in place with research institutes and Universities. These relationships necessitated the natural gravitation towards these external sources when a solution was required.

External Search Paths

As in classic models of search, searching units engage in exploitative and exploratory search, albeit externally focused. However, in this study, another dimension is added to the technological trajectory of search. In external search actions, searching units also search along a social dimension, using both formal and informal search mechanisms. Informal search mechanisms occur in response to personal and operational needs and generally do not have prior or formal recognition from the firm's decision making centre. Formal search mechanisms on the other hand, are enacted in response to functional and strategic objectives and generally have authorisation from the firm's decision making centre. Taken together the technological and social trajectories of external search illustrate four search paths searching units follow into the external search space. These external search paths are as follows, informal exploitation, informal exploration, formal exploitation and formal exploration.

In this study we found that informal search mechanisms draw predominantly on the personal and professional networks of search actors. These informal mechanisms provided access to both local and distant external knowledge sources. From the perspective of informal exploration, having access to personal and professional networks outside of one's own industry, enabled searchers to overcome many of the confidentiality issues that prevent within-industry knowledge sharing. Whereas, when the aim of external search actions was to retrieve exploitative knowledge, informal mechanisms aimed at personal and professional networks across the subsidiary networks of all case firms. In addition, conference attendance, as well as, non-personal sources of knowledge, such as the Internet and journal databases were important sources of external knowledge accessed through informal mechanisms.

Formal search mechanisms aimed at sourcing local knowledge focused on contracted relationships with research institutions and training bodies, as well as, other searching units located within their subsidiary network. For instance, the APD group at the Medical Device firm located exploitative knowledge through the formation of contractual relationships with research institutions with similar technical bases, such as the Industrial Chemical Institute (ICI). In addition, the technology transfer group performed multiple site visits to similar operations to theirs, including a competitor site. Formal search mechanisms aimed at sourcing exploratory knowledge focused on search relationships with research institutions and Universities, firms in non-competing industries and government agencies. For example, contract relationships between the Welding Institute and the National Centre for Laser applications developed out of the Medical Device firms' need to 'explore different ways of bonding polymers, so it is quite new', these relationships had positive outcomes for the group as, 'we didn't have it here so it was handy for us, we could just go over and do our experimentation over there, and use their expertise, they came here as well and gave us a lecture'. In addition, the Consumer Healthcare firm had recently acquired an oral care facility, which was located on the same site, and was in the process of assimilating management across both plants. These findings build on recent work by Rothaermel and Alexandre (2009) who also identify the combinatory affect of a technological and geographic dimension, albeit in relation to ambidexterity, i.e. the balance of exploitation and exploration activity.

Key Sources of External Knowledge

Three key sources of external knowledge were identified in this study, these being, personal and professional networks, supplier organisations and subsidiary network partners. The distinction between personal and professional networks reflects differences cited by Ingram and Roberts (2000). Personal networks include networks where membership of an organisation is not a pre-requisite for joining the network, for instance, members of the APD group in the Medical Device firm regularly acquired knowledge from family members

working in other industries, friends working in other industries, friends from previous employment and friends from educational background. As commented by the head of supply chain in the Consumer Healthcare firm, ' I would often draw on the knowledge of other people, that I even went to school with, who are in similar positions, so even that far back'. While usually associated with strong tie principles (Granovetter, 1985), personal networks can be a cost efficient means to transfer valued information (Bian, 1997), however, Burt (2000) finds the formation and maintenance of weak ties to be much less costly and therefore more appealing to managers. In the context of this study, accessing personal networks allowed many searchers to overcome the confidentiality issues and enforced protectionism which defined two of the firms in particular.

Professional networks include relationships developed and mediated through membership of an organisation. To this end, Granovetter (1985) found that boundary spanning behaviour in professional networks is usually embedded in the larger organisational networks. The importance of personal and professional networks to firm performance is established by Ostgaard and Birley (1996). While specific to this study, Johannissson (1998) finds that people in high technology firms spend more time building and accessing these networks, than those in medium to low technology sectors. For example, external professional networks developed by members of the APD group included contacts made at conferences, both academic and practitioner, colleagues from previous employment, previous work colleagues from the medical device firm, technical communities such as the Six Sigma and Decision Support System councils, peers that have remained in academia and people from external bodies previously involved in collaboration projects with the group. In general terms, the advantages to be gained from membership of such networks include, benefits in accessing information beyond what could personally be processed, receiving business referrals from network members and the access to information early, conferring temporal advantages (Burt, 2000).

The importance of suppliers as sources of external knowledge is reflected elsewhere in the literature (e.g. Dyer and Hatch, 2006). In all cases searching units frequently relied on suppliers to provide technical knowledge on equipment and testing capabilities.

Lastly, searching units demonstrated a preference for accessing subsidiary partners as a source of external knowledge. For instance the Medical Device firm had strong relationships with their US based headquarters, which was fostered by an employee exchange programme. This important knowledge sharing relationship was reflected in both the Consumer Healthcare and Biotechnology firms also. Essentially, sharing knowledge with subsidiary partners should pose less risk, than sharing knowledge with external parties outside the network. In addition, Powell et al (1996) find that firms sharing knowledge more frequently in their network, gain more experience at knowledge sharing and are more likely to form new and diverse knowledge ties, and in turn become dominant players in the subsidiary network. Of course, it is possible that continuing to share knowledge within a subsidiary network can create over embeddedness and risk aversion among network members (Brass et al., 2004), as well as a lack of diverse knowledge (Baum et al., 2000). The importance of subsidiary partners as a source of external knowledge is of course, a reflection of the context of this study.

External Search Frequency

Classic models of search discuss search in punctuated equilibrium terms (Levinthal and March, 1981; Nelson and Winter, 1982), whereby search actions happen within specified search periods, each search period begins once the outcome of a previous search period has been identified and ends once an increase or decrease in performance has been detected, thus implying that the adoption of one successful search outcomes per period should be sufficient (Levinthal and March, 1981). In this study external search is found to be an ongoing activity. The frequency of external search does not remain constant however and is interrupted at times by higher and lower levels of activity. In all cases searching units were continually involved in either emergent or reactionary external search activity. As one engineer commented, 'I would not split it out, for me it is an ongoing thing'. This differing perspective from classic models of search could be accounted for by their sole focus on firm level search action, and their limited analysis of micro level search actions. This closely reflects recent theorising in organisational change, which calls for recognition of micro level agents of change and a conceptualisation of change as transformational and continual (Tsoukas and Chia, 2003).

4. Discussion and implications

External search activity is an understudied domain, but one that is likely to be both managerially important and rich in theory building insights. In this paper we provide initial empirical documentation of the external search process – an activity aimed at the motivated problem-solving and at times arbitrary location, of knowledge held by external sources. External search is the mechanism by which firms seek knowledge to replenish their internal stocks. In our comparative analysis of three large multinational firms, external search was found to be an ongoing and valuable activity. Based on this analysis we also develop a framework of the external search process followed by searching units.

5. Theoretical contributions

The central contribution of this research is the distinction made between internal and external search by investigating external knowledge search specifically. Existing literature on search makes no such distinction, implying that the characteristics and drivers of one are commonplace for both (e.g. Mezias and Glynn, 1993; Stuart and Podolny, 1996).

As evidenced by Allen (1977: 108) in his landmark study over three decades ago, 'even the largest R&D labs support only a very minor portion of the world's scientific and technological activity', thus highlighting the central role of external knowledge acquisition in successful R&D performance. Despite this however, studies detailing external search as part of the innovation process are limited. Therefore, this line of research is especially important as the organisation field tries to develop more answers to the question of how new knowledge is created in the face of the declining value of internal R&D systems.

From an empirical perspective, this research follows McNamara and Baden-Fuller (1999) who call for more case based research on search issues, by the adopting interpretivist methods as a novel approach within the organisational search field, which to date is dominated by stochastic modelling and the use of firm level survey data (e.g. Levinthal and March, 1981; March, 1991; Stuart and Podolny, 1996; Katila, 2002).

6. Managerial implications

An improved understanding of external knowledge search activity has managerial implications. Technology managers who plan search actions and assign resources to search can possibly benefit from understanding the importance of external search to the firm. Mastering external search activity can provide a source of additional value for the organisation, since current research proposes that most organisations require supplementary external knowledge, driven by a need to innovate across an ever-broadening technological base (Hargadon, 2003; Chesbrough, 2003). Developing a systematic conception of external knowledge search can help to structure and focus search efforts, and create an environment conducive to targeted innovation and inward knowledge transfer. As according to Appleyard (2003: 137), it is only through an improved understanding of the mechanisms and determinants of knowledge flows, that 'company managers and public policy makers can influence knowledge diffusion effectively'.

Of course, the managerial implications outlined above assume the firm is willing to create the permeable boundaries necessary for the large scale acquisition of external knowledge at all levels. There also exists the possibility that the opposite is the case, and the firm is in fact attempting to limit external influence and protect firm resources from external parties. In this instance, managers can follow three paths when protecting internal knowledge resources. Firms can seek to access external knowledge through more formalised external search channels, such as formal alliances, within which safeguards to protect internal knowledge can be accounted for. In addition, managers can empower employees to act as the protectors of the firm's knowledge, thereby ensuring that they search externally through trusted channels, this can be further re-enforced through penalty systems, as is the case in many large organisations. Lastly, managers can attempt to supplement inter-personal knowledge sharing by providing access to external knowledge through non-personal sources such as comprehensive databases, journal subscriptions and the internet. As according to Grimpe and Kaiser (2010) there are 'pains' as well as 'gains' for firms engaged in externalised R&D activity.

7. Limitations and future research

We identify limitations and areas of improvement congruent to our framework. A central exclusion is the failure to conduct research with the search targets and partners mentioned in all three case studies. In this

instance, the perspective of external search is always from the searchers point of view and is therefore not fully inclusive. A second improvement on the present research should be the implementation of a larger study. An obvious extension of this research is to use the presented framework of external knowledge search to structure an explanatory study with additional case firms. An explanatory study should allow future research to move towards the identification of a model of external knowledge search.

In addition there are multiple possibilities for future research. This research presented a view of external searching units as problem solvers. One interesting question for future work is to study the impact external knowledge search has on problem solving efficiency. For example, the idea that a searcher's problem solving ability can be strongly linked to the variance of their external ties provides an interesting avenue for future research.

In sum external search actions need not be considered random or intangible. The study shows that they can be studied comprehensively, and that it is possible to characterise the ways in which search units plan and execute their external search for knowledge. This line of research is especially important as the organisation studies field seeks to develop answers to the question of how new knowledge is created in the face of the declining value of internal R&D systems.

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