How Internet technologies impact information flows in R&D; reconsidering the technological gatekeeper

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Previous studies have firmly established the technological gatekeeper to be a key node in the innovation process – acquiring, translating, and disseminating external information throughout the R&D unit. However, the gatekeeper concept has received modest attention in recent times. We argue that the concept needs to be re-examined in light of the recent advances in Internet technologies that have dramatically altered how knowledge workers source and share their information. Drawing on social network analysis and interview evidence from a medical devices R&D group, we find that the gatekeeper role is still vital, but no longer needs to be performed by a single individual. Instead, the modern R&D group can keep abreast of the latest technological advances through a combination of Internet-enabled internal and external communication specialists. This study makes a number of important contributions. The gatekeeper theory is extended through the development of an updated conceptual framework. We also discuss the practical implications of our findings and advise R&D managers on how to organise resources to maximise optimal information flows.

1. Introduction

The importance of optimal information flows has long been stressed throughout the study of the innovation process in R&D settings (Allen 1977; Katz and Tushman 1981; Tushman and Scanlan 1981; De Meyer 1985; Macdonald and Williams 1993; Assimakopoulos and Yan 2006; Allen, James et al. 2007; Doak and Assimakopoulos 2007). To remain competitive, R&D organisations must acquire and exploit information of emerging scientific and technological developments (Allen and Cohen 1969). No R&D unit is completely self sustaining and this information must be imported from beyond the firm's boundaries (Cohen and Levinthal 1990; Frishammar and Horte 2005) from sources such as customers, suppliers, universities, national labs, industry consortia, start-up firms, individual minds, and even rival firms (Chesbrough 2003). Previous studies have shown that external information flows are optimal when they are monopolised by a small number of uniquely skilled 'technological gatekeepers' (Allen and Cohen 1969; Taylor 1975; Allen 1977; Tushman 1977; Tushman and Katz 1980; Katz and Tushman 1981; Tushman and Scanlan 1981; Katz and Tushman 1983). Indeed, decades of innovation research have established the technological gatekeeper to be a highly significant and influential concept within the information diffusion process in R&D settings. However, this concept has received modest attention in recent times. This is surprising given the recent surge of interest in open innovation that advocates the importance of networking beyond organisational boundaries (Chesbrough 2003; Chesbrough and Crowther 2006; Fichter 2009).

We argue that the gatekeeper concept needs to be re-examined in light of the recent advances in Internet technologies that have dramatically altered how knowledge workers source and share their information. For the purposes of this

paper, Internet technologies are defined as "web-based communication technologies - such as browsers, websites, search engines, online forums, email, blogs, and wikis - that enable the easy exchange and retrieval of digitised content." What these technologies have changed is the ease and speed with which employees at all organisational levels can access and disseminate information (Cairncross 2001; Teigland and Wasko 2003; Tapscott and Williams 2007; Whelan 2007). As a result, recent studies have suggested that the emergence of Internet technologies may mitigate the role of the gatekeeper in the innovation process (Assimakopoulos and Yan 2006). Yet, we still have a limited understanding of how the role and tasks of the gatekeeper are changing due to the ability of every professional in an R&D group to quickly and easily access external information through web-based channels.

To address this research gap, we gathered social network analysis (SNA) and semi-structured interview data in a case study of an Irish based medical devices R&D group. Our findings make a number of important contributions. The gatekeeper concept is extended through the development of an updated conceptual framework. We also discuss the practical implications of our findings and advise R&D managers on how to organise resources to maximise optimal information flows.

This article is structured as follows. The extant research relating to the technological gatekeeper concept is first reviewed. This reveals a gap in the literature that this paper aims to address. The case study site is then described and the data collection methods are discussed. Next, the findings of the SNA and interviews are presented along with the updated gatekeeper conceptual framework. The paper ends with a discussion of these findings and identifies avenues for future research.

2. The technological gatekeeper

2.1 Origins and definition of the concept

R&D groups are charged with driving innovation in high-technology firms. In order for the group to sustain itself, the literature on R&D innovation emphasises the importance of acquiring a diverse and novel body of information from beyond the organisation's boundaries (Allen 1977; Tushman 1977; Aldrich and Herker 1997; Chesbrough 2003; Nooteboom 2004). This externally acquired information serves as the seeds for future technological developments (March and Simon 1958; Leonard-Barton 1992) and helps to build the firm's future 'absorptive capacity' (Cohen and Levinthal 1990). A rich stream of research through the 1970s and early 1980s examined the processes through which scientific and technological information enters the R&D group. This particular stream was headed by MIT's Thomas Allen and his seminal book, *Managing the Flow of Technology* (Allen 1977), documents over a decade's worth of studies with some of the largest American R&D corporations. As is illustrated in figure 1, Allen discovered that not every R&D professional was directly connected with external sources of information and that information of the latest scientific and technological developments entered the R&D group through a two-step or multi-step process. An analysis of the communication patterns in multiple R&D groups revealed the existence of a small number of key people who mediated between the average R&D professional and the world outside. These individuals were first termed 'technological gatekeepers' (Allen and Cohen 1969; Allen 1971) as they act as the 'gate' through which information of external technology flows into the R&D group. A more formal definition explains that technological gatekeepers are those key individual technologists who are strongly connected to both internal colleagues and external sources of information and who possess the ability to translate

between the two systems (Allen and Cohen 1969; Allen 1977; Tushman and Scanlan 1981).

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Essentially gatekeepers perform three tasks that make them critical to the R&D information flow network. Firstly, they perform the task of *external information acquisition*. Gatekeepers act as the firm's antennae, scanning the outside world for emerging scientific and technological developments relevant to the work of their R&D group. Secondly, they perform the task of *external information translation*. This task involves delivering external information in a way that ensures its use by others within the R&D group (Macdonald and Williams 1993). For example, the gatekeeper can translate information gained from journal papers and personal contacts into terms and uses that are understandable and relevant to local R&D colleagues. This translation of external information is required due to the divergence in language, routines, and coding schemes that exist between the R&D group and the world outside (Tushman 1977). Allen (1977) even suggests that the gatekeeper's principle contribution comes by way of the translation that he/she performs between the two systems. Thirdly, gatekeepers perform the task of *internal information dissemination*. Although gatekeepers may well have their own use for the information they acquire, they are also keenly interested in passing it on to others in the organisation for their use (Macdonald and Williams 1994). However, gatekeepers do not simply release external information on mass. Rather, they disseminate information to targeted work colleagues whom they know would be able to use the information they have acquired.

2.2 Development of the gatekeeper concept

The gatekeeper concept has generated much interest in the technology and innovation management literatures. In one particular stream, subsequent studies have examined the relationship between the presence of gatekeepers and R&D project performance for different types of tasks (i.e., research work vs. development work). Development projects with gatekeepers were significantly higher performing than those without gatekeepers (Tushman and Katz 1980; Katz and Tushman 1981). Thus, development projects are more effectively linked to external information through an intermediary - the technological gatekeeper. In contrast, the same studies found that the presence of gatekeepers is not conducive to high performance in research focused R&D projects. The reason offered for this contrast relates to the communication impedance separating the R&D project from external information sources. Development projects are locally defined and associated with the evolution of local values, norms, and language unique to that unit. The disparity in coding schemes between development projects and the external environment is more pronounced; therefore, an intermediary is needed to translate between the two systems. In contrast, research projects would seem to face low communication impedance and the addition of an intermediary only impairs external communication (Tushman and Katz 1980, Katz and Tushman 1981). Taking the above findings into account, this study has chosen to focus on the technological gatekeeper concept within development R&D as opposed to pure research R&D.

An additional stream of literature has considered the characteristics and abilities of those performing the gatekeeper role. What became clear is that not every person possesses these characteristics, hence only a handful of individuals can effectively perform the gatekeeper role. The original studies suggest that the

gatekeeper is a highly competent technical performer who is likely to be a first line supervisor (Allen and Cohen 1969; Allen 1971; Allen 1977). Seldom are gatekeepers found with fewer than five years organisational experience as it takes time to develop one's communication network within the organisation. Indeed, a significant characteristic of gatekeepers is their social networking abilities (Macdonald and Williams 1994). Much of their expertise lies in knowing who is doing what, both inside and outside the firm. Attempts by management to formally appoint employees to perform the gatekeeping role have proved unsuccessful, primarily because appointed individuals lack the social networking skills of the emergent gatekeeper (Nochur and Allen 1992). Gatekeeping is a serious activity and these individuals purposefully build a network of personal contacts inside and outside the firm. The relationships developed by the gatekeeper are generally not sufficiently close for these individuals to be regarded as friends, rather they are of a weak tie nature (Granovetter 1979) and regarded as colleagues and acquaintances there to serve a very specific purpose (Macdonald and Williams 1993). For this reason, technological gatekeepers bear a resemblance to the promotor theory (Witte 1977) and particularly the 'relationship promotor' as described by Walter and Gemünden (2000). Relationship promotors are individuals who support the innovation process through their internal and external networking activities. However, Gemünden et al. (2007) are careful to delineate between the two concepts. While the focus of the gatekeeper is on the diffusion of external information, the relationship promotor is ultimately concerned with the exploitation of that that information.

In one of the few recent studies to examine the concept, Harada (2003) reports that the classic definition of a technological gatekeeper could not be applied to a Japanese R&D firm. Instead, the firm members who were highly connected to

external information were largely different to those firm members who were highly connected internally. From this finding, Harada infers that external information flows into the R&D group through a multi-step process whereby external communication stars pass the outside information they acquire to the internal communication stars, who in turn transmit to other members of the firm. However, we believe this inference remains open to question as Harada's study relies exclusively on statistical measures of communication. Statistical measures may point towards a certain sequence, but these measures alone are insufficient to demonstrate that such a sequence is reality. In response, the study at hand adopts a multi-method approach to examine the flow of information throughout the R&D network.

While the technological gatekeeper has proved to be a highly influential theory of information diffusion in R&D settings, the concept has received modest attention in recent times. The gatekeeper theory was formulated in the 1970s, a time when it was a difficult and time consuming process for the average R&D professional to acquire information from beyond the company's boundaries. Due to the emergence of Internet technologies, we now inhabit a world where all information and certain forms of knowledge can be codified and stored in digital form (Davenport and Prusak 2000). Any amount of this content is instantly accessible and the cost is almost nothing. In terms of acquiring and disseminating information, distance is now irrelevant (Cairncross 2001; Friedman 2006). With a computer and an Internet connection, a knowledge worker can easily join computer-supported social networks to seek solutions, share expertise, and discuss ideas with like-minded individuals far beyond the reach of their local social network of friends, contacts, and colleagues (Wasko et al. 2004). Thus, the purpose of this paper is to examine how these advances in Internet technologies have impacted the concept of the technological gatekeeper and

the gatekeeper's tasks of acquiring, translating, and disseminating external information.

3. Methodology

For the purpose of our research, a case study method is appropriate as 1) the objective of the study is theory building (Eisenhardt and Graebner 2007), 2) there is a need to focus on contemporary events (Benbasat, Goldstein et al. 1987; Yin 1994), and 3) the phenomenon of interest cannot be studied outside its natural setting (Yin 1994). In order to compare with the original high-technology engineering gatekeeper studies, we have collected data from MediTech, a high technology firm in the medical device field that has requested to remain anonymous. The case study setting is further described below.

3.1 Case study setting

MediTech is a US multinational that has been in the medical device business for over 25 years with an annual turnover of $8.3 billion. MediTech employs approximately 4,200 people in a subsidiary in Ireland. The company has advanced the practice of minimal-invasive medicine by providing a broad and deep portfolio of innovative products, technologies and services across a wide range of medical specialties. The company employs approximately 3,000 R&D engineers, scientists, and technicians worldwide. While the majority of these are based in the US, an R&D group comprising 76 R&D professionals are located in MediTech's Irish subsidiary (referred to as Irish R&D in the rest of this paper). While a high level of collaboration exists between the Irish and US R&D bases, Irish R&D is largely a stand alone entity. Both the Irish and US groups are design owners of certain products, and it is the

responsibility of each group to advance those designs. The group is headed by an R&D Director and is organised on a functional basis into four specialist subgroups. The subgroup has a formal reporting structure with technicians reporting to engineers who report to senior engineers who in turn report to the subgroup head. Each of the four subgroups has a technology brief which relates to a specific part of the product design. For example, one subgroup is dedicated to advancing stent delivery systems while another works on developing medical technologies to diagnose and treat peripheral vascular disease. Members of each subgroup are specialists in that particular technology. As part of the company's product development process, Irish R&D members are assigned to various project teams along with individuals outside of R&D who may specialise in, for example, project management, marketing, process development, operations, and design assurance. Irish R&D members are seated along side their subgroup colleagues as opposed to their project team. This structure is commonly referred to in the literature as a matrix organisation. All 76 R&D professionals are housed on the same floor but in two separate open plans areas which are about 60 metres apart. Each group member has their own desk and a PC with Internet and email access.

3.2 Data collection and analysis

Data were gathered from Irish R&D during February and March 2008. The data collection methods are summarised in table 1.

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Phase 1 involved analysing the flows of information into and around Irish R&D using SNA techniques. SNA or sociometry is an established social science approach of studying human relations and social structures by disclosing the affinities, attractions and repulsions between people and objects (Moreno 1937). SNA views social relationships as nodes and ties that can be illustrated visually and mathematically. As such, it can provide an x-ray of the inner workings of a particular network. With this tool, important patterns become visible, the relationships between people can be better understood, the health of a group can be assessed, and the people playing key roles within the group can be identified (Cross and Parker 2004). In recent years, SNA has been increasingly used as a structured way to analyse the extent of informal relationships that exist within various formally defined groups (Cross, Nohria et al. 2002). However, despite the knowledge intensive nature of R&D, network analyses of the R&D function remain relatively rare (Allen et al. 2007).

The purpose of phase 1 was to identify the 'stars' of the R&D information flow network. To collect these data, all R&D members were asked to complete a short online questionnaire on their internal and external communications. To measure internal communications, we used the question asked by the original gatekeeper scholars (Allen 1971; Taylor 1975; Allen 1977; Tushamn and Katz 1980; Katz and Tushman 1981) – *'Please identify which work colleagues you discuss technical issues with at least once a week.'* The choice of once-a-week frequency is purely arbitrary although it does represent a fairly heavy degree of consistent communication (Allen 1977). Adapted from the original gatekeeper literature, to measure external communications, respondents were asked to indicate how often they used three different sources of external information: personal contacts, internet sources, and academic publications. An earlier pilot study by one of the authors indicated that

these three information sources were the most frequently used by R&D professionals when acquiring information from outside the company (Whelan et al. 2008). We used the SNA software package UCINET v 6.0 (Borgatti et al. 2002) to illustrate the information flow network in Irish R&D. To increase validity, only reciprocated interactions between group members were included in the analysis. This ensured that group members who reported higher than actual interactions did not distort the analysis. The percentage of reciprocated relationships was 64%, a level high enough to proceed with our analysis (Cross and Parker 2004).

Following the approach of previous gatekeeper scholars (Allen 1977; Tushman and Katz 1980; Katz and Tushman 1981), we categorised the Irish R&D members based on the SNA results from phase 1 as either a) a gatekeeper, b) an internal communication star, c) an external communication star, or d) a non-star. Gatekeepers were those individuals who were in the top 20% of *both* the internal and external communication distributions. Internal stars were operationalised as those individuals in the top 20% of the internal communication distribution but below the top 20% of the external communication distribution. The same logic applies for external stars. Non-stars were those who fell below the top 20% in either internal or external communication. As discussed below, with this analysis, we found 4 gatekeepers, 10 external stars, 10 internal stars, and 46 non-stars. The only correlation we found between the formal organisational chart and the informal communication network was in relation to the non-stars, who tended to be employed at the technician level. The other communication star positions were just as likely to be occupied by an engineer as senior management.

In phase 2, we conducted semi-structured interviews with 11 members of Irish R&D. Details of the 11 interviewees are provided in table 2. The objective of these

interviews was to explore how the use of Internet technologies impacts the acquisition, translation, and dissemination functions of the technological gatekeeper. To get a non-biased view of how information flows around the R&D group, we interviewed a sample of each category of R&D professional i.e. 3 gatekeepers, 2 external stars, 4 internal stars, and 2 non-stars. The interviews with communication stars mainly focused on how they themselves operate in the information flow network. As non-stars are not at the heart of the information flow network, they are often in a better position to observe how information actually flows through the group. Indeed, the interviews with the two non-stars proved quite valuable from a triangulation point of view. Additionally, we had planned to interview a 3rd external star but due to upcoming project deadlines, this individual could not commit, nor could a substitute external star be found. Care was also taken to ensure that all levels of the formal group hierarchy were represented in the interviewee sample. All interviews were conducted face-to-face and ranged in length from 30 minutes to 75 minutes. All interviewees gave permission for the interview to be recorded. The procedures outlined in the dramaturgical model (Myers and Newman 2007) were adopted in order to ensure that high-quality interviews were conducted. Interview data analysis was performed using the NVivo software package and followed established inductive qualitative methods: coding, data categorisation, and pattern identification (Miles and Huberman 1984; Eisenhardt 1989; Yin 1994).

*****Take in Table 2 Here*****

4. Findings

4.1 Phase 1, social network analysis

Figure 2 illustrates the flow of technical information into and around Irish R&D. The nodes in the diagram are the individual members of Irish R&D and the lines represent the flow of technical information between them. The gatekeepers are represented by diamonds, the external stars by up-triangles, the internal stars by down-triangles, and the non-stars by circles. The size of the node reflects how well connected that individual is to external information sources. For example, Node 52 is the biggest triangle as this individual is the most frequent user of external information.

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The SNA data reveal that only 4 members (nodes 5, 9, 11, and 54), or 6%, of the group can be classified as technological gatekeepers. In the initial formulation of the concept, Allen reported the gatekeeper level to be almost 20%, i.e., those classified as internal stars were almost always external stars also (Allen and Cohen 1969; Allen 1977). Rather than relying on single individuals to both acquire and disseminate external information, the SNA evidence shows that one set of boundary spanning individuals specialise in acquiring external information and a largely different set of individuals specialise in distributing that information around the group. This suggests that the gatekeeper role has undergone a division of labour. A number of relationships between external communication stars and internal communication stars can be identified in figure 2, which indicates that they combine their activities to perform the gatekeeper role – nodes 51 and 53, nodes 37 and 13, nodes 37 and 38. The relationship between node 62 and node 66 is probably the clearest example of this

process. Figure 3 separates this relationship from the rest of the network. Node 62 is an external communication star. This individual is well connected to external information sources but is not very well connected internally. One of the few individuals whom node 62 has frequent interactions with is node 66. Node 66 is an internal star with many connections to other R&D colleagues - nodes 64, 67, 68, 70, 74, 76. An interpretation of the network analysis suggests that node 62 specialises in acquiring information from outside the firm. This information is communicated to node 66 who specialises in distributing that information around the R&D group through his/her own personal network of contacts. The semi-structured interviews with Irish R&D members partly focused upon validating whether such a sequence is reality.

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We also investigated where the external stars go to acquire their information. The Internet was by far the most widely used source with 79% of external stars using this source daily; 29% reported consulting academic publications daily while only 21% would consult an external colleague daily.

4.2 Phase 2, semi-structured interviews

External Information Acquisition

The SNA data suggested that external information flows into the group via external communication stars who predominately use the Internet to acquire this information. The interview data also supported this assertion. Even though external information is easily accessible by every member of Irish R&D, only a handful of individuals have

the interest and ability to keep abreast of emerging technological developments which runs counter to our initial premise.

In our interviews, we found that there are a number of specific medical technology websites that these external stars access in order to keep up-to-date with developments in the field. For example, cvpipeline.com is one website that many of the external stars identified as being a good source for information of new technological developments. Cvpipeline.com is a subscription based service that promotes itself as *"a new online database solution that keeps you up to date with emerging companies, products, technologies, people, and clinical studies in the fast-changing cardiovascular market"* (www.cvpipeline.com). One theme in the interviews with Irish R&D's external stars that emerged was that websites such as cvpipeline.com offered significant benefits over traditional sources of external information, e.g., conferences and academic publications. As is reflected in the following quotation, the prime advantage of the Internet relates to the ease with which technical professionals can keep abreast of the latest developments in the industry:

> *I would use the Internet quite a bit. For my own development, I use it to keep up-to-date with new technologies, new medical device developments. Recently I subscribed to a [trade] magazine…which I think is very good for providing information on new technologies and new medical devices outside. I think another good source of information would be attending conferences…but I think that can be got through the Internet. You'd get current information, very up-to-date. I think the Internet is a great source of information in that way…it's there at your fingertips and it's just a matter of using Google.*

While access to external information has become inherently easier, there is also a downside. Irish R&D is saturated in potentially useful information, particularly due to advances in Internet technologies. The interviews reveal that deciphering the relevant from the non-relevant in the vast amount of external information available has become a complex and time consuming process. As one of the external stars explained; "*Finding the gems of information on the Internet is certainly time consuming…you can do it but you do need to have time and patience."* Another external star explained that this problem of information overload is primarily the reason why she tends to specialise in external communication to the detriment of internal communications:

> *With the Internet we have access to almost everything in here. You can access the information you want relatively quickly, but you have to spend a lot of time trawling through that information [in order to] figure out what is of use. Bear in mind, you still have your day-to-day work. It's a personal choice, you're either into it or you're not. There is a niche for everyone. People like [Dan] are very well connected inside the company. If I find something new that I can't use myself, then I'll usually let [Dan] know about it. He knows what everyone is into and he can raise it with them to see if there are any takers.*

A commonality shared by the external stars in Irish R&D is that they have a deep, as opposed to a wide ranging knowledge of a specific technology domain. For example, both the external stars interviewed completed PhDs within the past two years, in the fields of chemistry and materials science respectively. Having a deep and narrow knowledge domain would seem to be an important antecedent to being an effective external star. In the following quote, a gatekeeper explains that the Internet is the

conduit through which the Irish R&D identifies new technological advances. Yet, an R&D professional cannot truly know if a development is really new unless they have considerable expertise in that particular domain:

> *I think the 'Net' is the most direct and open way to finding new things. I suppose the idea of finding a new concept that's out there - you can't really go looking for something new and unknown if you have no reference for it. That's particularly true in my area - drug eluting stents. Unless you know the field inside out, you are not going to know what the new developments are.*

External Information Translation

The translation of external information into understandable and relevant terms is an integral step in Irish R&D's absorption of external information. The exact nature of the technical discussions between Irish R&D colleagues was explored in the interviews and these essentially revolve around one of two purposes – translating external information or problem-solving. We find that many people across the R&D group are consulted by their colleagues to aid in problem-solving. In contrast, our analysis of the interview data reveals the existence of a small number of individuals who are specifically targeted to perform the information translating function for Irish R&D. These individuals are frequently sought out by their colleagues hence the reason they are also likely to be internal communication stars. Both the gatekeepers and internal stars that were interviewed confirmed that often the nature of their discussions with Irish R&D colleagues revolved around understanding if and how a new technology fits with the projects currently being undertaken by the group. One interviewee, Chris (fictitious name), acknowledged that many of his colleagues often consult with him when they have discovered novel external information. The network

analysis reveals that while he is one of the most connected people internally, Chris has very low exposure to external sources of information himself. Chris acknowledges that certain group members have the deep technical expertise needed to keep abreast of the latest developments in their field, but they might not have the skills needed to translate that information for others. His own knowledge base is wide-ranging as opposed to deep. This provides him with the ability to see the bigger picture within the whole R&D group, and to understand how external information needs to be modified in order to fit into that bigger picture:

> *My skill sets would lie in that I know a little about a lot of different things, and I probably have a good appreciation for how they all fit together into the overall picture. We do have people who are bond experts, who are crimping experts, who are balloon experts, [but] they probably wouldn't have as good an appreciation for the impact that something new would have on other people…whereas I probably would have that visibility. The skill set I have – other people probably don't have that.*

Chris elaborates on this point and provides an example of the value he added to a piece of external information that was passed to him. One of his colleagues had learned of a new type of disposable plastic that the toothpaste industry was beginning to use in the manufacture of toothpaste containers. His colleague believed the material could be used to improve the flexibility of the catheters developed by MediTech. Numerous prototypes were developed but none delivered the required results. Chris was consulted for guidance. Straightaway he was drawn to an innovative technique that the technician had used to develop one of the prototypes. The material itself never worked out but with Chris's direction, the particular

technique was applied to a different domain - the crimping of stents. The technique proved very successful and resulted in a patent application from Irish R&D.

While the Internet is the most widely used source of external information, there is a realisation within the group of the need to be selective when gathering Internet-based information. There are no guarantees that information sourced from the Internet is truly accurate. The medical devices industry is highly regulated and the information used to produce medical products has to be documented for FDA and EU inspection. Popular websites like wikipedia are extremely convenient for explaining a particular topic; however, anyone in the world has the potential to edit a wikipedia article. Thus, the reliability of this information is always open to question. One internal communication star acknowledged that while wikipedia is frequently used as an information source, the validation of this source is an important process:

> *I've heard comments where people talk about something like wikipedia [but] you have to be careful with it. I suppose I'm guilty of it myself – it's just convenient, you just pull the information. If it's just for illustration purposes it's not a problem. But if it's something where you're probably going to rely on this as a source to make a decision or to go and use it in support of a submission to a Regulator, then yes – clearly you have to go and check the source of the information. And we do enough cross referencing, reviewing or peer reviewing of our internal documents, and that in itself is the catch for it. We go look for a source document.*

Internal Information Dissemination

Through a combination of email and face-to-face discussions, information from beyond MediTech's boundaries is disseminated around Irish R&D principally by the

internal communication stars. The process of disseminating novel external information begins with the internal star sending an email with the attached content (e.g., documents, Weblinks, powerpoint slides) to the group members they know would be interested in that information. The email will include one or two sentences explaining why the internal star believes the attached content is relevant to the receiver. This short introduction is a vital step in the information dissemination process. Due to the large volume of email traffic, many members of Irish R&D have their email client set to 'preview mode', whereby only the first 2-3 lines of the incoming message are displayed. If the preview does not grab the receiver's attention, the email is likely to be deleted. The internal stars realise that they only have 2-3 sentences to explain why the content contained in the email is relevant to the recipient. If the content is of interest to that individual, they then return to the internal star and have a face-to-face discussion about how that information can be used by the group. An example of this process is provided in the following interview quotation from one of the non-stars interviews. The functional manager mentioned is also an internal communication star:

> *During the week, one of the members of our group found some interesting news on a new material that could be used by us. He sent an email to the functional manager who was my boss as well, and the manager sent it out to all our extended team saying, "we've just found this new material that could be useful for us, if we're interested, please come back to me". The same applies with new recruits from universities…they may have spent a lot of their last year or two in conferences. They may have exposure to new developments that people here may not have known about. They would communicate that to the functional manager, and the manager will then feed it out to everyone else.*

While email is used to distribute external information, face-to-face discussions are needed in order to figure out how to exploit that information. The consensus among the interviewees is that it would be virtually impossible to perform the work of the R&D group without face-to-face interaction among peers. R&D work in the medical devices sector is very technical in nature. Email is useful for alerting people to external developments but a discussion about those developments through email is cumbersome. For this very reason, group members frequently travel to their sister site in the US. In fact, when people are being interviewed for positions in R&D, it is explained to them that travel is part of the job. Face-to-face time is a vital component of the group's work. This is highlighted in the following quotation from an internal communication star, who explains that integrating new information into the group requires face-to-face discussion:

> *You can only truly understand something new if the other person asks questions and you reply straight away, so that you can address their needs straight away…whereas in e-mail you can't do that. You do need face-to-face time. You can do a certain amount over email and the phone but you have to build up that face-to-face rapport. What happens is once you build up that face-to-face rapport, people get the measure of you. They understand what your convictions are, where your strengths are, how you behave – or misbehave – and how to manage that.*

5. Discussion and conclusion

Our initial premise for conducting this study suggested that the technological gatekeeper may no longer exist in R&D settings due to the recent advances in Internet

technologies which enable knowledge workers to easily access and disseminate information of emerging technological developments. Our findings ultimately show that this initial premise was rather simplistic. While access to external information has become exponentially easier due to the Internet, the verification, translation, and internalisation of that information requires specialist competencies which only a small proportion of the R&D staff possess. In the R&D group studied here, the locus of the technological gatekeeping role has shifted from accessing external information to evaluating that information and ensuring that it reaches the people who are best equipped to exploit it. While it is possible for a single individual to perform the gatekeeping tasks, the evidence from this case study suggests that it is rare. Only four members of Irish R&D could be defined as technological gatekeepers. While we find that the gatekeeping tasks of acquiring, translating, and disseminating external information are integral to the Irish R&D, we also find that separate communication specialists combine to perform these tasks. Consistent with the findings of Harada (2003), the evidence from the case study suggests that the gatekeeper role has undergone a division of labour. While it would be a mistake to make a statistical generalisation to a wider population based solely on this one case study, we can use our findings to make 'analytical generalisations' i.e. test and extend previously developed theory (Yin 1994). A conceptual framework which extends the gatekeeper theory, based on our evidence, is presented in figure 4.

*****Take in Figure 4 Here*****

The framework explains that information of the latest technological developments are principally acquired from the Internet and imported into the R&D group by the

external communication stars. They verify the reliability of this information before discussing it with the 'go-to' people of the R&D group – the internal communication stars. Due to their extensive comprehension of the internal R&D operations, the internal stars are well placed to understand how that information can potentially be exploited by the group. The internal star will usually identify a group member or members who are best placed to make use of that information, and will translate the external information into a form that is understandable and relevant to them. The first step in disseminating that information involves the internal star sending an email alerting the recipient of the novel information. The email will include 2-3 sentences explaining why the sender believes the information contained is relevant to the recipient. If the information is of interest to the recipient, they then return to the internal star and have a face-to-face discussion about how that information can be used by the group.

We now turn our attention to explaining these findings and why the gatekeeper role has undergone a division of labour. Much has changed since the gatekeeper concept was first formulated. Not least of these changes has been the advancement and widespread adoption of communication technologies, and particularly Internet technologies. The abundance of information sources now available to the modern R&D group would seem to be central to the splitting of the gatekeeper role. Allen's gatekeeper existed in a time when external information sources were scarce relative to today and difficult to access. Thus, the acquisition, translation, and dissemination of those limited resources could be performed by single individuals who possessed the necessary skills. However, our evidence from Irish R&D suggests that the mass of information easily available today necessitates that separate individuals specialise in specific parts of the gatekeeping function. With so much external information

available through the Internet, distilling the valuable information has become a complex and time consuming process which necessitates the attentions of specialists.

The findings of this study are of benefit to development focused R&D practitioners wishing to understand and improve information flows in knowledge intensive settings. Those who possess numerous years of industry experience and maintain a deep expertise in a particular field (as evidenced by a PhD qualification) are best suited to the external star position. This is due to the vast array of information sources made easily accessible with the prevalence of Internet technologies. It is only with a deep knowledge of a specific field that a knowledge worker can distil the valuable information sources from the rest. To maximise their contribution to the information flow network, external stars should be freed of any mundane administrative duties and allocated the time they need to scan the external environment for emerging technologies and trends. In terms of resources, all they need is a computer with an Internet connection. However, it would be more beneficial if external stars are given priority for external networking events such as conferences or tradeshows. External stars specialise in acquiring valuable external information. This is a time consuming and complex process that inhibits their ability to distribute that information around the internal communication network themselves. This is the domain of a different set of individuals, the internal communication stars. Internal stars have a natural flair for getting to know others. Rather than possessing a deep knowledge of a specialist field, these individuals possess knowledge of a broad set of fields. If management fails to recognise the valuable role performed by these individuals, there is a danger that their information dissemination efforts could be stifled. Internal stars need the opportunity and resources to network. Involving these individuals in multiple projects throughout the firm will enable them to build their

network more rapidly, allowing them to become more effective disseminators of information. Additionally, specific attention should be given to establishing connections between the external stars and the internal stars of a particular grouping. This study finds that it is primarily through these particular connections that valuable external information becomes integrated into the firm.

We see a number of avenues for future research. Firstly, a limitation of this study is the fact that it is based solely on one case study of one firm's R&D unit in one industry. As a result, it is difficult to assess how representative the findings are for other R&D organisations or industries. This study focused upon development-focused R&D engineers who were for the most part of Irish nationality. For the purposes of generalisability, future research studies should examine multiple R&D groups in differing industries and cultural settings. Secondly, as the purpose of this study was to contrast the role of the gatekeeper in contemporary R&D units with those of yesteryear, we asked the same question used by the original gatekeeper studies i.e. 'Please identify which work colleagues you discuss technical issues with at least once a week.' Our interviews showed that 'technical issues' is quite a broad term with many types of discussions falling under this umbrella. A fruitful area of future research would be to identify the various categories of technical discussions and to contrast how this differing information diffuses around R&D units. Thirdly, our study focused the frequencies of interactions in order to identify those performing the gatekeeper role. This approach does not consider the usefulness of the information exchanged. Future studies should incorporate measures of information usefulness in order to identify the key nodes in the R&D social network. Finally, future research needs to examine whether the enhanced division of labour in sourcing and sharing information leads to an improved innovation performance for

development projects, or whether a more effective strategy would be to improve the information sourcing capabilities of all R&D staff.

References

Aldrich, H. E. and Herker, D. (1997) Boundary spanning roles and organization structure. *Academy of Management Review,* **2**, April, 217-230.

Allen, J., James, A. D. and Gamlen, P. (2007) Formal versus informal knowledge networks in R&D: A case study using social network analysis. *R&D Management,* **37,** 3, 179-196.

Allen, T. J. (1971) Communication networks in R&D laboratories. *R&D Management*, **1**, 14-21.

Allen, T. J. (1977) *Managing the Flow of Technology*. Cambridge, MA, MIT Press.

Allen, T. J. and Cohen, S.I. (1969) Information flow in research and development laboratories. *Administrative Science Quarterly,* **14,** 1, 12-19.

Allen, T. J., Tushman, M. L. and Lee, D.M.S (1979) Technology transfer as a function of position in the spectrum from research through development to technical services. *Academy of Management Journal*, **22,** 4, 694-708.

Assimakopoulos, D. and Yan, J. (2006) Sources of knowledge acquisition for Chinese software engineers. *R&D Management,* **36,** 1, 97-106.

Benbasat, I., Goldstein, D. K. and Mead, M. (1987) The case research strategy in studies of information systems. *MIS Quarterly*, **September**, 369-386.

Borgatti, S. P., Everett, M. G. and Freeman, M.C. (2002) *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA, Analytic Technologies.

Cairncross, F. (2001) *The Death of Distance*. Cambridge, MA, Harvard Business School Press.

Chesbrough, H. M. (2003) *Open Innovation*. Boston, MA, Harvard Business School Press.

Chesbrough, H. M. and Crowther, A. K. (2006) Beyond high tech: early adopters of open innovation in other industries. *R&D Management*, **36**, 3, 229-236.

Cohen, W. and Levinthal, D. (1990) Absorptive capacity: a new perspective on learning and innovation. *Administration Science Quarterly*, **35**, 128-152.

Cross, R., Nohria, N. and Parker, A. (2002) Six myths about informal networks - and how to overcome them. *MIT Sloan Management Review* **43**, 3, 66-75.

Cross, R. and Parker, A. (2004) *The Hidden Power of Social Networks*. Boston, Harvard Business School Publishing.

Davenport, T. and Prusak, L. (2000) *Working Knowledge; How Organizations Manage What They Know*. Boston, MA, Harvard Business School Press.

De Meyer, A. (1985) The flow of technological innovation in an R&D department. *Research Policy,* **14**, 315-328.

Doak, S. and Assimakopoulos, D. (2007) How forensic scientists learn to investigate cases in practice. *R&D Management,* **37**, 2, 113-122.

Eisenhardt, K.M (1989) Building theories from case study research. *Academy of Management Review,* **14**, 532-550.

Eisenhardt, K.M and Graebner, M.E. (2007) Theory building from cases: opportunities and challenges. *Academy of Management Journal,* **50,** 1, 32.

Fichter, K. (2009) Innovation communities: the role of networks of promoters in open innovation. *R&D Management,* **39**, 4, 357-370.

Friedman, T. L. (2006) *The World is Flat.* London, Penguin.

Frishammar, J. and Horte, S. A. (2005) Managing external information in manufacturing firms: The impact on innovation performance. *Journal of Product Innovation Management,* **22**, 251-266.

Frost, P. and Whitley, R. (1971) Communication patterns in a research laboratory. *R&D Management,* **1**, 71-79.

Gemünden, H.G., Salomo, S. and Holzle, K. (2007) Role models for radical innovations in times of open innovation. *Creativity and Innovation Management,* **16**, 4, 408-421.

Granovetter, M. (1973) The strength of weak ties. *American Journal of Sociology,* **78**, 1360-1380.

Hall, K. R. and Ritchie, E. (1975) A study of communication behaviour in an R&D laboratory. *R&D Management***, 5**, 243-245.

Harada, T. (2003) Three steps in knowledge communication: the emergence of knowledge transformers. *Research Policy,* **32**, 1737-1751.

Katz, R. and Tushman, M. (1981) An investigation into the managerial roles and career paths of gatekeepers and project supervisors in a major R&D facility. *R&D Management,* **11**, 103-110.

Katz, R. and Tushman, M. (1983) A longitudinal study of the effects of boundary spanning supervision on turnover and promotion in research and development. *Academy of Management Journal*, **26**, 427-456.

Leonard-Barton, D. (1992) Core capabilities and core rigidities: a paradox in managing new product development. *Strategic Management Journal*, **17**, 93-108.

Macdonald, S. and Williams, C. (1993) Beyond the boundary: An information perspective on the role of the gatekeeper in the organization. *Journal of Product Innovation Management,* **10**, 417-427.

Macdonald, S. and Williams, C. (1994) The survival of the gatekeeper. *Research Policy,* **23**, 123-132.

March, J. G. and Simon, H. (1958) *Organizations*. New York, Wiley.

Miles, M. B. and Huberman, A. (1984) *Qualitative Data Analysis.* London, Sage.

Moreno, J. L. (1937) Sociometry in relation to other social sciences. *Sociometry,* **1,** 1/2, 206-219.

Myers, M. D. and Newman, M. (2007) The qualitative interview in IS research: examining the craft. *Information and Organization,* **17**, 2-26.

Nochur, K.S. and Allen, T.J. (1992) Do nominated boundary spanners become effective technological gatekeepers? *IEEE Transactions on Engineering Management,* **19**, 3, 265-269.

Nonaka, I. (1994) A dynamic theory of organizational knowledge creation. *Organization Science*, **5**, 1, 14-37.

Nooteboom, B. (2004) *Inter-Firm Collaboration, Learning and Networks*. London, Routledge.

Tapscott, D. and Williams, A. D. (2007) *Wikinomics*. London, Atlantic Books.

Teigland, R. and Wasko, M. (2003) Integrating knowledge through information trading: examining the relationship between boundary spanning communication and individual performance. *Decision Sciences,* **34**, 2, 261-287.

Tushman, M. (1977) Special boundary roles in the innovation process. *Administrative Science Quarterly*, **22**, December, 587-605.

Tushman, M. and Katz, R. (1980) External communication and project performance: An investigation into the role of gatekeepers. *Management Science,* **26**, 11, 1071-1085.

Tushman, M. and Scanlan, T. (1981) Boundary spanning individuals: their role in information transfer and their antecedents. *Academy of Management Journal*, **24**, 2, 289-305.

Taylor, R.L. (1975) The technological gatekeeper. *R&D Management*, **5**, 3, 239-242.

Walter, A. and Gemünden, H.G (2000) Bridging the gap between suppliers and customers through relationship promotors: a theoretical and empirical analysis. *Journal of Business & Industrial Marketing,* **15**, 86-105.

Wasko, M., Faraj, S. A. and Teigland, R. (2004) Collective action and knowledge contribution in electronic networks of practice. *Journal of the Association for Information Systems*, **5,** 11-12, 493-513.

Whelan, E. (2007) Exploring knowledge exchange in electronic networks of practice. *Journal of Information Technology,* **22**, 5-13.

Whelan, E., Ahonen, M. and Donnellan, B. (2008) Knowledge diffusion in R&D groups; the impact of Internet technologies, In: *Proceedings of the 16th European Conference on Information Systems*, Galway, Ireland, June 8-11.

Witte, E. (1973) Power and innovation: a two center theory. *International Studies of Management and Organization,* **7**, 47-70.

Yin, R. K. (1994) *Case Study Research; Design and Methods*. London, Sage.

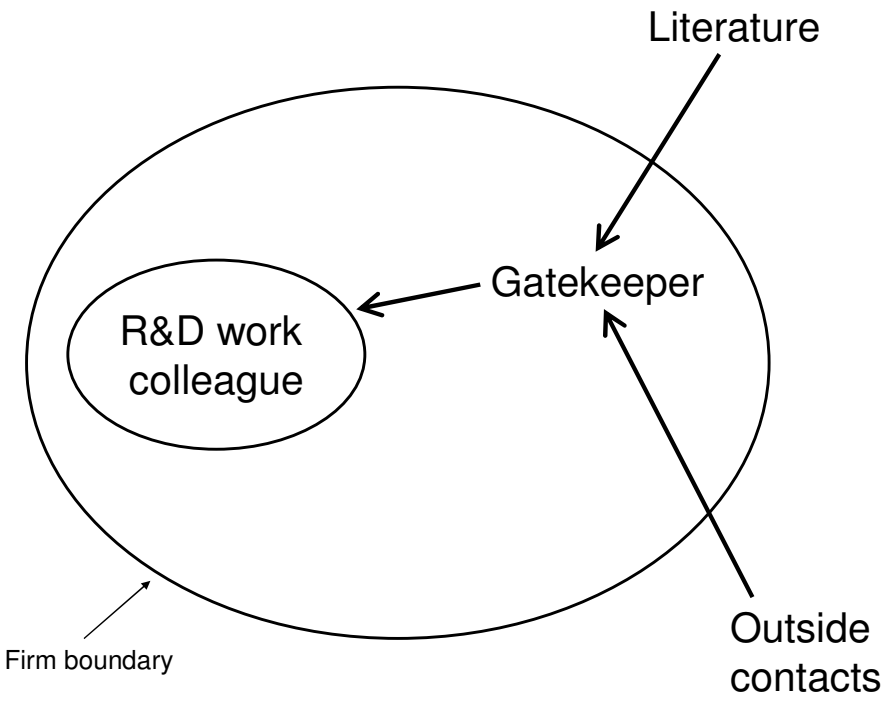

Figure 1. The multi-step flow of technological knowledge (Adapted from Allen 1977)

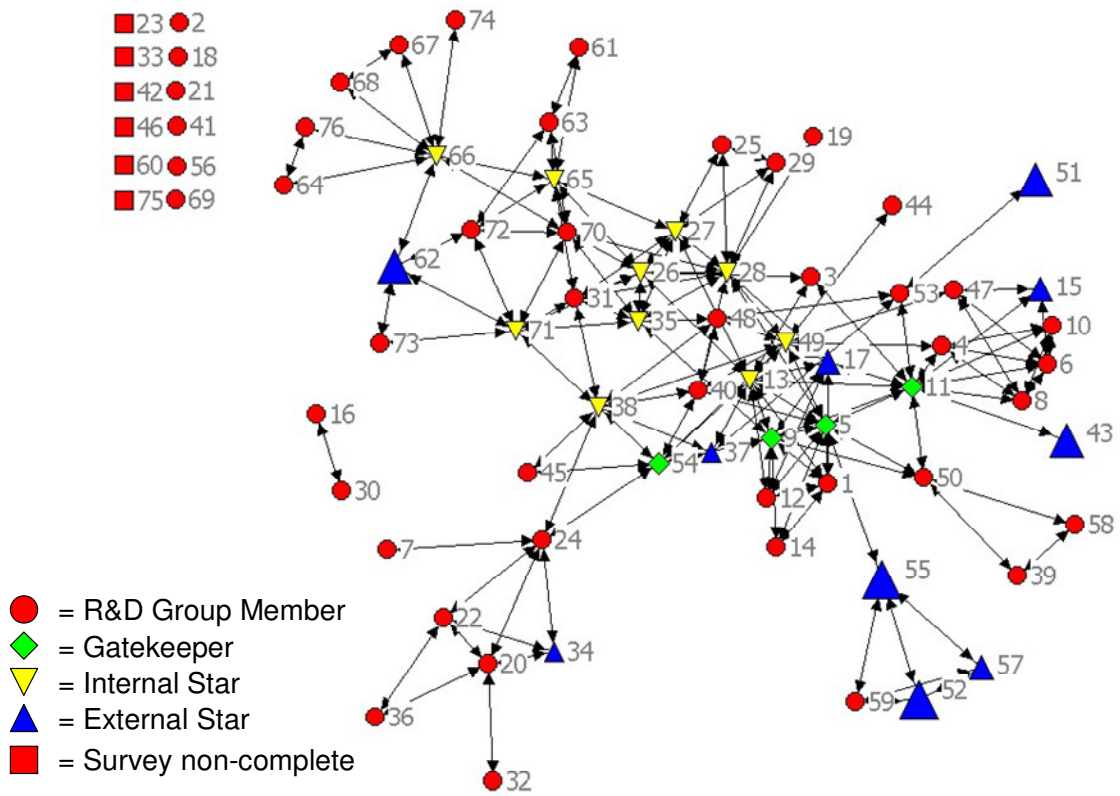

Figure 2. Irish R&D's information flow network

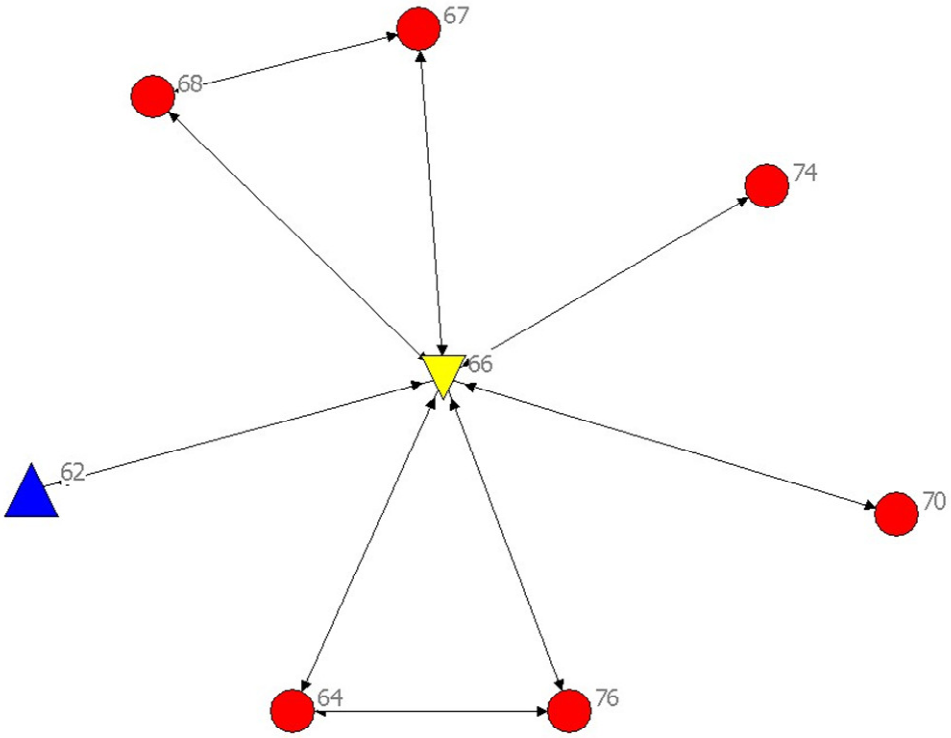

Figure 3. Example of gatekeeper division of labour: 62 is an external communication star who is connected to 66, an internal communication star.

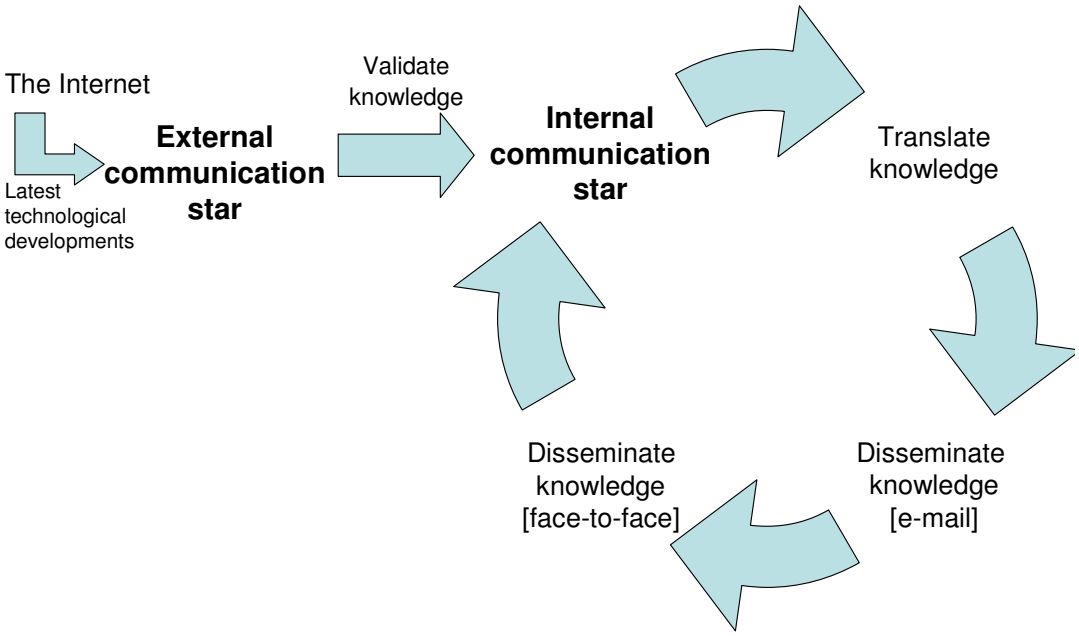

Figure 4. An updated conceptual framework of the technological gatekeeper role

Table 1. Data Collection Methods

Methods	***Details***
Phase 1 – Social network analysis	Online survey issued to all 76 group members, 70 completed (92% response rate)
Phase 2 – Semi-structured interviews	n = 11, recorded and transcribed Interviewees = 3 gatekeepers, 2 external stars, 4 internal stars, 2 non-stars

Table 2. Interviewee details

Node	**Classification**	**R&D Subgroup**	**Formal Position**
5	Technological Gatekeeper	Subgroup A	Engineer
9	Technological Gatekeeper	Subgroup A	Engineer
11	Technological Gatekeeper	Subgroup B	Senior Engineer
57	External Communication Star	Subgroup B	Engineer
62	External Communication Star	Subgroup C	Senior Engineer
13	Internal Communication Star	Subgroup A	Subgroup Head
49	Internal Communication Star	Subgroup B	Senior Engineer
26	Internal Communication Star	Subgroup D	Subgroup Head
28	Internal Communication Star	Subgroup D	Engineer
74	Non Communication Star	Subgroup C	Engineer
19	Non Communication Star	Subgroup D	Technician