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Harnessing a Network of Experts for Competitive Advantage: Technology Scouting in the ICT Industry

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In order to identify discontinuous technological change and develop appropriate action, companies are increasingly building technology foresight (TF) practices. This paper explores how, using networks of experts, technology foresight capabilities can be built. On the basis of three case studies and 43 interviews, it is shown that building foresight systems through networks of scouts yields several benefits, including the support for sourcing external technologies. Using insights from the three major telecommunication incumbents in Europe, the paper describes and discusses (1) what can be achieved by technology scouting, (2) how a process can be set up, (3) what is important in the design of a scouting network, and (4) the characteristics that should be aimed for when choosing technology scouts. The paper contributes to the methodological base of corporate foresight, to the technology management literature, and to the understanding of how companies can increase their open-innovation capabilities by extending the intertwinement with their environment.

1. Introduction

Technology has been recognized as one of the major sources of competitive advantage (Edler et al., 2002; Kocaoglu et al., 2001; Liao, 2005; Phaal et al., 2006). Large global players such as Siemens and General Electric were built on technological inventions that have become break-through innovations. With his invention of a telegraph, Werner von Siemens, the founder of Siemens, revolutionized the way in which messages were transmitted over long distances. Thomas Edison, the founder of General Electric, invented the light bulb, which led to the subsequent replacement of candles, gas, and petroleum as primary sources of light (Fouquet & Pearson, 2006).

For such companies, the initial invention provided a temporary monopoly in newly created markets and in consequence gave them the necessary revenues and time to establish themselves as global champions. But any innovation will eventually be commoditized, thus leading to a loss of the competitive advantage (Christensen & Raynor, 2003). Therefore, for any technology-based company, two questions arise:

- How can it sustain its technological leadership and thus its competitiveness?
- How can it develop promising new technologies and use them to move into new business fields?

Research on technological disruptions has also shown that discontinuous technological changes threaten the competitive position of incumbent companies, because they are slower to react than smaller rivals (Arnold, 2003; Christensen, 1997; Danneels, 2004; Taylor & Helfat, 2009). It also has been shown that being aware of discontinuous technological change does not ensure that the company will be able to produce adequate reactions (Lucas & Goh, 2009; Paap & Katz, 2004). Investigations of the mortality rate of Fortune 500 companies found that the average life expectancy of these global champions is less than 50 years, because of the inability to adapt to discontinuous change in a timely manner (de Geus, 1997; Stubbart & Knight, 2006).

In consequence, companies are faced with two challenges (Levinthal, 1992):

- Identifying, anticipating, and assessing discontinuous change
- Effectively using this information to plan and execute appropriate reactions

This research aims specifically to extend the knowledge of how a network of experts can help with the identification, anticipation, and assessment of discontinuous technological change and at the same time how this same network can support the planning and execution of appropriate action.

A particularly suitable industry to study such capabilities is the information and communication technology (ICT) industry. The telecommunication operators have been faced with discontinuous change in several areas and thus have a high perceived need to develop appropriate approaches to proactively manage discontinuous change.

Building on case-study data from three telecommunication operators, this paper describes and discusses the technology scouting approach of Deutsche Telekom (Germany) and compares it to the practices of British Telecom (United Kingdom) and Telefónica (Spain).

Forty-three interviews were conducted at the three companies. In order to assess the TF activity as well as its internal value creation, the informants were chosen to reflect three distinct perspectives: The *internal stakeholder*, reporting on value creation, the *activity responsible*, reporting on goals and intertwinement with other processes, and the *foresighters*, who were interviewed about process, methods, and execution of the TF activity. To further triangulate the data, 13 internal documents such as foresight reports, process descriptions, and innovation strategy papers were collected and analysed.

2. Brief overview of past research

The importance of conducting technology foresight (TF) has been expressed by practitioners (Ashton, 1997) as well as academics (Bodelle & Jablon, 1993; Brenner, 1996). It has been argued that a formal process needs to be put in place (McDonald & Richardson, 1997; Norling et al., 2000) and optimal methods should be chosen depending on the task (Lichtenthaler, 2005; Meade & Islam, 1998; Porter et al., 2004), size of the company (Lichtenthaler, 2004; Savioz & Blum, 2002), and the context, e.g., the industry clock speed and the level of complexity of the environment (Raymond et al., 2001; Rohrbeck & Gemuenden, 2008).

Previous work on TF has emphasized its importance for delivering state-of-the-art products (Bodelle & Jablon, 1993; Carlson, 2004). TF monitors the technological capabilities of competitors (Brockhoff, 1991), allocates the R&D budget to the most promising technologies (Yap & Souder, 1993), maps emerging technologies to products (Lischka & Gemünden, 2008), assesses and predicts the performance potential of existing and emerging technologies (Tschirky, 1994), and supports make-or-buy decisions (Anderson, 1997).

Less understanding exists on how companies trigger action after foresight insights have been generated. The theory of dynamic capabilities suggests that companies which are faced with disruptions in the environment (Arnold, 2003; Christensen, 1997) need to adapt their strategic resources (e.g., their R&D capabilities) to regain a competitive advantage (Afuah & Utterback, 1997; Eisenhardt & Martin, 2000; Teece et al., 1997). Thus, technology foresight should (1) identify needed capabilities and (2) facilitate their acquisition or development (Helfat & Peteraf, 2003).

This study builds on dynamic-capability theory and investigates how technology scouting can help companies acquire new strategic capabilities, particularly R&D capabilities and technologies.

3. Defining technology scouting

The technology scout

The technology scout is either an employee of the company or an external consultant (Dougherty, 1989; Wolff, 1992). He or she may be assigned part-time or full-time to the scouting task. The desired characteristics of a technology scout are similar to the characteristics associated with the technological gatekeeper (Allen et al., 1971; Nochur & Allen, 1992). These characteristics include being a lateral thinker, knowledgeable in science and technology, respected inside the company, cross-disciplinary orientated, and imaginative (Wolff, 1992).

Technology scouting

Although various authors use the term *technology scouting* as a synonym for TF (Bodelle & Jablon, 1993; Brenner, 1996; Monteiro, 2006), this paper defines technology scouting as a systematic approach by companies whereby they assign part of their staff or employ external consultants to gather information in the field of science and technology and through which they facilitate or execute technology sourcing. Technology scouting is either directed at a specific technological area or undirected, identifying relevant developments in technological white spaces. Technology scouting relies on formal and informal information sources, including the personal networks of the scouts.

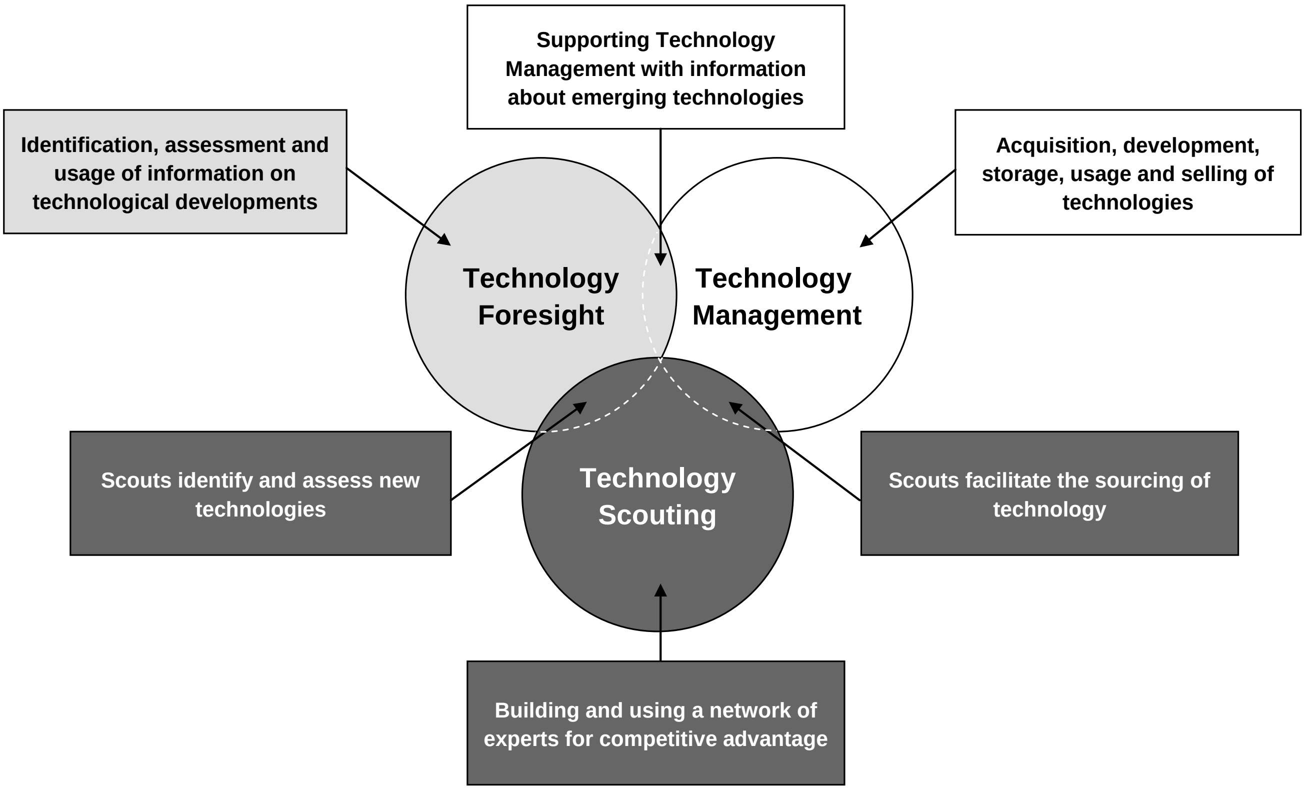

Figure 1: Contributions of Technology Scouting to Technology Foresight and Technology Management

The two aspects of technology scouting—(1) identification, assessment and usage of information and (2) sourcing of technology—are shown in Figure 1. The figure also illustrates the interdependency with both TF and technology management.

4. Explaining the need for technology scouting in the ICT industry

A recent past with many technological disruptions

The telecommunications industry has been hit by two major technological disruptions that have resulted in a high perceived need for TF.

Firstly, the *emergence of mobile telephony* has thoroughly transformed the industry. Mobile telephony became a mass market only 13 years ago. At first the incumbent operators regarded mobile telephony as a threat which would take away revenue from the fixed-line business. When it became clear that mobile telephony would not go away, most operators quickly embraced this new market and acquired a strong position in their home country. Some also used the opportunity to move to other markets and build up new networks. Today, counting the number of users, the mobile telephony market worldwide is more than twice the size of the fixed-line market.

If the incumbent operators had gone along with their first reaction and ignored the trend towards mobile telephony, it is likely that they would not have survived.

The second major disruption is the *horizontalization of service architecture.* Services in the telecommunications industry typically have been highly integrated vertical silos. To offer voice telephony, it was necessary to build large networks and complex switching facilities. Today—with the emergence of the Internet—even small software developers, such as Skype, a voice over Internet protocol (VoIP) provider, can offer voice calls over the Internet with comparably negligible investment and operating costs. The network is free of charge and only the access is billed; the usual high costs for connecting and billing are executed by a software application, allowing a practically indefinite number of users to be provided service with negligible operating costs.

Fighting the threat of VoIP is relatively easy for incumbent operators. All they need to do is change their pricing schemes to flat rates, in which a monthly lump sum is billed and the calls are then free.

What is not so clear is how to deal with the other effect of horizontalization: the slow commoditization of voice and data services. Christensen argues that when a company's products are commoditized, the company should look for de-commoditization in other parts of the value chain (Christensen & Raynor, 2003). And indeed, companies offering value-added services, such as trading sites (e.g., eBay) and device manufacturers (e.g., Nokia and Apple) can today demand premium prices in the ICT industry.

Such a recent history of disruptions is the prime reason why companies in the ICT industry are looking for new methods of identifying changes early, assessing them to understand their full implications, and designing processes to produce effective responses to rising challenges.

A future of increased technological complexity

A second reason for the particularly strong interest in foresight is the increase in technological complexity in the ICT industry. Three major factors are responsible for this increase.

First, the *globalization of R&D*, in which companies move R&D activities to other countries (Serapio & Dalton, 1999) including increasingly strategic R&D activities (Pearce, 1999). Formerly, all that was needed to stay up-to-date on technological development was to observe the triad regions: the United States, Japan, and Europe. Today there are at least five major regions (the triad plus China and India) that need to be observed for breakthrough research and many more for state-of-the-art development capabilities (von Zedtwitz & Gassmann, 2002).

Second, the *specialization of R&D regions* such as the region of Bangalore, India for software development, Silicon Valley for services and business models using information technology and Israel for Internet security solutions.

Third, the *convergence of technologies*, which forces telecommunication companies to build up capabilities in information technologies. Companies who used to compete entirely on radio frequency and power-management technologies now have to master technologies such as media storage, video streaming, social media, and identity management. They also need to become application developers.

As a consequence, telecommunication operators and their suppliers are unable to build up capabilities in all relevant technology fields. They increasingly need to in-source external technologies (Porter & Stern, 2001). This sourcing of technology can be achieved by joint research, licensing, buying intellectual property rights (IPRs), creating joint-ventures, or the outright acquisition of start-ups (Chatterji, 1996; Gray & Meister, 2004; Veugelers, 1997).

Specific advantages of scouting

The most widely used TF methods are using automated search mechanisms to find information in databases. Such methods include publication and patent analysis (Daim et al., 2006; Porter, 2005) as well as trend curves, such as technology lifecycles (Jones et al., 2001), and the S-curve analysis (Modis, 2007; Phillips, 2007; Sood & Tellis, 2005).

Using such methods in combination with intelligent data-mining tools (Porter & Cunningham, 2005) makes is possible to retrieve useful information and—provided you ask the right question—can give you appropriate answers in a timely manner.

What such automated instruments are not capable of doing is making sense of technological evolution in its early stages. Initially, technologies are often developed with different names in parallel and cannot be found by automated searches. In addition, early technology-development projects need a technological expert to judge their potential value for different applications, because it is usually the case that no market data are available at that moment.

To overcome these limitations, national foresight exercises in particular made use of the Delphi method (Landeta, 2006; Ronde, 2003; Rowe et al., 2005). This method is based on expert opinions that are collected and in multiple iterative rounds consolidated to form consent.

In the corporate context, these two groups of methods—automated data mining and expert interviews—have three major limitations:

- Firstly, they do not involve the internal stakeholders (e.g., the product managers or the R&D project managers), and thus produce *results with little internal acceptance*.
- Secondly, there is a time lag between the initial technological development and its detection by the TF method. In database search, *a lag of at least 12 to 18 months* should be expected, because of publication and patenting processes (Lichtenthaler, 2002).
- Thirdly, there is *no link established to the source of the technological information*. For a TF insight with strategic relevance, further interaction with the information is typically needed. For a promising emerging technology, the company needs to be able to get into direct contact with the technology developer and source the technology.

For these three reasons, Deutsche Telekom has established a TF system that is based on a worldwide network of technology scouts. These scouts search for relevant technological information and discuss them proactively with internal stakeholders.

Integrating internal stakeholders increases acceptance of the gathered intelligence, reduces the time lag between initial development and detection by the TF system, and allows facilitating discussions with the source of the technological information and the in-sourcing of the technology.

5. Technology scouting at Deutsche Telekom

Goals

In a broader sense, the goal of technology scouting is to gain a competitive advantage by identifying opportunities and threats arising from technological developments at an early stage and to provide the technological capabilities needed to face these challenges.

More specifically, the technology scouting approach—called ‘technology radar’—has four major goals:

- *Early identification* of technologies, technological trends and technological shocks
- *Raising awareness* of the threats and opportunities of technological development

- *Stimulation of innovation* by combining the technology reports with business potential assessment
- *Facilitation of the sourcing of external technologies* by allowing for a direct channel through the network of technology scouts to their sources of information

Process

The process at Deutsche Telekom's technology radar consists of four stages, shown in Figure 2.

In the *identification phase*, a network of technology scouts is used to access sources of information on technological developments in industry and academia. For technologies with potential relevance, a short description is prepared, including technology assessment, research status, and business potential. This summary is sent to the technology exploration unit of Deutsche Telekom.

The *selection phase* consists of two separate screening steps. In the first step, the technologies are selected according to their degree of external novelty and the newness to Deutsche Telekom. A second step ensures that the technology is not yet being assessed elsewhere at Deutsche Telekom.

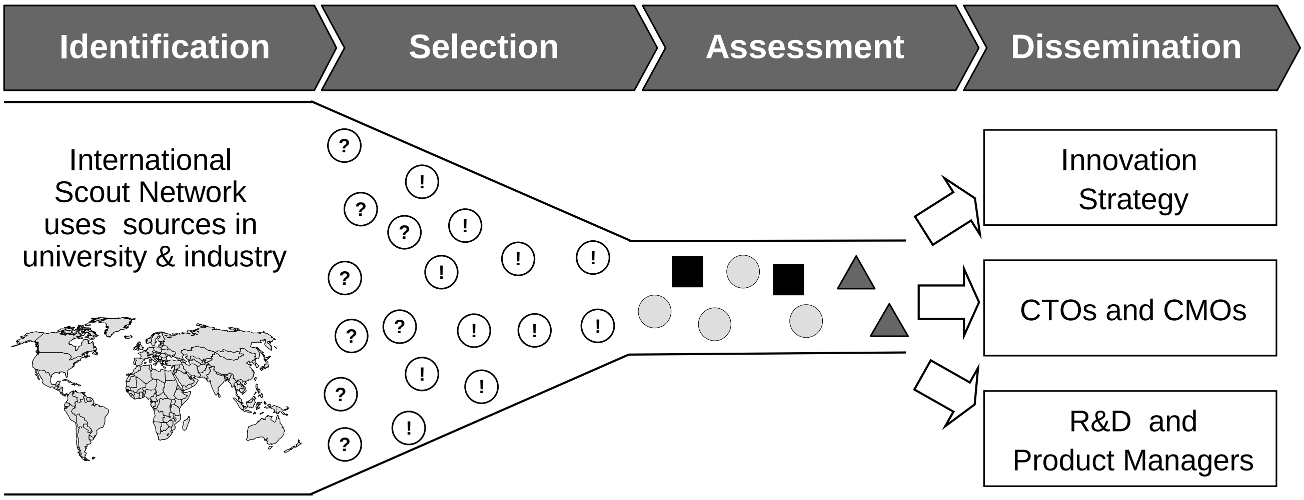

Figure 2: Technology Radar Process

In the *assessment phase*, the technologies are ranked according to two criteria: 'market potential' (with the underlying factors 'potential market size', 'cost savings' and 'disruptive potential') and 'technological realization complexity' (with the underlying factors 'complexity', 'implementation risk' and 'development costs'). The ranking is done in a workshop with technology scouts, internal stakeholders, and the technology foresight team from corporate R&D, which publishes the technology radar. In this workshop, all scouts participate in all technology ratings, ensuring that cross-technological enabling characteristics of a technology are detected and broader technological trends are identified.

In the *dissemination phase*, the technologies are described in a 'technology one-pager', which includes a description, latest developments, research status, and a discussion of the business potential.

In the knowledge transfer, four mechanisms are used to promote communication between the internal stakeholders, the scouts, and the source of the technological information:

- Firstly, the scouts' names and *contact details are listed* in the technology 'one-pagers'.
- Secondly, *workshops with R&D and product managers* are used to discuss the findings of the scouting network and kick-off projects.
- Thirdly, different *follow-up options* are offered, including in-depth workshops with the sources of the technological insights, in depth reports on certain technological trends, and consulting by the scouts.
- A matching of the technology radar findings with the current R&D activities. A *gap analysis* identifies and triggers new R&D projects.

Central visualization of findings

To provide convenient access to the scouting results and to promote the usage of the technologies central visualization is used. This radar screen provides metadata on the technologies along three dimensions (see Figure 3):

- The *maturity* of the technologies, which is divided into five levels: 'basic research', 'applied research', 'product concept', 'market ready' and 'market presence'. The maturity is visualized as concentric circles and makes it possible to browse for technologies that may be introduced in the next generation of products.
- The *technological area*, which at Deutsche Telekom is structured along its value chain and includes the areas 'fixed and mobile devices', 'access network', 'core network', 'network

services', 'end-user services', and 'cross-functional'. In the radar, it is visualized as a segment of the circle.
- The *need for awareness*, which has a three-level rating scale: high, medium, and low. It is illustrated with different symbols and colours to enable efficient identification of the most relevant technologies.

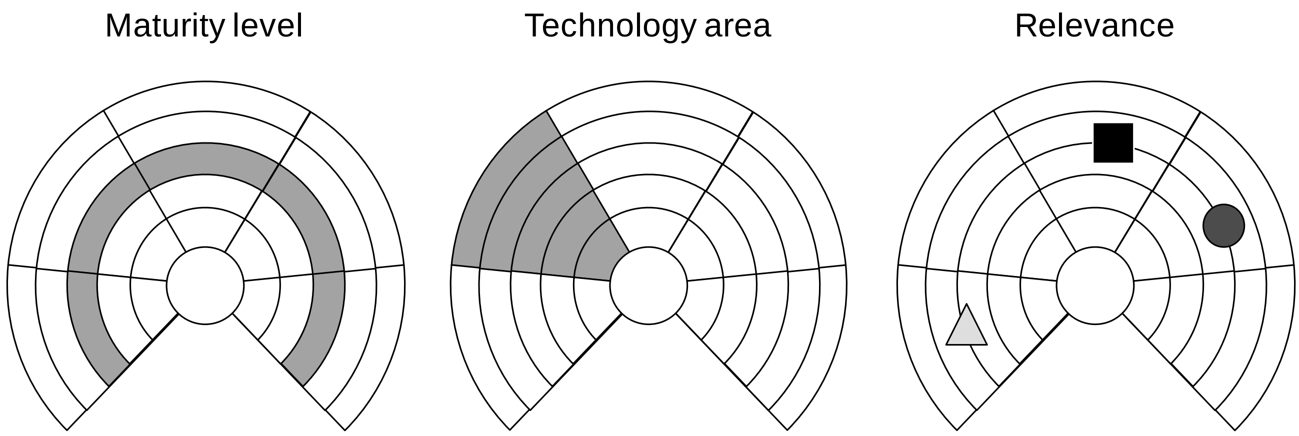

Figure 3: Central Visualization: the Technology Radar Screen

In the case studies, the internal stakeholders have repeatedly emphasized the importance of the radar screen. It has been praised for its intuitive usage, the depth of information (maturity level, technology area, and relevance) and the ability to provide an overview of approximately 60 technologies. It was described as the primary appeal for top management, which is keen on being able to process much information with few figures.

Structure of the scouting network

The structure of the scouting network of Deutsche Telekom follows three major principles:

- Involve scouts with a large formal and informal network.
- Ensure a strong linkage between the scouts.
- Promote the connection between scouts and internal stakeholders.
- Facilitate communication between external expert and internal stakeholder.

The resulting structure is shown in Figure 4 (the figure illustrates only the structure of, and not the actual numbers of actors in, the scouting network).

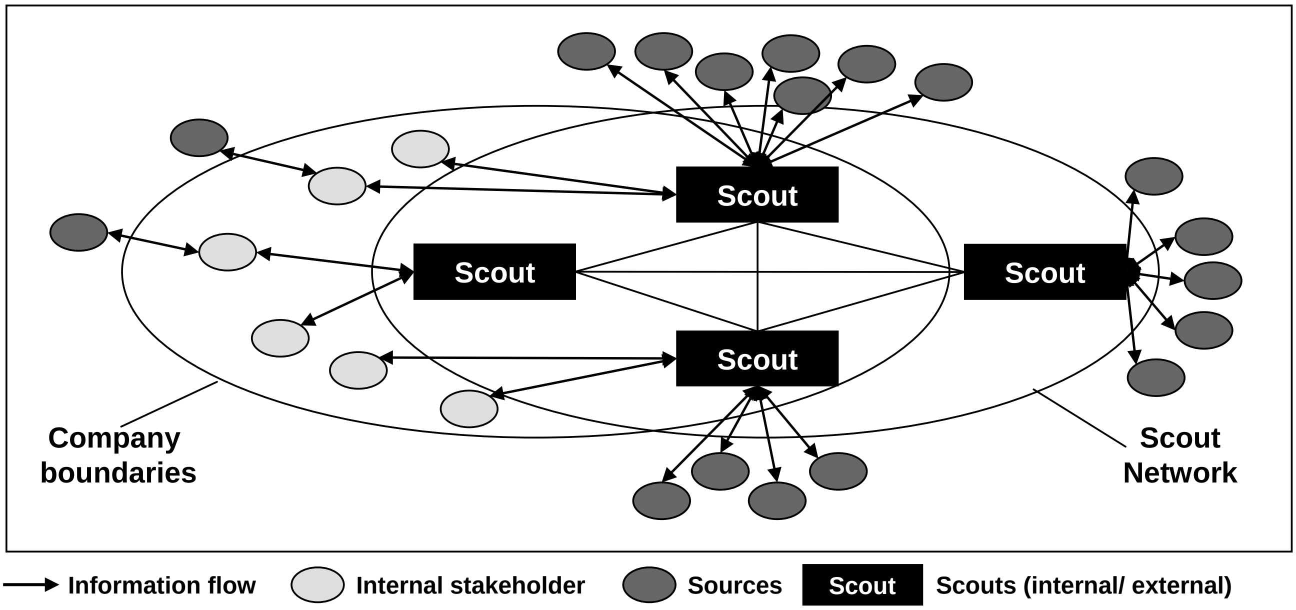

Figure 4: Structure of Scouting Network

What can be observed is that each scout has several sources of information (external experts). *A typical scout would have around 10 major sources and more minor ones*, which he or she uses only occasionally. These sources are from industry and academia. Some scouts may focus exclusively on one of the two domains, but most have contacts in both.

These sources can be connected formally, through for example communities of practice, or informally, through personal ties. In both cases, the scout should be able to gather information about technological advances much earlier than the foresighters working with information from databases.

In addition, the information gathered by a scout is typically very rich. The richness, it was observed, was particularly valuable. For example, an academic researcher may provide an estimate about when the technology will be market-ready or what interdependencies to other technologies need to be monitored. He or she may also provide insights into potential application fields, thereby supplying new product ideas to Deutsche Telekom.

Another way to look at the scouting network is through the relationships and interests of the actors. It has been emphasized that understanding the interests of the various stakeholders and developing mechanisms which provide these benefits are crucial to the success of the approach. As the manager of the technology foresight activity pointed out, 'Money-for-information is not sufficient to ensure the success of a scouting network.'

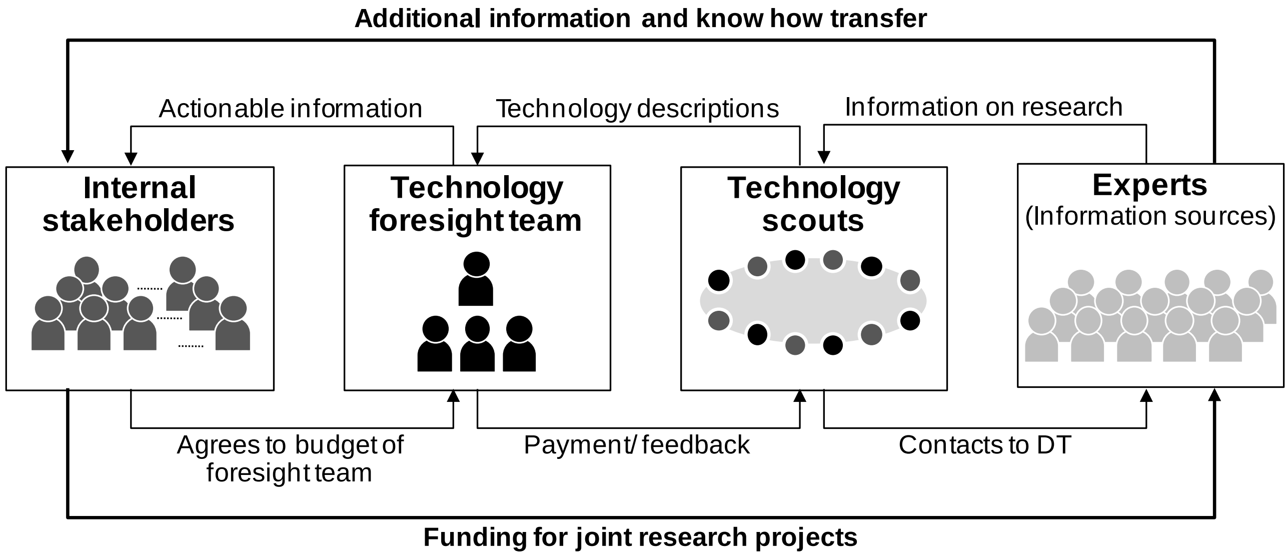

Figure 5: Actors, Their Relationships, and Their Interests

The scouting network of Deutsche Telekom consists of four major actors: (1) the *internal stakeholders*, such as R&D project managers and strategic planning, (2) the *technology foresight team*, (3) the *technology scouts*, who can be internal or external, and (4) the *experts*, or sources of information whom the technology scouts approach (see Figure 5).

Among these actors, four major relationships or exchange interfaces exist. It can be assumed that in order to be stable and successful, a scouting network needs to ensure that all exchanges are satisfactory to the actors involved.

- In the first exchange, the *internal stakeholders receive the technological information* which should lead to action, meaning that it should be in the language of the internal stakeholders and fit into their decision or work process. If satisfied with the information, the *internal stakeholders will agree to the budget* of the foresight activity and ensure its stability.
- In the second exchange, *the technology scouts provide descriptions on emerging technologies in exchange for direct payment*, feedback on the technology, and recognition from the company. Internal scouts are remunerated either through their work contract or as part of their bonus scheme. External scouts are generally paid directly.
- In the third exchange, the experts from industry and academia provide information on their ongoing research in exchange for contacts into DT. These contacts are of value because they yield the potential to start joint research activities or gain access to empirical data for the research.
- Whereas the first three exchanges are needed to allow the scouting network to function, the fourth is the most important one and is needed to stabilize the scouting network and make it succeed in the long run. In this exchange, the *experts provide to the internal stakeholders additional information and transfer know-how* in order to turn technological insights into applied technologies and successful projects. In exchange, *internal stakeholders provide funding for joint research projects*.

It is particularly the fourth exchange which will decide the fate of the scouting network. It is also the exchange where the most money is involved. This is because the internal stakeholders are prepared to spend only a limited amount of money on technological insights, but much more for technological knowledge, which can be utilized directly in new product development. It is therefore this exchange which should be tracked to monitor the success of the overall scouting network.

Typology of scouts

In past research, different recommendations have been made on who should be hired as a technology scout. Wolff has proposed that the ideal scout is an internal employee who works full time (Wolff, 1992). Dougherty, in contrast, sees the technology scout rather as a well-known expert, who is hired by different companies as a consultant (Dougherty, 1989). The older concept of a technological gatekeeper also emphasizes the usage of internal personnel to channel information into the company (Allen et al., 1971; Taylor, 1975).

All authors name a variety of different advantages and disadvantages to support their recommendation. The bottom line seems to be that internal full-time employees are superior in the dissemination of information and better suited to identify technologies with high relevance for the information, while external consultants are better at identifying technological developments in white spaces, have larger networks, and may have more in-depth expert knowledge.

In both cases, the respondents emphasized that the knowledge about the company and its priorities is important to the success of the foresight activity. One internal stakeholder explained that ‘each scout has to be able to not only to understand the technology, but he also needs to be an expert in the innovation priorities of the company’s business lines.’

Therefore, even if external consultants are used, it is important to ensure that sufficient knowledge about the company and its internal requirements and priorities is available to the scouts.

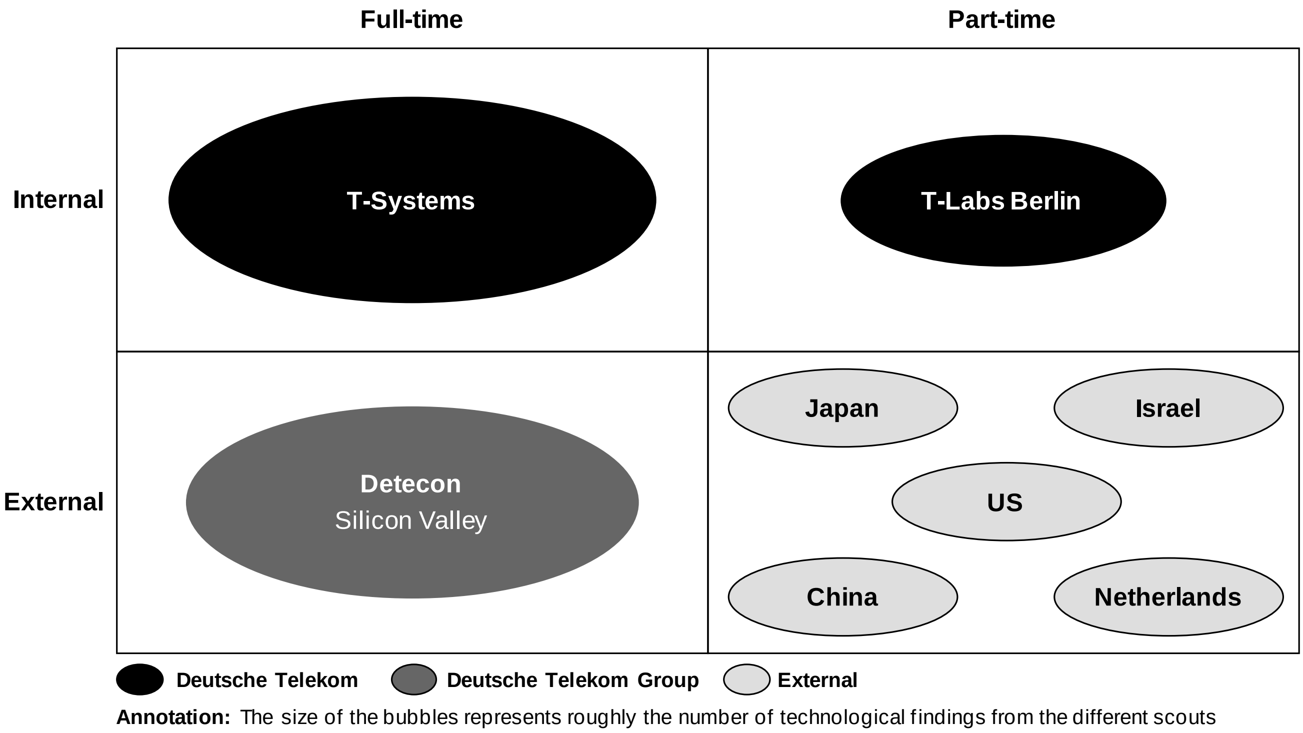

Figure 6: Typology of Scouts

When categorizing the scouts of Deutsche Telekom in internal/external and full-time/part-time, we see that the portfolio of scouts is balanced in both dimensions (see Figure 6). Although counting the number of technological findings, there is a slight emphasis on the internal scouts.

Following the argument of Wolff and Dougherty, it can be expected that the scouting network of Deutsche Telekom should deliver information that is both relevant and sufficiently focused on white spaces, i.e., on solutions from outside the current technology portfolio.

6. Cross-case comparison

In comparing British Telecom (BT), Telefónica, and Deutsche Telekom (DT), it is surprising that all three companies chose to build their foresight practice on the basis of scouts. Even more unexpected was the finding that the configuration of the scouting practices have much in common.

All companies confirmed that they were following three primary *goals*:

- early identification of emerging technologies (with a particular focus on technologies with disruptive potential)
- stimulating innovation
- supporting the sourcing of technologies

BT reported the additional aim of continuously challenging their R&D departments with insights from foresight in order to ensure that their new product developments are state-of-the-art. DT added that they aim also to trigger more discussion on technological change and raise awareness about emerging technologies.

Concerning the *process*, that of DT was the most structured and formalized. The process of Telefónica was also well-structured and in addition had a direct process link to R&D and innovation management. BT had the least structured process but the most interaction with its internal stakeholders. The communication of insights at BT was done primarily through workshops with R&D or with product management from the operational units.

Another commonality is that they all had a *central visualization* for the presentation of findings, but all three companies used different frameworks. DT used the radar screen, as described above. BT uses a timeline which is structured in different technology areas. Telefónica uses an architecture overview which has similar technological areas as in the radar screen used by DT but lacks the maturity dimension. One important commonality between the visualization frameworks is that technological areas can be matched with an internal manager. This ensures that a top manager who reads the TF report can find for each emerging technology a person who would be responsible for developing that specific technology.

Concerning the *structure of the scouting network*, the commonality is that all companies aimed at achieving a global reach for their foresight activity. In so doing, they all extended their foresight activity to countries outside the usual triad of the United States, Europe, and Japan, adding countries such as India, China, South Korea, and Brazil.

Major differences existed in the *typology of scout*. Whereas DT has a balanced portfolio along the two dimensions, BT and Telefónica are using primarily internal staff. The primary reasons given are the perceived importance for confidentiality and the need to employ scouts with a strong knowledge about the technological needs of the company.

7. Conclusion

From the case studies, it can be concluded that in the ICT industry the use of people and their personal networks for technology foresight (technology scouting) is well-established. This has been attributed to the specific advantages of technology scouting: (1) fast discovery of emerging technologies, (2) robustness of approach when faced with changing terminologies, (3) richness of information on emerging technologies, and (4) the support for technologies from external sources.

The fourth advantage drew much commentary, being identified as particularly important. If a company can build strong relationships between the external experts (who aim to acquire research funding) and the internal stakeholders (who aim to source superior technologies), than it will also achieve increase its technological competitiveness.

Through the in-depth case study at DT, it has also been possible to illuminate the way in which a large multinational company operationalized the technology foresight task. This made it possible to describe and discuss in detail (1) what can be achieved by technology scouting, (2) how a process can be set up, (3) what is important in the design of a scouting network, and (4) which characteristics should be aimed for when choosing the technology scouts.

The cross-case analysis made it possible to increase the generalizability of the findings, showing that in one industry companies have independently chosen a similar setup for their foresight system. The comparison also revealed that the usual triad (the United States, Europe, and Japan) has been extended by all companies to include China and India.

By providing insights into the move towards people-based foresight systems in the ICT industry, this study can be considered a basis for further research on technology foresight and innovation management. By showing that technology scouting can support the sourcing of technology, this research also adds to the literature on open innovation (Chesbrough, 2003; Gassmann, 2006; Rohrbeck et al., 2009). Building on networks of technology scouts should increase the company's intertwinement with its environment and increase its openness to potential collaboration partners (Ritter & Gemunden, 2003).

There are great opportunities for further research, particularly in the relationship between different foresight approaches and the openness of a company. Moreover, it would be interesting to empirically test how foresight is conducted in different industries in order to provide better recommendations on how to configure a foresight system. The task of anticipating discontinuous change is not one in which the sole focus can be on technology. It would, therefore, also be interesting to investigate the way in which technology scouting can be combined with foresight in the consumer, political, and competitive environment, within the larger framework of corporate foresight (Becker, 2002; Daheim & Uerz, 2008; Rohrbeck & Gemuenden, 2008) and how it can be combined with other methods such as technology roadmapping (Yoon et al., 2008).

References

Afuah, A. N. and Utterback, J. M. (1997) Responding to Structural Industry Changes: A Technological Evolution Perspective. *Industrial and Corporate Change*, **6**, 183-202.

Allen, T. J., Piepmeier, J. M. and Cooney, S. (1971) International Technological Gatekeeper. *Technology Review*, **73**, 36-43.

Anderson, J. (1997) Technology foresight for competitive advantage. *Long Range Planning*, **30**, 665-677.

Arnold, H. M. (2003) *Technology Shocks: Origins, Management Responses and Firm Performance*. Heidelberg and New York: Physica Verlag Springer-Verlag GmbH & Co.KG.

Ashton, W. B. (1997) Tech intelligence survey finds few are world-class. *Research Technology Management*, **40**, 3-5.

Becker, P. (2002) Corporate Foresight in Europe: A First Overview *Working Paper European Commission*. Brussels: European Commission, 31.

Bodelle, J. and Jablon, C. (1993) Science and technology scouting at Elf Aquitaine. *Research Technology Management*, **36**, 24-28.

Brenner, M. S. (1996) Technology Intelligence and Technology Scouting. *Competitive Intelligence Review*, **7**, 20-27.

Brockhoff, K. (1991) Competitor Technology Intelligence in German Companies. *Industrial Marketing Management*, **20**, 91-98.

Carlson, L. W. (2004) Using Technology Foresight to Create Business Value. *Research Technology Management*, **47**, 51-60.

Chatterji, D. (1996) Accessing external sources of technology. *Research Technology Management*, **39**, 48-56.

Chesbrough, H. W. (2003) The Era of Open Innovation. *Mit Sloan Management Review*, **44**, 35-41.

Christensen, C. M. (1997) *The innovator's dilemma : when new technologies cause great firms to fail*. Boston, Mass.: Harvard Business School Press.

Christensen, C. M. and Raynor, M. E. (2003) *The Innovator's Solution: Creating and Sustaining Successful Growth*. Boston, Massachusetts: Harvard Business School Press.

Daheim, C. and Uerz, G. (2008) Corporate foresight in Europe: from trend based logics to open foresight. *Technology Analysis & Strategic Management*, **20**, 321-336.

Daim, T. U., Rueda, G., Martin, H. and Gerdsri, P. (2006) Forecasting emerging technologies: Use of bibliometrics and patent analysis. *Technological Forecasting & Social Change*, **73**, 981–1012.

Danneels, E. (2004) Disruptive technology reconsidered: A critique and research agenda. *Journal of Product Innovation Management*, **21**, 246-258.

de Geus, A. (1997) The living company. *Harvard Business Review*, **75**, 51-59.

Dougherty, E. (1989) Tech Scouts: R&D's Globetrotters. *Research & Development*, **31**, 44-50.

Edler, J., Meyer-Krahmer, F. and Reger, G. (2002) Changes in the strategic management of technology: results of a global benchmarking study. *R & D Management*, **32**, 149-164.

Eisenhardt, K. M. and Martin, J. A. (2000) Dynamic capabilities: What are they? *Strategic Management Journal*, **21**, 1105-1121.

Fouquet, R. and Pearson, P. (2006) Seven Centuries of Energy Services: The Price and Use of Light in the United Kingdom (1300-2000). *Energy Journal*, **27**, 139-177.

Gassmann, O. (2006) Opening up the innovation process: towards an agenda. *R & D Management*, **36**, 223-228.

Gray, P. H. and Meister, D. B. (2004) Knowledge Sourcing Effectiveness. *Management Science*, **50**, 821-835.

Helfat, C. E. and Peteraf, M. A. (2003) The dynamic resource-based view: Capability lifecycles. *Strategic Management Journal*, **24**, 997-1010.

Jones, G. K., Lanctot, A. and Teegen, H. J. (2001) Determinants and performance impacts of external technology acquisition. *Journal of Business Venturing*, **16**, 255-283.

Kocaoglu, D. F., Anderson, T. R. and Milosevic, D. (2001) *Technology management in the Knowledge Era*. Portland, Oregon: IEEE.

Landeta, J. (2006) Current validity of the Delphi method in social sciences. *Technological Forecasting and Social Change*, **73**, 467-482.

Levinthal, D. (1992) Surviving Schumpeterian Environments: An Evolutionary Perspective. *Industrial and Corporate Change*, **1**, 427-443.

Liao, S.-h. (2005) Technology management methodologies and applications - A literature review from 1995 to 2003. *Technovation*, **25**, 381-393.

Lichtenthaler, E. (2002) *Organisation der Technology Intelligence - Eine empirische Untersuchung der Technologiefrühaufklärung in technologieintensiven Grossunternehmen*: Verlag Industrielle Organisation.

Lichtenthaler, E. (2004) Technology intelligence processes in leading European and North American multinationals. *R & D Management*, **34**, 121-135.

Lichtenthaler, E. (2005) The choice of technology intelligence methods in multinationals: towards a contingency approach. *International Journal of Technology Management*, **32**, 388-407.

Lischka, J.-M. and Gemünden, H. G. (2008) Technology Roadmapping in manufacturing – a case study at Siemens Power Generation. *International Journal for Technology Intelligence and Planning*, **4**, 201-214.

Lucas, H. C. and Goh, J. M. (2009) Disruptive technology: How Kodak missed the digital photography revolution. *Journal of Strategic Information Systems*, **In Press**.

McDonald, D. W. and Richardson, J. L. (1997) Designing and Implementing Technology Intelligence Systems. In: Ashton, W. B. and Klavans, R. A., eds. *Keeping abreast of science and technology: technical intelligence for business*. Columbus, Ohio: Battelle Press, 123-156.

Meade, N. and Islam, T. (1998) Technological forecasting - Model selection, model stability, and combining models. *Management Science*, **44**, 1115-1130.

Modis, T. (2007) Strengths and weaknesses of S-curves. *Technological Forecasting and Social Change*, **74**, 866-872.

Monteiro, L. F. (2006) Sensing the Globe for External Knowledge: Uncovering the Technology Scouting Process *London Business School, Working Paper*. London: London Business School, 42.

Nochur, K. S. and Allen, T. J. (1992) Do Nominated Boundary Spanners Become Effective Technological Gatekeepers? *Ieee Transactions on Engineering Management*, **39**, 265-269.

Norling, P. M., Herring, J. P., Rosenkrans, W. A., Jr., Stellpflug, M. and Kaufman, S. B. (2000) Putting competitive technology intelligence to work. *Research Technology Management*, **43**, 23-28.

Paap, J. and Katz, R. (2004) Anticipating Disruptive Innovation. *Research-Technology Management*, **47**, 13-22.

Pearce, R. D. (1999) Decentralised R&D and strategic competitiveness: globalised approaches to generation and use of technology in multinational enterprises (MNEs). *Research Policy*, **28**, 157-178.

Phaal, R., Farrukh, C. J. P. and Probert, D. R. (2006) Technology management tools: concept, development and application. *Technovation*, **26**, 336–344.

Phillips, F. (2007) On S-curves and tipping points. *Technological Forecasting and Social Change*, **74**, 715-730.

Porter, A. L. (2005) QTIP: Quick technology intelligence processes. *Technological Forecasting & Social Change*, **72**, 1070–1081.

Porter, A. L., Ashton, W. B., Clar, G., Coates, J. F., Cuhls, K., Cunningham, S. W., Ducatel, K., van der Duin, P., Cunningham, S. W., Ducatel, K., van der Duin, P., Georgehiou, L., Gordon, T., Linstone, H., Marchau, V., Massari, G., Miles, I., Mogee, M., Salo, A., Scapolo, F., Smits, R., Thissen, W. and Group, T. F. A. M. W. (2004)

Technology futures analysis: Toward integration of the field and new methods. *Technological Forecasting & Social Change*, **71**, 287-303.

Porter, A. L. and Cunningham, S. W. (2005) *Tech mining : exploiting new technologies for competitive advantage*. Hoboken, N.J.: Wiley.

Porter, M. E. and Stern, S. (2001) Innovation: Location Matters. *Mit Sloan Management Review*, **42**, 28-36.

Raymond, L., Julien, P. A. and Ramangalahy, C. (2001) Technological scanning by small Canadian manufacturers. *Journal of Small Business Management*, **39**, 123-138.

Ritter, T. and Gemunden, H. G. (2003) Network competence: Its impact on innovation success and its antecedents. *Journal of Business Research*, **56**, 745-755.

Rohrbeck, R. and Gemuenden, H. G. (2008) Strategic Foresight in Multinational Enterprises: Building a Best-Practice Framework from Case Studies *R&D Management Conference "Emerging methods in R&D management"* Ottawa, Canada, 10.

Rohrbeck, R., Hölzle, K. and Gemünden, H. G. (2009) Opening up for competitive advantage - How Deutsche Telekom creates an open innovation ecosystem. *R & D Management*, **39**, 420-430.

Ronde, P. (2003) Delphi analysis of national specificities in selected innovative areas in Germany and France. *Technological Forecasting and Social Change*, **70**, 419-448.

Rowe, G., Wright, G. and McColl, A. (2005) Judgment change during Delphi-like procedures: The role of majority influence, expertise, and confidence. *Technological Forecasting & Social Change*, **72**, 377–399.

Savioz, P. and Blum, M. (2002) Strategic forecast tool for SMEs: how the opportunity landscape interacts with business strategy to anticipate technological trends. *Technovation*, **22**, 91-100.

Serapio , M. G. J. and Dalton, D. H. (1999) Globalization of industrial R&D: an examination of foreign direct investments in R&D in the. *Research Policy*, **28**, 303.

Sood, A. and Tellis, G. J. (2005) Technological Evolution and Radical Innovation. *Journal of Marketing*, **69**, 152-168.

Stubbart, C. I. and Knight, M. B. (2006) The case of the disappearing firms: empirical evidence and implications. *Journal of Organizational Behavior*, **27**, 79-100.

Taylor, A. and Helfat, C. E. (2009) Organizational Linkages for Surviving Technological Change: Complementary Assets, Middle Management, and Ambidexterity. *Organization Science*, **20**, 718-739.

Taylor, R. L. (1975) Technological Gatekeeper. *R & D Management*, **5**, 239-242.

Teece, D. J., Pisano, G. and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal*, **18**, 509-533.

Tschirky, H. P. (1994) The Role of Technology-Forecasting and Assessment in Technology Management. *R & D Management*, **24**, 121-129.

Veugelers, R. (1997) Internal R&D expenditures and external technology sourcing. *Research Policy*, **26**, 303-315.

von Zedtwitz, M. and Gassmann, O. (2002) Market versus technology drive in R&D internationalization: four different patterns of managing research and development. *Research Policy*, **31**, 569-588.

Wolff, M. F. (1992) Scouting for Technology. *Research Technology Management*, **35**, 10-12.

Yap, C. M. and Souder, W. E. (1993) A Filter System for Technology Evaluation and Selection. *Technovation*, **13**, 449-469.

Yoon, B., Phaal, R. and Probert, D. (2008) Morphology analysis for technology roadmapping: application of text mining. *R & D Management*, **38**, 51-68.